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RESEARCH ARTICLE

Formulation and Evaluation of Herbal Soap by using Melt and Pour Method

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ABSTRACT

The aim of our study was to develop the herbal soap by using melt and pour method. Soap was made by blending *kapok gum*, 20%, musk melon ,10% olive oil,5%, argan oil,3%, soap base,90%. Which formed a penny brown? Herbal soap has been used traditionally for treating several epidermal dysfunctions, such as eczema, psoriasis, and acne and helps to boost immune response in tissue of affected skin area. The results of the selected physical and chemical properties of this study show that the moisture content of the soap was 6% with 7%PH, foaming height 9cm, foam retention time 5mins, alcohol soluble 17%, free alkaline 0.26%. Also, the evaluation tests showed that the herbal soap has satisfactory antimicrobial results as compared to standard antibiotic. Moreover, oil used are added to treat various skin infection and for daily usage. The results imply that herbal soap is suitable for human skin and can be a therapeutic alternative to skin problems.

Keywords: kapok gum, muskmelon, arganoil, formulation, evaluation

INTRODUCTION

The body's outermost layer, human skin, acts as the body's first line of defense against a range of infections [1]. The skin is constantly exposed to a range of stimuli because it interacts with the environment. As a result, the skin is prone to injury [2]. When badly damaged skin tries to heal, scar tissue emerges, which is typically decolorized and depigmented. Chemical soaps, on the other hand, are known to promote skin irritation and dryness [3]. Natural-ingredient cosmetics are becoming more popular among consumers as a healthier, organic, and ecologically responsible option. Ayurvedic cosmetics are sometimes known as herbal cosmetics [4]. The natural component of herbal medicine has no negative effects on the human body in the vast majority of cases. A pharmaceutical or medication that contains antibacterial and antifungal ingredients is known as an "herbal soap preparation." It's made up of plant parts including leaves, stems, roots, and fruits, and it's used to treat damage, disease, and keep people healthy [5]. Soaps have been used in our daily lives for over 6,000 years and have a rich history. Ancient Babylonians developed a cleaning material by combining animal fats, wood ash, and water, which became known as "soap." Saponification is the basic method of soap production in which fats or oils react with a base/lye. Soaps are divided into two types: solid and liquid. Solid soaps are made with NaOH as the basis, while liquid soaps are made with KOH. Medicinal soaps differ from regular soaps in that synthetic or natural bioactive substances are added to the basic soap medium to give the end product a wide range of biological activity.

Because of the negative or harmful effects of synthesis chemicals, it is preferable to avoid using dangerous synthesis chemicals in medical soap products. Plant-based natural goods have been a popular synthetic ingredient in recent years as a way to improve the vital biological properties of medicinal soap. Many side effects associated with medicinal soaps containing synthetic ingredients were alleviated by replacing synthetic foaming agents such as sodium lauryl sulphate with saponins, synthetic antibacterial agents such as Triclosan with natural antibacterial agents, and synthetic antioxidants such as BHT with natural phenolic compounds. Some of the most commonly used ingredients in skin care products, including medicinal soaps, include coconut oil, olive oil, turmeric, sandalwood, jasmine, and lemon essence. [6-16] While the skin provides some protection from the sun, pollution, and viruses, it is the most vulnerable portion of the body. Eczema, warts, acne, rashes, psoriasis, allergies, and other skin disorders are some of the most common. Hand hygiene is important in preventing infectious diseases because it protects the skin from microbial infection and spread. This herbal soap or solution aids in the more effective prevention of contagious illness transmission in the healthcare setting[17] *Bombax ceiba*, also called "Bird's Paradise." It is "God's best creation for humanity" and a prized gift from nature because of its multifunctionality [18] It's employed in Ayurveda, Unani, and Siddha treatments for medicinal purposes used to remove Dead skin removal, skin whitening, and anti-aging

MATERIALS AND METHOD

Collection of plant sample:
Bombax ceiba, orange, argan oil, soap base was collected from the local market, Salem.

Apparatus:

- A glass measuring cup, a microwave, and a water bath
- Spoon
- Moulds for soap
- As a soap base.
- Optionally, add goods, colour, and aroma to the mix.
- Digital balance.

Preformulation

Organoleptic Properties

The organoleptic quality of a Natural substance refers to its appearance, odor, color, and taste. The study's first stage is to characterize these features, which assists in the primary identification of the Natural substance as well as estimating the probability of patient acceptability of the raw materials odor, taste, and color, as well as its probable inclusion in the final dose form. Changes in the color and odor of the raw material in the formulation might sometimes indicate changes in the formulation's stability (under identical conditions).

Solubilities

Solubility refers to the ability of a substance to dissolve in a solvent. One gramme of powder is precisely weighed and added to a beaker containing 100 milliliters of water. To boost the solubility, this was well shaken and warmed. The mixture is then cooled and filtered, and the residue is weighed and recorded.

ATR-FTIR spectra analysis:

The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR-FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample holder.

Compatabilities

Physical compatibility studies:

The physical mixture of drug and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak. Following a weak, the samples are examined for any physical changes such as discoloration, odour, etc.,

Chemical compatibility studies:

These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wave number region of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded.

Procedure for soap :

Melt and pour process :

The most notable benefit of melt and pour soap bases is that they avoid the need to deal with lye, a caustic chemical that has already been mixed into the soap base. Another benefit of melt and pour soap bases is that, unlike cold-processed soaps, the final product does not require a curing period, which means the soap does not need to be left untouched for days or weeks in order for the lye to be neutralised and the saponification process to be completed; melt and pour soaps are ready to use right away once they have been removed from their moulds. As the soap sits, it will get harder and gentler. As a result, the melt and pour approach has gained popularity.

Procedure

- The goat milk basis should be weighed and sliced.
- Grind the *kapok gum* and strain it through a number 150 sieve to make a fine powder.
- Then mix together the finely powdered kapok seed and the excipients specified below.
- The juice of a musk melon, Aloe vera juice comes from a plant called aloe vera,Argan oil is a Moroccan oil that derives from the Argan tree (vitamin E),Orange, Before pouring these ingredients into the goat milk base, fully combine them.
- Base melt it into a liquid and properly incorporate all of the ingredients while it's heating.
- After adding the essential oil, pour the liquid into the mould and place it in the refrigerator for about 2 hours before removing it.

Allow one day for it to sit. (Table.no:1)

Evaluation of Studies for Prepared Formulations:

To determine the quality of the prepared formulations, many physicochemical characteristics were used, as listed below. [6-16]

Determining a sample's pH

Digital pH was used to determine the pH of all of the produced formulations Meter. The formulations were diluted in 100 mL of distilled water and kept in the refrigerator for two weeks hours. The pH of the formulation was measured with a pH meter that had already been calibratedmeter. [6-16]

Irritation of the skin test:
The herbal soap composition was subjected to a skin irritancy test. There is no irritancy or redness in the preparation. The condition was observed for a period of 24 hours.

Washing Capability:
The herbal soap was put through a formulation test, as well as the simplicity with which it could be washed with water.

Foam ability:
Approximately 1.0 gm of herbal soap was taken and dissolved in distilled water (about 50 ml) in a 100 ml graduated measuring cylinder to determine the soap's ability to produce foam. It was shaken for roughly 10 minutes in the measuring cycle. After 10 minutes, the foam height was measured. The mean was calculated after recording the observations for five consecutive experiments.

Foam Retention Time:
Foam retention time relates to the amount of time that the soap's foam lasts. The foam internal was measured for around 5–10 minutes after repeating the aforesaid process.

Moisture content:
The moisture content was used to measure the percentage of water in the soap by drying it to a consistent weight. Before being dried in a dryer at temperatures ranging from 100 to 1150 degrees Celsius, the soap was weighed and recorded as the "wet weight of the sample." The sample was refrigerated and weighed to determine the "dry weight of the sample." Moisture content = (22% Initial weight – Final weight / Final weight 100)

Stability test :
Introduction
The time from the date of manufacture and packaging of the formulation until its chemical or biological activity is not less than a predetermined level of labelled potency and its physical features have not changed considerably or deleteriously is referred to as drug stability. The stability of the active component must be a major consideration in selecting whether or not to accept or reject dosage forms for medications in any design or evaluation.

The study's purpose
Stability testing enables recommended storage conditions, re-test intervals, and shelf-lives by predicting how the quality of a drug ingredient or drug product changes over time under the effect of a number of environmental elements such as temperature, humidity, and light. Generally speaking, observing the rate at which a product declines at room temperature takes a lengthy period of time. The idea of expedited stability investigations is used to avoid this unfavorable delay. The stability test requirements are described in the International Conference on Harmonization (ICH) Guidelines under "stability testing of New Drug Substances and Products" (QIA). In the current study, the optimized formulation was subjected to a one-month stability test at 40 °C, 2 °C, 75% RH, and 5% RH.

RESULT AND DISCUSSION

Result

Organoleptic Characteristics:
A natural substance's organoleptic quality refers to its appearance, aroma, color, and taste. The first stage of the study is to characterize these properties, which aids in the primary identification of the natural substance as well as determining the possibility of patient acceptability of the raw materials' aroma, taste, and color, as well as their likely inclusion in the final dose form. Changes in the color and odor of a formulation's raw material might sometimes

signal that the formulation's stability has deteriorated (other identical conditions). As a result, a soap with a mixture of surfactants is required.

Solubility:
Solubility is defined as a substance's capacity to dissolve in a solvent. One gramme of powder is precisely weighed and added to a beaker containing 100 milliliters of water. To boost the solubility, this was well shaken and warmed. The residue thus obtained is weighed and noted after it has been cooled and filtered.

ATR FTIR Spectra Analysis:
The spectrum was collected between the wavelengths of 4000 and 400 cm-1. After placing a sample directly into the cavity of the sample holder, an ATR-FTIR spectrophotometer was used to acquire an ATR-FTIR spectrum. (The result shown in the Fig.no:01)

Compatibility research:
Studies on physical compatibility:
For a weak stability test, the physical mixture of drag and excipient was kept in a Petri dish and stored at normal and high temperatures in a stability chamber at 45 °C and 75 percent RH. Following a mediocre performance, any physical changes, such as discoloration or odour, are checked on the samples.

Compatibility studies:
The spectra was recorded in the wave number range of 4000 to 400 cm-1 for these compatibility investigations, which were conducted using an ATR-FTIR spectrophotometer. The natural oils and excipients were thoroughly combined in the mortar until they were completely mixed. The sample was then taken from the mortar and placed in the sample holder's cavity, where the spectrum was recorded. ATR-FTIR spectroscopy was fixed at the range of 4000-400cm^{-1}. There is no interaction between the drugs and excipients. To optimize formulation concentrations of excipients that affect foaming ability, soap base concentrations were altered to see how they affected foam ability. Five trials were prepared and carried out to investigate the influence of a single excipient in each formulation, with one formulation (F3) remaining optimized for multion. (The result shown in the (Fig .no :02)

Determining of pH:
The pH of all of the created formulations was determined using a digital pH meter. The formulations were diluted in 100 mL of distilled water and kept for two hours in the refrigerator. The pH of the formulation was determined using a pH meter that had already been calibrated. The pH of all formulations is represented in the graph above, and it ranges from (5.1) to (10.0). (9.5). (5.6). The ideal pH level has been established to be 5.5. (The result shown in the table No. 2)

Irritation of the skin:
The herbal soap formulation was evaluated for irritancy of the skin. The medication causes no irritation or redness. The situation was monitored for a total of 24 hours. One of the most important factors to consider while making soap is how to avoid skin discomfort. The above table displays the results of all formulations. (The result shown in the table.no:3)

Wash ability Evaluation:
The herbal soap was put through a formulation test, as well as the simplicity with which it could be washed with water. Wool yarn was used to test the cleaning activity. Although the primary goal of a soap is to clean or remove dirt or sebum, standardizing experimental detergency evaluation has proven challenging due to a lack of consensus on a standard soil, a repeatable soiling technique, or the amount of soil a soap should remove. (The result shown in the table No. 4)

Foam-forming ability:

For the purpose of determining its ability to generate foam, approximately 1.0 gm of herbal soap was taken and diluted in distilled water (about 50 ml) in a 100 ml graduated measuring cup. It was shaken for around 10 minutes with the measurement cylinder. After 10 minutes, the foam height was recorded. The mean was calculated after recording the observations for five experiments. Although foam formation has little to do with soap's cleansing function, it is extremely essential to consumers and thus an important criterion in soap evaluation. In distilled water, all five soaps had identical foaming qualities. The foaming qualities of all five soaps were similar. The foam ability range was discovered to be 16-17 cm. The foam ability of the F3 formulation was determined to be 16.5 cm. (The result shown in the table.no:5)

Foam retention time:

Foam retention time refers to the amount of time that the soap's foam remains intact. The foam internal was measured for around 5–10 minutes after repeating the aforesaid process. All five composition of soap showed comparable the foam retension time. The foam retention time of herbal soap is listed in F3 was determine to be a 10minutes. (The result shown in the table.no:6)

Moisture content:

The moisture content was calculated by drying the soap to a set weight and calculating the percentage of water in the soap. Before being dried in a dryer at temperatures ranging from 100 to 1150 degrees Celsius, the soap was weighed and recorded as the "wet weight of the sample." The sample was refrigerated and weighed to determine the "dry weight of the sample." The moisture content was calculated using the formula [19].

% Moisture content = initial weight – final weight/final weight ×100

The moisture content of all five soap compositions was similar. The moisture level of herbal soap, which is specified in F3, was found to be 6%. (The result shown in the table.no:7)

Stability studies

Stability tests were carried out in accordance with ICH norms for accelerated testing, with the necessary changes. The sample formulation was taken and stored for one month at 30 °C ambient temperature and 4 + 2 °C in the refrigerator. Physical appearance, pH, viscosity, and percent cleaning effect were all assessed on the samples. (The result shown in the table.No:8)

CONCLUSION

- An attempt was made using *Kapok gum* to create herbal soap that would provide an effective treatment for anti-wrinkle, skin whitening, anti-acne, and moisturiser.
- The ATR-FTIR spectra of *Kapok gum* and herbal soap were compared using Kapok gum.
- According to F3, the existing peak is not disappearing. This study indicates that the phytoconstituents of kapok gum, which are involved in anti-biotic activity, are not degraded or destroyed.
- The appearance, pH, moisture content, foam formation, foam retention time, and stability of herbal soaps containing Kapok gum were all tested in accordance with ICH standards.
- Physical compatibility experiments revealed no colour change, indicating that all excipients were compatible with Kapok gum.

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Tabel.No:1 Composition of Formulation Table

S.NO	INGREDIENTS	FORMULATION CODE				
		F1	F2	F3	F4	F5
1.	Silk cotton gum	10gm	10 gm	10gm	10gm	10gm
2.	Musk melon juice	5gm	5gm	5gm	5gm	5gm
3.	Orange juice	2 gm	2gm	2gm	2gm	2gm
4.	Aloe vera	5gm	5gm	5gm	5gm	5gm
5.	Argan oil (vitamin E)	5gm	5gm	5gm	5gm	5ml
6.	Olive oil	2gm	2gm	2gm	2gm	2gm

7.	Goat milk base	20gm	19gm	17gm	16gm	15gm
8.	Essential oil(Fragrance)	0.5gm	1gm	2gm	3gm	4gm
9 .	Rosemary oil	0.5gm	1gm	2gm	2gm	2gm
Total		50gm	50gm	50gm	50gm	50gm

Table.No:2 Determination of pH Test

Formulation. No:	pH Range
F1	5.1
F2	5.3
F3	5.5
F4	5.4
F5	5.6

Table .No:3 Determination of Skin Irritant

Formulation. No:	Skin irritant
F1	Non-irritant
F2	Non-irritant
F3	Non-irritant
F4	Non-irritant
F5	Non –irritant

Table .No:4 Determination of Wash ability

Formulation. No:	Washability
F1	Good
F2	Good
F3	Good
F4	Good
F5	Good

Table. No :5 Determination Foam Forming Ability

Formulation. No:	Foam index
F1	25cm
F2	20cm
F3	16.5cm
F4	10cm
F5	8cm

Table.No :6 Determination Of Retension Time Of Foam

Formulation.No:	Retension time
F1	15 minutes
F2	13minutes
F3	10 minutes
F4	6minutes
F5	5minutes

Table .No :7 Determination Of Moisture Content

Formulation.No:	Moisture content
F1	5%
F2	5%
F3	6%
F4	7%
F5	8%

Table.no 8. Determination of stability studies

Parameters	Initial	After one month 40/75(⁰c/RH)
Appearance	Penny brown	Penny brown
Feel on application	Smooth	Smooth
pH	5.5	5.6
Foam index	16.5cm	15cm
Foam retension time	10mins	8mins
Washability	Good	Good
Moisture Content	6%	7%
Skin irritant	Non irritant	Non irritant

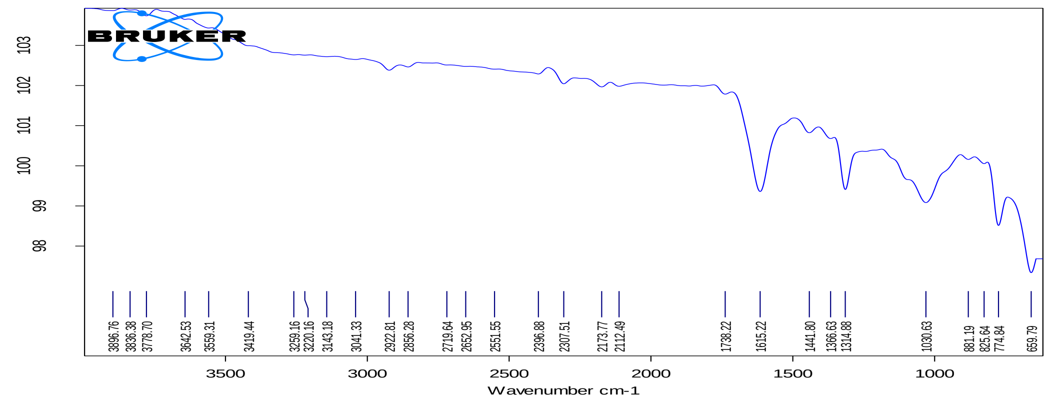

Fig.No. 1 ATR-FTIR Of Bombax ceiba gum powder

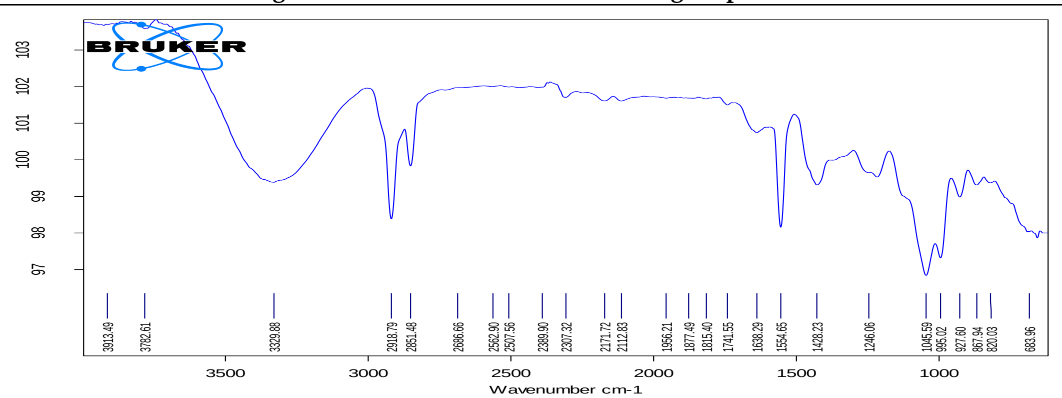

Fig.No. 2 ATR-FTIR Of Bombax ceiba gum +Musk melon+ Aloe vera +Rose mary oil+ Orange peel powder

RESEARCH ARTICLE

Formulation and Evaluation of Self Healing Hydrogel by Guar Gum Powder

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ABSTRACT

Flexible, injectable, and strain-sensitive hydrogels have recently piqued interest in the research community for use as electronic skin and wearable strain sensors. Injectable, strain-sensitive, and self-healing guar gum hydrogels remain a major problem due to the synergistic combination of high flexibility, quick self-healing, and antifreezing properties. We created a compact three-dimensional dynamic cross-linked net made of glycerol water borax, inspired by the strong hydrogen bonding of glycerol and water, and the chelation cross-linking of glycerol and borax. Dynamic interactions of the glycerol water borax net operate as sacrificial bond energy for effective dissipation when the hydrogel is stressed, allowing it to attain great flexibility, stretchability, and injectability. More importantly, the antifreeze and moisturizing characteristics of the gel are improved due to the inclusion of glycerol. The hydrogel also demonstrated a 15-second self-healing ability. The hydrogel also possesses self-adhesive characteristics and is strain sensitive, according to the findings. The hydrogels could be utilized to create electronic skin that is flexible, wearable, and 3D-printable, as well as strain-sensitive sensors.

Keywords: self-healing, hydrogel, injectability, antifreezing, strain-sensitive

INTRODUCTION

Ionic hydrogel may transform mechanical deformation of hydrogels to electrical impulses, which is a helpful way for creating intelligent strain-sensitive electronics. As a cross-linker and conductivity fluid, using borax to manufacture GG ionic hydrogel is a straightforward and common method solution. Borax-crosslinked GG hydrogels, on the other hand, are extremely brittle, have poor elasticity, and have a slow self-healing action. Low-temperature tolerance is also an issue. The amount of options provided is limited due to these problems. Electrical sensing devices employ GG hydrogels. As a result, it would be the body's self-healing abilities, flexibility, and stability are all expected to improve considerably. Borax-crosslinked GG hydrogels can be manufactured at the same time utilizing a simple method. Glycerol (1,2,3-propanetriol or glycerin) is a colourless, odourless liquid. Because glycerol lowers the freezing point of water, a glycerol/water mix is commonly used in non-toxic antifreeze. A glycerol/water solution was used by 20,21 Lu et al. This approach may be used to make antifreeze hydrogel, which has great elasticity and flexibility in low-temperature conditions. Glycerol is a polyhydric alcohol, which means it can form a complex with the crosslinker borax.

Following the formation of a combination with borax, glycerol and borax created chelated connections. 23 K et al. used glycerol as a plasticizer for borax cross-linked PVA film, increasing the flexibility of the film. Guar gum has a polyhydroxy structure that is similar to that of PVA. As a result, these links may be able to assist GG hydrogels in overcoming their faults. Due to their vast diversity of sources, outstanding biocompatibility, and full degradation properties, guar gum and glycerol, in particular, provide significant advantages as smart sensor hydrogels in direct contact with human skin. Biomedicine, three-dimensional scaffolds, artificial skin, wearable sensor devices, and other fields will benefit from this easy and low-cost approach for manufacturing flexible and self-healing natural hydrogels that are anti-freezing, injectable, and strain-sensitive.

MATERIALS AND METHODOLOGY

➢ **Collection of materials**

The guar gum powder was provided by PC INDUSTRIES, and the other ingredients, such as borex, glycerol, and distilled water, were provided by vmcp, Salem.

• To begin, dissolve 2 mL glycerol in 18 mL deionized water. • Then, using a magnetic stirrer, 0.3 g GG powder was added to the glycerol/water solvent.

• Finally, 4 wt percent borax solutions were dripped on the gel in stages until it was completely formed. Various hydrogel samples were created using solutions containing varying amounts of borax (0.5 wt. percent, 1 wt percent, 2 wt percent, 4 wt percent).

Preparation of Guar Gum Hydrogel

The Guar Gum hydrogel was prepared by dissolving 0.15 g of Guar Gum in 10 ml deionized water, and then 4 wt% borax solutions was added into the guar gum solution until the gel was completely formed.

Preparation of Guar Gum -Glycerol Hydrogel

- First, 2 ml glycerol was dissolved in 18 ml deionized water.
- Then, 0.3 g GG powder was added in the glycerol/water solvent and stirring by magnetic stirrer
- Finally, 4 wt% borax solutions were gradually dropped until the gel is completely formed. Solutions with different borax concentrations (0.5 wt%, 1 wt%, 2 wt%, 4 wt%) were used to prepare different hydrogel samples. (The result shown in the table no:1)

Evaluation Of Hydrogel

Appearance:

The formulated gel was visually evaluated for colour, appearance, and transparency. The smoothness of the gel was stimulated by rubbing the formulation between the fingers to observe the smoothness, clumps, roughness.

Viscosity Measurements

The viscosity of the produced solutions was determined using a 100ml sample. Measurements were taken with an appropriate spindle number 64 and sheared at 3, 4, 5, 6, 10, 12, 20, 30, 50, 60, 100rpm while maintaining a temperature of 37°C. After 30 seconds, the viscosity was measured directly. All measurements were taken three times. Plotting viscosity versus angular velocity revealed the rheological velocity.

pH Measurement

The pH of the produced solution for all formulations was determined using a digital pH metre at 25 + 0.5o C after calibration with standard buffer solutions of pH 4, 7, and 9, and the results were recorded.

***In-vitro* drug diffusion study**

Franz diffusion cell apparatus was used to conduct in-vitro drug release experiments on the formulations. By putting the egg in dil, the membrane can be separated from the egg. The *in-vitro* diffusion of the formulations was investigated using HCl. A freshly manufactured pH 6.4 buffer was used to fill the receptor chamber. 1gm of formulation was placed in the donor chamber. At defined intervals of time, aliquots of receptor media were removed and replaced with fresh medium, and the drug content was determined spectrophotometrically.

Spreadability

We chose two clean glass slides with conventional dimention 100 gm was placed upon the upper slid and gel between two slides is pressed uniformly in form a thin layer .the two slides in position were then fixed to a stand(at anglee 45)without any disturbance and in such a way that only the lower slide was held finally by the clamp allowing the upper slide to travel a distance of 0.5 cm under the direction of weight which was noticed .The extra gel sticking to the slide was scerapped off and the weight was removed. The experiment was done three times, with the average times recorded. such determination were calculated

The following formula was used to calculate spreadability:

S=m×1/t

Where **s** stands for spreadability, **m** for the weight attached to the higher slides, **l** for the length of the glass slide, and **t** for the time taken in seconds.

Stability Studies

Stability testing enables recommended storage conditions, re-test intervals, and shelf-lives by predicting how the quality of a drug ingredient or drug product changes over time under the effect of a number of environmental elements such as temperature, humidity, and light. Generally speaking, observing the rate at which a product declines at room temperature takes a lengthy period. The ideas of expedited stability investigations are used to avoid this unfavorable delay. The stability test requirements are described in the International Conference on Harmonization (ICH) Guidelines under "stability testing of New Drug Substances and Products" (QIA).

RESULT AND DISCUSSION

organoleptic properties

The organoleptic quality of a Natural substance refers to its appearance odour, colour. and taste. The study's first stage is to characterize these features, which assists in the primary identification of the Natural substance as well as estimating the probability of patient acceptability of the raw materials odour, taste and colour as well as its probable inclusion in the final dose form. Changes in the colour and odour of the raw material in the formulation might sometimes indicate changes in the fo99rmulation's stability (Under identical conditions). Therefore, a self-healing hydrogel for guar gum powder containing a combination of surfactant is necessary.

ATR-FTIR Spectra Analysis:

The spectrum was captured between the wavelengths of 4000 and 400cm-1. an ATR- FTIR spectrum was obtained using an ATR- FTIR spectrophotometer. (The result shown in the fig no: 1)

Compatability Studies

ATR-FTIR spectrum of crude drug and prepared gel was compared to study crude drug with the excipients and the spectrum was recorder in the wave number region of 4000 to 400cm-1. According to functional category, the dried plant powder were mixed, and shows no destrution or deterioration with the excipients used. This indicates that the drug is compatible with the formulation components and the results shown in the. ATR-FTIR spectroscopy was fixed at the range of 4000-400cm-1. There is no interaction between the drugs and excipients. (The result shown in the fig no: 2)

Evaluation Of guar Gum Hydrogel

Appearance

The prepared gel was visually inspected for the appearance, colour, and texture. All formulations were light brown in color and odorless. Physical appearance of all formulation is opaque in nature.

Colour : Light-colored
Odor : Pleasant odor
Smoothness : Good

Determination of pH

Using pH paper, the pH of a cleaner solution (10%w/v) in distilled water was tested at room temperature. pH of all formulations was found to be between 6 to 7.25 that is within the range, which are presented in Table no: 7.3. The Ph of all formulations is basic in nature. So, it is skin friendly that does not cause any irritation (The result shown in the table no:2)

Viscosity (cps)

Viscosity of all the formulations was noted the result shows range from (3498) to (9756) cps.F3 Shows a better consistency with viscosity level of 0.894 cps (The result shown in the table no: 3)

Spreadability

The spreadability of the gel was determined by its viscosity and was evaluated across all four formulations. When compared to other formulations, F4 has superior spreadability. Because the F4 had a better consistency, the gel could be easily spread with a small amount of shear. (The result shown in the table no: 4)

***In Vitro* Drug Release Study**

The prepared formulations were subjected for *in vitro* dissolution study in phosphate buffer (pH6.4)to study the effect of different variable so percentage of drug release. (The result shown in the table no: 5)

Stability Studies:

Stability study test are used to find out whether the formulations are maintaining their quality during the storage period or not. Stability study tests are used to find out the best formulation. It can best died by applying as tress to the formulation such as temperature, humidity and light. Here stability study was conducted for F4at40ºC/75%RH. The control tests were carried out attend of the one month. (The result shown in the table no:6)

ACKNOWLEDGEMENT

The authors are thankful to Dr. B.Jaykar, Professor and Registrar, Vinayaka Mission's Research Foundation (Deemed to be University) and Vinayaka Mission's College of Pharmacy, Salem, Tamil Nadu for extending their support and facilities for this research.

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Table.No:1 Formulation of hydrogel

INGREDIENTS	F1	F2	F3	F4
Guar gum powder(gm)	2	2	2	2
Borax (gm)	10	8	6	4
Glycerol (gm)	24	18	12	6
Water (gm)	50	50	50	50

Table.No:2 Determination of pH

Formulation. No:	pH Range
F1	5.5
F2	5.7
F3	6.0
F4	6.5

Table. No- 3 Determination of Viscosity (cps)

FORMATION .NO	Viscosity (cps)
F1	3498
F2	5621
F3	6874
F4	9756

Table No- 4 Spreadability of the gel preparation

Formulation code	Spreadability(g.cm/sec)
F1	24.22(g.cm/sec)
F2	35.42(g.cm/sec)
F3	41.34 (g cm/sec)
F4	46.62(g.cm/sec)

TableNo-5 In-vitro release data for guar gum Hydrogel

Time(hrs)	F1	F2	F3	F4
0	0	0	0	0
0.5	21.32	32.04	20.15	28.63
1	30.53	50.56	40.41	35.63
2	49.90	55.35	53.98	48.52
3	46.96	58.52	55.09	55.31
4	54.14	63.75	50.54	57.25
5	63.85	75.54	70.36	65.77
6	79.92	84.26	65.67	68.15
7	83.51	86.64	80.95	73.56
8	85.36	87.54	76.77	78.28
9	87.28	88.54	85.42	86.65
10	89.14	90.14	90.02	89.85
11	91.60	93.15	89.46	93.28
12	92.14	95.42	96.39	98.86

Table. No-6 Stability studies

Parameters	Controlled	After1month
Appearance	White	White
Ph	7.0	7.0
Viscosity	33254±516 cps	33255±515 cps
Moisture Content %	35.69	35.69
Spreadibility (cm)	7.8	7.7

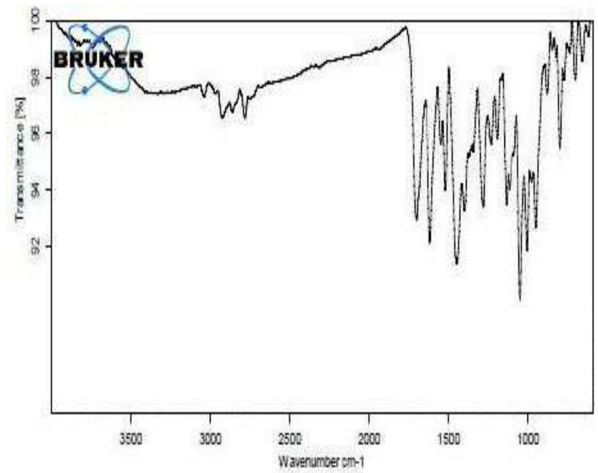

Fig No-4.1: FTIR Graph of pure Powder

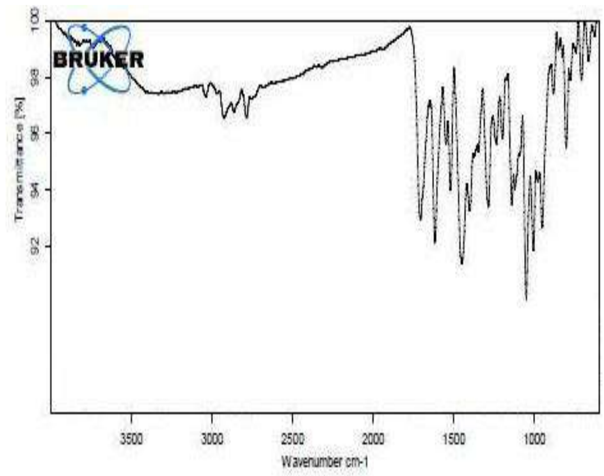

Fig No-2 FTIR graph for powder and excipient formulation

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RESEARCH ARTICLE

Preparation and Evaluation of Transdermal Patch of Benzoic Acid by Solvent Casting Method

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ABSTRACT

In transdermal drug delivery systems (TDDS), innovations have made significant contributions to medical practice by advancing treatment delivery with existing and novel drugs. Transdermal drug delivery systems (TDDS), also called as "patches," are dosage forms designed to deliver a therapeutically effective amount of drug across a patient's skin. It's a desirable form of drug delivery because of the apparent advantages. This research aims to develop and evaluate benzoic acid transdermal patches utilizing a solvent casting approach to deliver a precise and controlled amount of medication via the skin and into the bloodstream. The objective is to prepare transdermal patches of benzoic acid. To avoid sweatiness, skin irritation, by use an ointment type dosage form. So that a drug delivered through the skin using transdermal patches can be progressed in a revolutionary drug delivery system.

Keywords: Benzoic acid, HPMC, polyethylene glycol, polypropylene glycol, glycerine etc

INTRODUCTION

Novel Drug Delivery System

The goal of the novel drug delivery system is to deliver therapeutic doses of drug to the relevant spot in the body quickly and maintain the optimal drug concentration. The drug delivery system should supply the drug at a controlled rate determined by the body's need throughout a set treatment period.

The two essential aspects of idealized drug delivery are as follows:
Spatial drug delivery: Targeting a drug to a particular organ or tissue.
Temporal drug delivery: The drug dosage delivery rate to a targeted tissue is controlled.
Novel drug delivery systems are intended to provide continuous drug distribution with predictable and repeatable kinetics in circulation for a more extended period. Minimizing drug-related side effects due to controlled therapeutic blood levels rather than oscillating blood levels, increased patient compliance due to reduced dosing frequency, and a reduction in the overall dose of drug provided are all potential benefits of this idea. As a result, a delivery system with both sustained and regulated release qualities would further improve therapeutic efficacy. [1]

Transdermal Drug Delivery Systems

TDDS development has made significant contributions to medical practice by bringing advancements in transdermal delivery systems. The transdermal medicine delivery technology was created to improve these qualities. Transdermal drug delivery varies from typical topical drug administration in that it delivers a drug via the skin to create a systemic effect. Because medications are given through the skin at a predetermined and controlled rate, transdermal drug delivery systems can increase therapeutic efficacy and safety. For both local and systemic effects, the skin is an important location of medication application. The transdermal drug delivery system (TDDS) has advantages over traditional drug administration systems. Compared to conventional therapy, TDDS provides continuous drug release, avoidance of the first-pass effect, patient compliance, ease of application and removal in the event of toxicity, and a reduction in adverse effects. [2]

Transdermal Patch

A transdermal patch is a medicated adhesive patch applied to the skin to deliver a particular amount of medication into the bloodstream through the skin. Drugs are delivered topically through transdermal patches, where they are absorbed by the skin and absorbed into the bloodstream. They administer little amounts of medicine into the bloodstream over a lengthy period regularly. The dose of medication administered and the length of time it is worn varies from patch to patch. [3] The stratum corneum acts as a barrier that prevents substances from penetrating the skin, yet this barrier can be overcome via permeation-increasing techniques. The fundamental disadvantage of transdermal delivery systems is that the skin acts as a very effective barrier; therefore, only drugs with molecules tiny enough to permeate the skin can be supplied this way. Transdermal patches are medication currently accessible in a wide range of medications. The quality, size, time of onset & duration, adhesive property, thickness, the weight of patch, moisture of content, uniformity, and cutaneous toxicity tests are all used to characterize transdermal patches. [4] Candidate drugs for transdermal administration are chosen. For a substantial number of medications, the transdermal delivery route is ineffective. The most crucial decision in developing a transdermal system is the selection of the medicinal ingredient. [5]

Advantages of Transdermal Drug Delivery System

1. Self-administration and continuous, persistent drug release are both conceivable.
2. Avoids GIT enzymatic breakdown and first-pass hepatic metabolism.
3. Patient compliance increases with less frequent dosing.
4. For individuals who cannot take oral drugs, an alternative method is available.
5. Dose delivery is unaffected by nausea or vomiting.
6. When the patch is removed, the drug administration stops. [6-7]

Disadvantages Of Transdermal Drug Delivery System

1. Currently, only tiny lipophilic medicines can be given through the skin.
2. Incompatible with high-dosage medications.
3. Adhesion varies depending on patch type and ambient factors.
4. Skin irritation and hypersensitivity reactions are possible side effects.
5. The skin's barrier function varies from one location to the next on the same individual, person to person, and age. [6-7]

MATERIALS AND METHODS

Materials: Benzoic acid was received from Oxford lab fine chem llp, Maharashtra, HPMC, Polyethylene glycol, Polypropylene glycol, Glycerine, Ethanol.

Preparation of Benzoic Acid in Transdermal Patches by Solvent Casting Method

Drug-loaded matrix-type transdermal patches of benzoic acid were prepared by using solvent casting method. A petri dish with a total area of 10 cm2 was used. Drug were accurately weighed and dissolved in 10 mL of ethanol solution and kept aside to form clear solution. Polymer hydroxy propyl methyl cellulose was dissolved in the above solution and mixed until clear solution was obtained. Polyethylene glycol (30% W/W of total polymer) was used as plasticizer and propylene glycol (15% W/W of total polymer) was used as permeation enhancer. 1ml of glycerine was added to the above solution. The resulted uniform solution was cast on the petri dish, which was lubricated with glycerine and dried at room temperature for 24. After 24, the dried patches were taken out and stored in a desiccator for further studies.

Pre formulation studies

Organoleptic properties of Benzoic acid

The organoleptic quality of a drug substance refers to its appearance, odour, colour, taste and solubility.

Uv Spectroscopy

Preparation of standard benzoic acid solutions

From these stock solutions, 1ml aliquots were transferred to 10ml volumetric flasks and diluted up to the mark with distilled water to make a working standard solution with a concentration of BA 100g/m.

Calibration curve for Benzoic Acid

Working standard solutions of BENZOIC ACID with concentrations ranging from 20 to 50 g/ml were produced from standard stock solutions of pharmaceuticals to test the method's linearity curve graph. Prepared quantity of 2.0,2.5,3.0,3.5,4.0,4.5, and 5.0ml of standard stock solutions of BA were transferred to a series of 10 ml volumetric flasks and diluted to mark with ethanol, and the absorbance was measured at 230nm.

IR Spectra Analysis

The spectrum was captured between the wavelengths of 4000 and 400cm-1. An IR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample of the medication was immediately put into the cavity of the sample holder.

Physical Compatibility Studies

The physical combination of medication and excipient was kept in a Petri dish and stored at normal and high temperatures for a weak in a stability chamber at 45°C/75 percent RH. After a weak, the samples are checked for physical changes such as discoloration, smell, etc.

Chemical Compatibility Studies

The spectra were obtained in the wavenumber range of 4000 to 400cm-1 for these compatibility investigations, which were done using an ATR-FTIR spectrophotometer. The natural oils and excipients were thoroughly combined in the mortar until completely blended. The sample was then taken from the mortar and placed in the sample holder's cavity, where the spectrum was recorded.

Thickness

Using a digital micrometre, the thickness of the drug-loaded patch is measured at several spots. The average thickness and standard deviation are calculated to ensure the thickness of the created patch.

Weight uniformity

Before testing, the produced patches must be dried at 60°C for 4 hours. A defined patch area must be split into distinct sections and weighed in a digital balance. Individual weights are used to establish the average weight and standard deviation.

Percentage Moisture content

The produced films must be weighed separately and maintained at room temperature for 24 hours in a desiccator containing fused calcium chloride. After 24 hours, reweigh the films and use the formula below to calculate the % moisture content.

[Initial weight- Final weight/ Final weight] % moisture content = 100

Percentage Moisture uptake

To maintain an RH of 84 percent, the weighted 22 films must be stored in a desiccator at room temperature for 24 hours in a saturated potassium chloride solution. After 24 hours, reweigh the films and use the calculation below to calculate the % moisture uptake. [Final weight- Initial weight/ initial weight] x 100 Equals percentage moisture uptake.

Folding endurance

A strip of a particular area must be cut uniformly up to 2cm in length and repeatedly folded at the exact location until it breaks. The value of the folding endurance was determined by the number of times the film could be folded in the same place without breaking.

Percentage Elongation break test

The percentage elongation break is determined by recording the length shortly before the breakpoint and using the method below to get the percentage elongation. (Final length-initial length/ initial length)/100

Where

L1 is the final length of each strip and

L2 is the initial length of each strip.

In *Vitro* Diffusion Test

Egg membrane test

Prepare acetic buffer solution at pH 5.5 and makeup to 900ml.Prepare egg membrane by breaking the top of the egg, then dip the eggshell into hydrochloric acid. After 30 mins, take out the membrane from the acid and wash with distilled water. Fill the prepared patch into the membrane and tie it with thread. Hold and tie the membrane with rope to the double side open burette. Dip the double side open burette (membrane) into the 1000ml beaker containing 900ml of acetic buffer solution placed in a magnetic stirrer. Set 60rpm and maintain the temperature at 37^{0}C With the help of a magnetic stirrer, the buffer solution will rotate. Take sample in a different time interval period like 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300 and 330.The absorbance of the sample can be determined by using UV spectrometer Take sample in a different time interval period like 0, 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, and 330.The absorbance of the sample can be determined by using UV spectrometer.

RESULT AND DISCUSSION

Organoleptic properties of benzoic acid : The Preformulation studies were carried out to find out the solubility of benzoic acid. The sample received for its organoleptic properties such as white or colourless crystalline, odour faintly pleasant, bitter taste and Solubility test gave an idea that benzoic acid is water soluble but more soluble in solvents like methanol, ethanol, chloroform and other polar solvent.

UV spectroscopy: The varied quantities of benzoic acid (2, 4, 6, 8, and 10 g/ml) were produced with ethanol and analysed using matching media as a blank under UV at 230nm.At 230nm, the UV spectra of benzoic acid were detected. With an R2 value of 0.999, the linearity was plotted versus concentration. ATR-FTIR of pure benzoic acid, benzoic acid + HPMC + polyethyleneglycol + polypropylene glycol mixture, benzoic acid transdermal patches. The results are shown in the fig .The comparison of ATR-FTIR spectra of benzoic acid and mixture of drug and polymer confirms that there is no appearance of additional new peaks and disappearance of existing peaks from that of the drug. This indicates that there is no interaction between the drug and polymer.

Physicochemical Evaluation Result: The prepared patches was subjected to evaluate the percentage of moisture content, percentage moisture uptake, thickness, percentage elongation break test, folding endurance, in vitro diffusion studies up to 12 hours are studied. The result are shown in the Table. The percentage of moisture content of prepared patches ranging from 1.87 to 3.14% by using HPMC polymer. The percentage of moisture uptake of prepared patches ranging from 1.24 to 4.12% by using HPMC polymer. The percentage of Elongation break of prepared patches ranging from 42.82 to 50.10% by using HPMC polymer. The folding endurance of prepared patch ranging from 2 to 4 by using HPMC polymer. *In vitro* drug release studies for best formulations –F-3: The result are shown in the Table. In vitro release studies of transdermal patches of benzoic acid were performed formulations 3 in pH 5.5 acetic buffer by egg membrane diffusion method. From the results, in vitro release was found to be controlled in pH 5.5 acetic buffer. Formulations containing HPMC show drug release 88.84. According to above data, the drug containing HPMC polymer shows maximum diffusion.

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The authors are thankful to Dr. B.Jaykar, Professor and Registrar, Vinayaka Mission's Research Foundation (Deemed to be University) and Vinayaka Mission's College of Pharmacy, Salem, Tamil Nadu for extending their support and facilities for this research.

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Table. No: 1 Formulation Of Benzoic Acid Transdermal Patches:

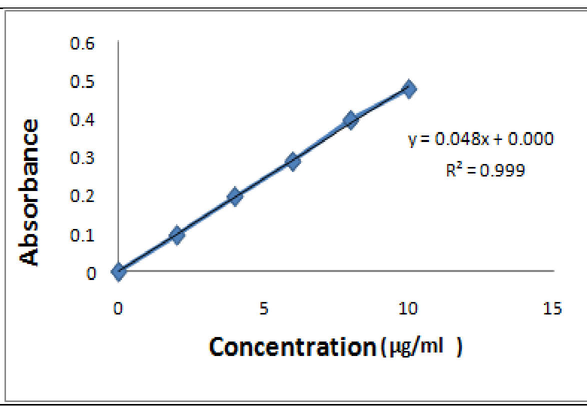
S. No	Benzoic Acid(mg)	Hpmc (mg)	Poly Ethylene glycol (mg)	Poly Propylene glycol (ml)	Gylcerin (ml)	Ethanol (ml)
F1	30	500	150	0.072	01	10
F2	30	600	180	0.086	01	10
F3	30	700	210	0.101	01	10
F4	30	800	240	0.011	01	10
F5	30	900	270	0.130	01	10

Table. No: 2 Standard Calibration Graph of Benzoic acid at 230nm Calibration curve data of BENZOIC ACID

S.NO	CONCENTRATION(μg/ml)	MEAN OF ABSORBANCE (At 230nm)
1.	0	0
2.	2	0.144
3.	4	0.207
4.	6	0.267
5.	8	0.385
6.	10	0.510

Physicochemical Evaluation Result

S.NO	THICKNESS(mg)	WEIGHT UNIFORMITY (mg)	PERCENTAGE MOISTURE UPTAKE (%)	PERCENTAGE MOISTURE CONTENT T (%)	PERCENTAGE ELONGATION BREAK TEST	FOLDING ENDURANCE
F-1	0.10	0.11mg	1.24	1.87	42.82	02
F-2	0.11	0.11mg	2.25	2.14	47.74	03
F-3	0.11	0.12mg	3.54	2.23	56.54	04
F-4	0.12	0.12mg	4.14	2.46	54.44	03
F-5	0.12	0.13mg	4.12	3.14	50.10	04



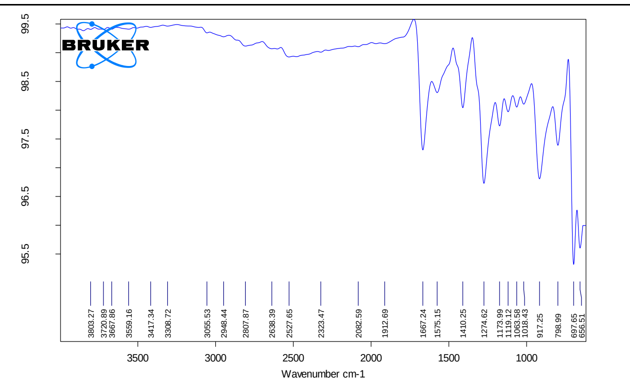
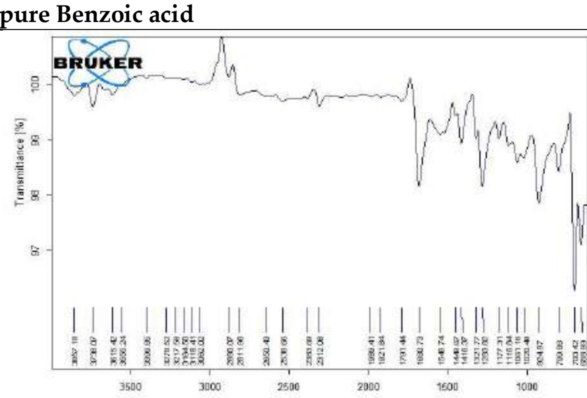


Figure. No: 1ATR- FTIR Spectroscopic Studies for pure Benzoic acid

Figure. No: 2ATR-FTIR of Benzoic acid+ HPMC +Polyethylene glycol +polypropylene glycol mixture



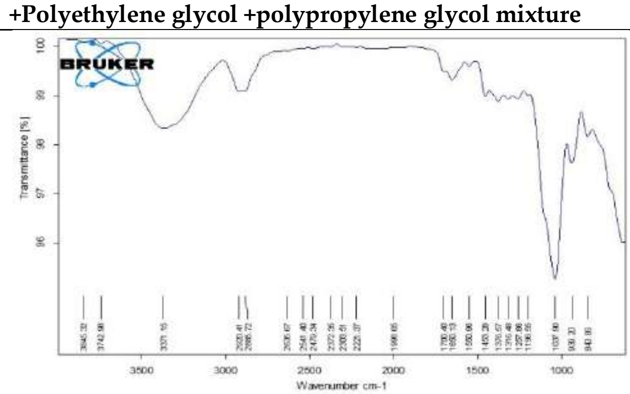


Figure. No: 3ATR- FTIR of Benzoic acid patches

RESEARCH ARTICLE

Formulation and Evaluation of Flax Seed Hair Cleanser

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ABSTRACT

The objective of this project is to design, formulate, and evaluate a flaxseed hair cleanser made from natural substances for hair washing purpose. Cleanser is a hair care solution that is used to progressively remove oils, dandruff, grime, pollutants, and other small foreign particles from the scalp and hair. Flaxseed hair cleanser was formulated using flaxseed gel, Rice water, thick coconut milk, banana leaf powder, Neem leaf powder, soapnut powder, and essential oils such as Rosemary, Rose, and Argan oil. Xanthum gum is used as a hair thickening, emulsifying, and stabilising agent as well as sodium benzoate as a preservative and then formulated cleanser was subjected to evaluation parameters like organoleptic properties, foaming stability, percentage of solid content, skin irritancy, nature of the hair after washing. Fourier transform infrared spectroscopy analysis, stability test. Flaxseed consists of omega-3 fatty acids which is responsible for promoting hair growth which directly leads to reduction of hair fall.

Keywords: Hair cleanser, promotes hair growth, reduces hair fall, herbal ingredients, evaluation parameters.

INTRODUCTION

Cleanser is one of the most commonly used cosmetic products in our daily lives for cleansing our hair and scalp [1]. which is devoid of sulphates. Herbal cleanser are cosmetic preparations that, like conventional cleanser, use traditional Ayurvedic herbs to cleanse the hair and scalp. They are used to remove oil, dandruff, filth, and pollutants from the environment, among other things. An herbal cleanser is a type of cosmetic product that uses plant-based herbs as an alternative to the synthetic cleansers on the market. The herbal cleanser is significant since people currently prefer herbal goods over chemical items because they have been shown to improve health. Herbal cosmetics are becoming more popular, owing to the belief that they are safe and free of adverse effects [2].Cleanser must have following properties like It should remove dust or soil, excessive sebum or other fatty substances, and loose corneal cells from the hair properly and thoroughly. It should produce a sufficient amount of foam to meet the user's psychological needs. After rinsing with water, it should be easily removed. It should leave the hair non-dry, soft, lustrous, manageable, and with little flyaway. It should leave the hair with a lovely scent. It should not cause any skin or eye irritation or adverse effects. It should not irritate or chap the skin of the hand [3,4].Flax seed *(Linum usitatissimum*), sometimes known as linseed, belongs to the *Linum* genus in the *Linaceae* family. Flax is an ancient agronomic crop with over 300 kinds that have been grown for food and fibre since ancient times. Flax seed can be identified by its colour or variety (brown and yellow) [5]. Flaxseed (also known as *linseed*) is gaining popularity as a functional food ingredient due to its high levels of -linolenic acid (ALA, an omega-3 fatty acid), lignans, and fibre [6].Flaxseed oil, fibres, and lignans may help to prevent cardiovascular disease, atherosclerosis, diabetes, cancer, arthritis, osteoporosis, autoimmune disorders, and neurological problems [7]. Flaxseed is also high in fatty acids and antioxidants, which aid in the removal of toxins and dead cells from the scalp. Flax seed gel can be used as a moisturiser on the scalp and hair to help encourage hair growth and strengthen existing hair. Gels are becoming more popular these days since they are more stable and may provide a more controlled release than other semisolid preparations. Gel formulations may have improved absorption qualities, resulting in increased medication bioavailability [8].The breakdown of testosterone into DHT by an enzyme known as 5a-reductase is principally responsible for genetic pattern baldness. Finasteride (commonly known as Propecia) works by inhibiting this enzyme and lowering DHT levels in the body. Pattern baldness (androgenic alopecia) causes protein receptors on hair follicles to become weaker and more responsive to DHT. This substance attaches to these receptors, triggering a chain of events that causes the follicle to shrink and eventually lose its ability to create new hair strands. It's tough to investigate how DHT inhibition affects hair follicles because they're such small structures. Testing prospective therapeutic chemicals on a condition known as benign prostatic hyperplasia (BPH), which is caused by high DHT levels in the circulation, is a much easier technique [9].

MATERIALS AND METHODS

Materials

Flaxseed, Banana leaf powder, neem leaf powder, rosemary oil, soapnut powder, xanthumgum, argan oil, rose oil was collected from the local market, Salem. pH meter(digital), Brookfield viscometer, ATR-FTIRmuslin cloth, mixer, measuring cylinder, China dish, Hot plate, sodium benzoate(chemical) were collected from the VMCP, Salem, Tamilnadu.

Methodology

Preformulation Studies

Organoleptic Properties

The organoleptic quality of a Natural substance refers to its appearance. odour, colourand taste. The study's first stage is to characterize these features, which assists in the primary identification of the Natural substance as well as estimating the probability of patient acceptability of the raw materials odour, taste and colour as well as its probable inclusion in the final dose form. Changes in the colour and odour of the raw material in the formulation might sometimes indicate changes in the formulation's stability.

IR Spectra Analysis

The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR-FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample holder.

Physical Compatibility Studies

The physical mixture of drug and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak. Following a weak, the samples are examined for any physical changes such as discoloration, odour.

Chemical Compatibility Studies

These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wavenumber region of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded.

Procedure for cleanser

The oil or water is first thoroughly and forcefully shaken with the calculated amount of gum in this manner. After the first liquid (either oil or water) has completely emulsified, the second liquid (either oil or water) is added all at once and the bottle is rapidly shaken again to form the primary emulsion method.(Table no 01)

Method of Preparation

Weighing

Weigh all the ingredients individually that are required for the preparation of the cleanser using a digital balance.

Preparation of hair cleanser

Cleanser was prepared by using primary emulsion method

Step-1

Take 30gm of flaxseed in 100ml of water, which contains 50ml of rice water, and add soap nut powder to it. Let it boil for about 20 minutes at a temperature of 20-degreecentigrade with continuous stirring. Check the consistency of the gel if it gets thicker and frothy. Strain it immediately while the mixture is hot.

Step-2

Separate the powdered mixtures into fine particles using a sieve. Then blend the residue with banana leaf powder, neem leaf powder, and thick coconut milk. Filter it through a muslin cloth and thoroughly mix it with the gel.

Step-3

Dissolve xanthum gum in hot water and keep it aside until it completely dissolves and becomes thick.

Step-4

In a beaker, combine flaxseed gel and xanthum gum, stirring constantly. Then add sodium benzoate and essential oils to it.

Evaluation test for cleanser

Visual inspection/physical appearance

The formulation prepared were evaluated in terms of their Clarity, Foam ability, Fluidity.

Determination of pH

At room temperature, the pH of a cleaner solution (10% w/v) in distilled water was determined. The pH was measured using a pH metre.

Viscosity

The viscosity of the shampoo was determined by using Brookfield Viscometer LVDV Prime-I.The viscosity of shampoo was measured at room temperature 30+2 degree centigrade with varying rpm and torque.

Foam ability

After one shake, the total volume of foam content was measured. Only the volume of foam was computed. The volume of shaking and the volume of foam were measured at 1-minute intervals for 4 minutes after shaking.

Percentage of solid content

A clean, dry China dish was weighed, and 4 grams of cleanser were added. The cleanser dish weighed a lot. The cleanser's exact weight was calculated. The cleanser-filled China dish was placed on a hot plate until the liquid portion disappeared. After drying, the weight was calculated.

% Solids = (Net weight of the dry sample / Net weight of the original sample) x 100

Skin irritancy

The skin irritancy of a cleanser can be determined by applying a small amount to the skin and then checking for any inflammatory reactions, redness, or local irritation after a few minutes.

Nature of the hair after wash

The nature of the hair after the cleansing of the hair of the volunteers can be noted by the responses after the washing of their hair for about 2 washes.

Extrudability

The quantity in percentage cleanser extruded from tube on application of finger pressure was used as the basis for evaluating cleanser formulation for extrudability in the current study. Extrudability improved as the quantity extruded increased. The study formulation was placed in a clean, lacquered aluminium collapsible 5 gm tube with a 5 mm nasal tip opening, and pressure was applied to the tube using a finger. The amount of cleanser extruded through the tip when a pressure was applied to a tube was then measured to assess tube extrudability.

Stability Test

Introduction

The time from the date of manufacture and packaging of the formulation until its chemical or biological activity is not less than a set level of labelled potency and its physical properties have not altered considerably or negatively can be characterized as the stability of a medicine. The stability of the active component must be a major consideration in selecting whether or not to accept or reject dosage forms for medications in any design or evaluation.

Objective of the study

Stability testing enables recommended storage settings, re-test intervals, and shelf-lives by predicting how the quality of a drug ingredient or drug product changes over time under the effect of various environmental elements such as temperature, humidity, and light. Observing the rate at which a product degrades under typical room temperature takes a lengthy period in most cases. The ideas of expedited stability investigations are used to avoid this unfavourable delay. The stability test requirements are described in the International Conference on Harmonization (ICH) Guidelines under "stability testing of New Drug Substances and Products" (QIA). The present work stability study was carried out for the optimized formulation at 40ºC±2ºC/75%RH±5%RH for one month.

RESULT AND DISCUSSION

Determination of organoleptic properties

The organoleptic quality of a Natural substance refers to its appearance. odour, colour. and taste. The study's first stage is to characterize these features, which assists in the primary identification of the Natural substance as well as estimating the probability of patient acceptability of the raw materials odour, taste and colour as well as its probable inclusion in the final dose form. Changes in the colour and odour of the raw material in the formulation might sometimes indicate changes in the formulation's stability(under identical conditions). Therefore, a cleanser containing a combination of surfactant is necessary(Table no 02)

IR Spectra Analysis

The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR- FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample hold. (The result shown in the Figure: 1)

Compatibility test

Physical compatibility studies

The physical mixture of drag and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak Following a weak. the samples are examined for any physical changes such as discoloration, odour.

Chemical compatibility studies

These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wave number region of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded ATR-FTIR spectroscopy was fixed at the range of 4000-400cm^{-1}. The active ingredient and excipients do not interact with each other. (The result shown in the Figure: 2)

Physical appearance/visual inspection

The clarity, foam-producing capabilities, and fluidity of the formulas were all examined Formulated cleanser is Turbid brown, Thick and in Clear solution. (The result shown in the table: 03)

Evaluation Studies:

To optimized formulation concentration of excipient which impact the viscosity or Thickening agent was selected Xantham gum concentration have been varied to the study the impact on viscosity. Four trials were planned and executed in a way to study the impact of single excipient in each formulation by keeping one formulation (F2) optimized formulation. (The result shown in the table no: 4)

Determination of pH

Using pH paper, the pH of a cleaner solution (10%w/v) in distilled water was tested at room temperature. The above result shows the pH of all formulation pH range from (5.1) to (5.5). The Optimized pH value determine to be a 5.5. (The result shown in the table no: 5)

Viscosity

Brookfield Viscometer LVDV Prime-I was used to determine the viscosity of the shampoo. Shampoo viscosity was determined at room temperature (30+2°C) with changing rpm and torque. All five shampoos showed comparable the viscosity range. The viscosity range of herbal shampoos is listed in F2 was determine to be a 1524cps. (The result shown in the table no: 6)

Foaming ability

The cylinder shaken method was done for determining foam ability. 1% of herbal cleanser solution was put into a 250ml graduated cylinder, covered it with my hand, and shaken for 10 times. Then the total volume of foam content after 1 minute was recorded. Immediately after shaking for 1minute intervals, for 4 minutes, were recorded. 1% of herbal cleanser gives excellent foam. Although foam generation has little to do with the cleansing ability of cleanser, it is of paramount importance to the consumer and is therefore an important criterion in evaluating cleanser. All the four cleanser, showed similar foaming characteristics in distilled water. All four cleanser, showed comparable foaming properties. The foaming ability was found to be good. The F2 formulation foam ability was determined to be good. (The result shown in the table no: 7, Figure no: 3)

Percentage of solid content

% Solids = (Net weight of the dry sample / Net weight of the original sample) x 100
A clean China dish was weighed and added about 1 gram of solution. The dish was weighed with the cleanser. The exact weight was calculated. The China dish with cleanser was kept on the hot plate until the liquid evaporated. If the cleanser has too many solids it will be hard to work into the hair or too hard to wash out. The result of percent of solids contents is F2 formulation 21.11%. (The result shown in the table no: 8)

Skin irritancy
It was performed on the skin on the hands of the five volunteers. The cleanser was applied to the skin for about 5 to 10 minutes and checked whether there was any irritancy on the skin. And this leads to positive results. From the above result, it was concluded that no irritancy was observed in all formulation. (The result shown in the table no: 9)

Nature of the hair after wash
It was done by collecting the responses of the volunteers, and they claimed that after washing the hair twice, it was soft and silky. (The result shown in the table no: 10)

Extrudability
The amount of cleanser extruded through the tip when a pressure was applied to a tube was then measured to assess tube extrudability. The extrudability of the cleanser was based upon the viscosity, and it was evaluated from all the 4 formulations range from (1.259gm) to(2.979gm) gm. The formulation (F2) having better consistency of the cleanser. (The result shown in the table no: 11)

Stability test
Stability tests were carried out in accordance with ICH norms for accelerated testing with the necessary changes. The sample taken formulation was taken and kept at room temperature (30± 2°C) as well as refrigerator (4+2°C) for duration of one month. The samples were tested for their physical appearance, pH, viscosity, % cleaning action. Stability and acceptability of organoleptic properties (odour and colour) of the selected F2 during the storage period indicated complete chemical and physical stability of the tested formula. The stability of the cleanser formulation. (The result shown in the table no:12, figure no: 4).

CONCLUSION

The goal of this research is to develop a successful flaxseed hair cleaner. The formulated cleanser was not only safer than other synthetic hair-washing products, but also promoted hair growth and reduced hair loss. Consumer use of herbal products has expanded significantly in recent years, according to the hair care market rating. This cleanser was created to address hair-related issues such as dandruff, hair loss, scalp irritation, and hair dryness. This results in smooth, silky hair with improved conditioning. A variety of characteristics were evaluated in order to design a flaxseed hair cleanser, including quality, pH, percentage of solid content, skin irritancy, nature of hair after washing, foam ability, and stability test, Fourier transform infrared analysis, which has resulted in a beneficial outcome. Hence, we conclude that the formulation of flaxseed hair cleanser F2 is more stable, effective, without irritation, and with few or no side effects.

ACKNOWLEDGEMENT

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Table No:1 Formulation Table

S. NO	INGREDIENTS	F1	F2	F3	F4
1	Flaxseed gel	30gm	30gm	30gm	30gm
2	Banana leaf powder	1gm	1gm	1gm	1gm
3	Neem leaf powder	0.5gm	0.5gm	0.5gm	0.5gm
4	Thick coconut milk	5gm	5gm	5gm	5gm
5	Soap nut powder	10.5gm	10.5gm	10.5gm	10.5gm
6	Xanthum gum	8gm	6gm	3gm	2gm
7	Sodium benzoate	10gm	10gm	10gm	10gm
8	Rosemary oil	1.5gm	1.5gm	1.5gm	1.5gm
9	Argan oil	10gm	10gm	10gm	10gm
10	Rose oil	0.5gm	1.5gm	2gm	2.5gm
11	Rice water (make upto)	100gm	100gm	100gm	100gm

Table No: 2 Organoleptic Properties of Flaxseed Powder

ORGANOLEPTIC PROPERTIES	OBSERVATION
Colour	Brown colour
Odour	Slightly toasty
Texture	Crispy, chewy
Taste	Bitter

Table No: 3 Organoleptic Properties Of Hair Cleanser

ORGANOLEPTIC PROPERTIES	OBSERVATION
Colour	Turbid brown
Odour	Pleasant smell
Texture	Smooth
Taste	Bitter

Table No: 4 Formulation Table for Best Cleanser

S. NO	INGREDIENTS	F1	F2	F3	F4
1	Flaxseed gel	30gm	30gm	30gm	30gm
2	Banana leaf powder	1gm	1gm	1gm	1gm
3	Neem leaf powder	0.5gm	0.5gm	0.5gm	0.5gm
4	Thick coconut milk	5gm	5gm	5gm	5gm
5	Soap nut powder	10.5gm	10.5gm	10.5gm	10.5gm
6	Xanthum gum	8gm	6gm	3gm	2gm
7	Sodium benzoate	10gm	10gm	10gm	10gm
8	Rosemary oil	1.5gm	1.5gm	1.5gm	1.5gm
9	Argan oil	10gm	10gm	10gm	10gm
10	Rose oil	0.5gm	1.5gm	2gm	2.5gm
11	Rice water(make upto)	100gm	100gm	100gm	100gm

Evaluation result of hair cleanser for best formulation (F2)

Table No: 5 Determination of pH

Formulation code	pH Range
F1	5.1
F2	5.5
F3	5.3
F4	5.4

Table No: 6 Determination of Viscosity

Formulation code	Viscosity
F1	2147cps
F2	1524cps
F3	1022cps
F4	8337cps

Table No:7 Determination Of Foaming Ability

Formulation code	Foam Height
F1	Good
F2	Good
F3	Good
F4	Good

Table No: 8 Determination of Percentage of Solid Content

Formulation No	Solid Content
F1	17.14%
F2	21.11%
F3	15.25%
F4	19.27%

Table No: 9 Determination of Skin Irritancy

Formulation No	Skin irritancy
F1	No irritancy
F2	No irritancy
F3	No irritancy
F4	No irritancy

Table No: 10 Determination of Nature of Hair After Wash

Formulation No	After washing
F1	Smooth
F2	Soft and silky
F3	Soft
F4	Smooth

Table No: 11 Determination of Extrudiability

Formulation no	Extrudability (gm)
F1	1.259gm
F2	2.979gm
F3	3.236gm
F4	5.958gm

Table No: S12 Determination of Stability Studies

Parameters	Initial	After one month 40/75(°C/ RH)
Appearance	Turbid brown	Turbid dark brown
Feel on Application	Smooth	Smooth
Ph	5.5	5.4
Viscosity	1524cps	1498cps
% of solid content	21.11%	21.05%
Nature of hair wash	Soft and silky	Silky
Extrudability	2.979gm	2.802gm

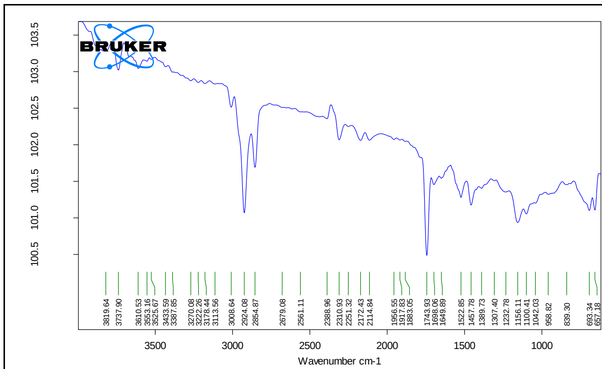

Figure: 1 ATR-FTIR of flaxseed powder

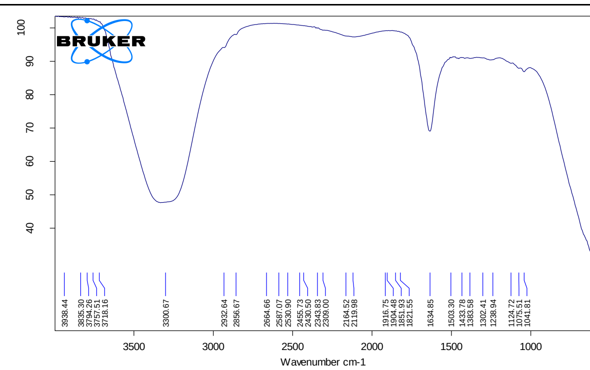

Figure: 2 ATR-FTIR of flaxseed hair cleanser

Figure no: 3 Foaming ability

Figure no:4 Hair cleanser

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RESEARCH ARTICLE

Formulation and Evaluation of Sodium Bicarbonate Lozenges.

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ABSTRACT

Acidity is a widespread condition caused by a misalignment of the stomach's and proximal intestine's acid-secreting systems. It causes a lot of problems in the lives of many people. An antacid relieves acid reflux by neutralizing excess acidity. Heartburn and acid indigestion are treated with sodium bicarbonate, which is used as an antacid. The major goal of this study was to make sodium bicarbonate antacid lozenges using a heating and congealing method and compare the trial formulation to those on the market using pharmacopeial and non-pharmacopeial methods. Sucrose, HPMC, glycerine, water, and menthol were utilized as excipients in addition to sodium bicarbonate. The weight of the lozenges was 0.750, and they were tested for hardness, friability, thickness, diameter, and disintegration.

Keywords: Heating and congealing, formulation, sodium bicarbonate, lozenges.

INTRODUCTION

Oral dose forms come in various shapes and sizes, and they have advantages over other dosage forms. They are both cost-effective and patient-friendly. They are the most natural and straightforward method of drug delivery. There is no need for nursing. Therefore, the patient can take it without assistance. Because of the delayed beginning of the action, their toxicity is delayed, allowing for a faster recovery than with other dose forms. They are suitable for any patient, regardless of age. Oral dosing types have their own set of drawbacks. If a patient suffers from chronic vomiting, they are not the first medication option. In the case of uncooperative patients, such as children and new burns, they are not a good choice. They are not acceptable in an emergency or for unconscious people.[3] They are inconvenient for patients suffering from gastrointestinal issues such as diarrhea, constipation, ulceration, or stomach hyperacidity. If a patient has the mal-absorption syndrome, in which absorption via the small intestine is compromised, they are inconvenient. Oral dose forms are insufficient for drugs susceptible to deactivation or destruction in the gastrointestinal tract. Insulin, for example, is a protein that, when taken orally, is processed in the stomach like the protein found in meat and fish. Sometimes the drug, such as aspirin and many NSAIDs, is the source of such difficulties in the GIT. Recurrent use of these medications can lead to stomach ulcers.

Finally, because absorption takes time, there is a delayed effect commencement. Lozenges are solid oral medicines that dissolve in the mouth or pharynx after being swallowed. They are meant to treat local irritation or infection of the mouth or pharynx and may also be used for systemic drug absorption, and may contain one or more medicaments in a flavored and sweetened foundation. Lozenges are meant to have a local calming and cleansing impact on the throat. They're sometimes used to help with coughing. Lozenges can have a systemic effect if the substance is absorbed well through the buccal linings or ingested. Lozenges are chewed and inserted into the mouth. The patient regulates the dissolution rate and absorption by sucking on the lozenge until it dissolves, therefore, the dissolution time is about 30 minutes.

1. Nicotine lozenges are used to assist smokers in quitting cigarettes. It is a smoking deterrent that works by delivering low doses of nicotine, which may aid in quitting smoking by reducing withdrawal symptoms. Nicotine should not be used
if you are allergic to any of the ingredients in nicotine lozenges, or
if you have recently had a heart attack.
One who is experiencing or has experienced severe or worsening chest pain or a severe irregular heartbeat. Acetaminophen, adrenergic antagonists (e.g., prazosin), beta-blockers (e.g., labetalol, propranolol), caffeine, insulin, oxazepam, pentazocine, theophylline, or tricyclic antidepressants (e.g., imipramine) may interact with nicotine lozenges because the risk of side effects may be increased when one stops smoking.
1.Pelargonium and Eucalyptus oil are the active ingredients in Linctagon. It offers calming relief from coughing and a sore, irritated throat. It is diabetic-friendly [5]
2.Fumagillin lozenges are used to treat infections caused by Candida yeast-like fungus in or around the mouth, throat, or tongue. Candidiasis, or thrush, is the name for this illness. The most prevalent cause of thrush is Candida albicans.
3.Flurbiprofen lozenges: Flurbiprofen is an NSAID (nonsteroidal anti-inflammatory drug). These drugs are used to treat inflammation and pain. The lozenges are used to relieve sore throat symptoms.
4.Behcet's syndrome is treated with low-dose natural human interferon-alpha lozenges. Low-dose local IFN is effective in treating recurrent mouth ulcer [6]
5.Actiq lozenges: These lozenges are made up of the active chemical fentanyl, an opioid analgesic (painkiller). Opioids are a class of potent pain relievers linked to morphine. Opioid painkillers are prescribed to those who are suffering from long-term, severe pain, such as that caused by cancer. However, despite taking these powerful medicines, the discomfort can sometimes worsen. This type of pain is referred to as "breakthrough" pain. In those who are already using opioid medicines, Actiq lozenges relieve this "breakthrough" discomfort. The lozenges are made up of lozenges that have been connected with edible glue to make them easier to handle. The lozenge is put near the cheek, and the handle is used to move it around the mouth. The drug is swiftly absorbed into the bloodstream through the mucosal skin within the mouth to give quick pain relief. It is used to treat those taking frequent opioid medicines for long-term, persistent, severe pain caused by cancer.
6. Lozenges containing zinc gluconate and zinc acetate: Zinc is an essential element and antioxidant that may be found in every body cell. It is required for more physiological functions than any other mineral, and it is a cofactor for more than 200 enzymes [7,8]
7.Fructose is used in advanced design to provide the necessary sweetness. Depending on the type, molding or compression may be used to make lozenges. Pastilles are moulded lozenges, whereas troches are compressed lozenges. Lozenges should dissolve gently in the mouth and have a smooth texture with no sharp edges. Lozenges come in a variety of shapes, including flat, circular, octagonal, biconvex, and bacilli, which are short rods or cylinders [9,10]

Advantages.

- It is simple to administer to both children and the elderly.
- It has a pleasant flavour and will extend when enough medication is in the mouth cavity to cause local activity.
- Drugs can be absorbed systemically through the buccal cavity, which can be prepared with little equipment.
- Sweeteners and flavours added in the formulation can hide the taste of the medications.

Disadvantages

- It could be mistakenly used as candy by children. Parents should be cautioned not to associate medications with candy and keep the product out of the reach of children.
- Some drugs may not be suitable with aldehyde candy bases, e.g., benzocaine.
- Heat stable drugs are suitable.
- Children above six years of age can use lozenges safely.
- Drugs having minimum bitter taste are suitable

Types of Lozenges[11]:

- chewable lozenges,
- hard lozenges,
- soft lozenges.

Chewable Lozenges:

Because they are gummy-type lozenges, chewable lozenges are popular among children. The majority of formulations are based on a glycerine and water suppository mix. These lozenges have an intense fruit flavour and may have a mild acidic aftertaste to mask the harsh glycerine taste.

Hard Lozenges:

Hard-candy lozenges are amorphous mixes of sucrose and other sugars and carbs. They are created from aqueous syrups; the water in the syrup evaporates when it is boiled during processing, leaving the end product with a moisture percentage of 0.5 percent to 1.5 percent. Some sellers of compounding supplies and firms specializing in providing supplies for creating candies and confectionaries supply flavors, colours, and unique moulds. In recent years, hard-candy lozenges have become a popular compounded dosage form, and many manufacturers offer specific moulds, sucker sticks, and wrappers [13].

Soft Lozenges:

Soft lozenges have grown popular due to their ease of production and adaptability to a variety of medications. Polyethylene glycols, acacia, and other similar compounds are commonly used as bases. The pastille, defined as a soft variation of lozenges, usually translucent, containing medication in glycerine gelatine or Acacia sucrose foundation, is one of these soft lozenges. Pastilles can be coloured and flavoured, and depending on the effect intended for the included medicine, they can be chewed or slowly dissolved in the mouth.

Formulations of Hard Candy Lozenges [14.15]

Raw Materials [12]: The types of raw materials used in medicated lozenges may vary according to several factors. Most medicated lozenges contain sugar, corn syrup, acidulant, colorant, flavour, and medicament.

Sucrose: A disaccharide of glucose and fructose, is obtained from sugarcane or beet. Beet or cane sugar is based on availability and geographical considerations. Sucrose and sucrose products are used in medicated lozenges because of their value as neutral sweeteners, their ready solubility, and their function as a "drier" to reduce the weight of the confection through crystallization. **Invert sugar:** Invert sugar, derived from sucrose, possesses the very desirable physical property of controlling the crystallization of concentrated sugar solutions and maintaining the freshness of the finished product through its humectant properties.

Corn syrup: Corn syrup is used in almost every type of confection to control sucrose and dextrose crystallization, which may lead to crumbling. Corn syrup in appropriate proportion with sucrose and dextrose allows the formation of an amorphous glass and produces a candy with a desirable appearance**.**

The following physical properties of corn syrup are extremely important in preparing medicated candies: density, dextrose equivalent (DE), hygroscopicity, sugar crystallization, viscosity, freezing point depression, and osmotic pressure.

Isomaltose: Isomaltose is an almost equimolar mixture of 6-glucopyranosyl-sorbitol (6- GPS) and 1- glucopyranosyl-mannitol (1-GPM), and the weight percentage can vary between 43 to 57% of 6-GPS to 57% to 43% of 1-GPM. **Isomaltose has properties like a binding agent, i.e., to a certain extent, it can establish a binding between the individual particles in the composition and further in the binding during the kneading step in the process of preparing a lozenge.**

Colorants

Colorants are incorporated into medicated lozenges for appearance, product identification, and masking of physical degradation.

Dyes and other organic colorants: Dyes and other organic colorants may degrade by heat or light via oxidation, hydrolysis, photo-oxidation, etc. Before selection, their compatibility with drugs, excipients, and process conditions should be studied. Suppliers of colours are excellent sources of information on the current regulatory status of colorants

Acidulants: Acidulants are generally added to medicated lozenges to fortify and strengthen their flavour profile. Organic acids such as citric, malic, fumaric, and tartaric are most commonly used.

Flavours: Flavours used in medicated lozenges must be compatible with the drug and excipients and capable of withstanding the rigors of the manufacturing conditions. Flavours consist of numerous chemicals that may interact with excipients or medicaments and degrade by heat and light. Aldehydes, ketones, and esters may react with drugs. A classic example of flavour–drug interaction is that of a primary amine drug (benzocaine, phenylpropanolamine) with aldehyde containing flavour components like cherry, banana, etc., resulting in the formation of a Schiff base, drug decomposition, and loss of efficacy. Adjusting lozenge base pH to accentuate certain flavours (e.g., citrus) may also result in incompatibility with some medicaments (e.g., benzocaine).

Salvage: The last major ingredient in lozenges is salvage obtained from lozenge batches rejected because of imperfect shape or size, presence of air bubbles, or unacceptable drug concentration. Salvage, if properly heated, can be reused in finished products without altering colour, texture, lozenge base composition, or drug concentration. Before any salvage can be used as part of a medicated lozenge base, it should be adjusted to a pH of 4.5–7.5 to prevent excessive and uncontrolled formation of reducing sugars, and the stability of the drug at cooking cycles should be determined.

Applications of Lozenges: The use of lozenges for treating both local and systemic illnesses is common. They can contain a variety of pharmacological candidates for the treatment and relief of oral and throat infections such as oral thrush, sore throat, cough, gingivitis, pharyngitis, decongestants, and so on. Furthermore, these have been employed to distribute the medication for smoking cessation and pain relief systemically.

Uses [16,17].

Drug candidates which can be incorporated in lozenges, belong to one of the following categories:

- Emulgents Antiseptics
- Local anesthetics'
- Antibiotics
- Antihistamines
- Antitussives
- Analgesics
- Decongestants

Need For the Study

Even though sodium bicarbonate is already available in the oral dosage form, the literature studies looked into various dosage forms for sodium bicarbonate, a drug of choice in the management and treatment of heartburn and antacid. Dissolvable pills and lozenges are available. As a fast-acting option, lozenges are smaller, softer, and more chewable than tablets, and they dissolve more quickly, often in 2 to 3 minutes. Tablets are larger than regular tablets and take longer to dissolve, usually 8 to 10 minutes. So far, the lozenges have shown to be the most effective. They were compared to tablets in terms of speed of action and drug disintegration. At the same time, they produce a fast-acting antacid and heartburn treatment.

MATERIALS AND METHODS

Method Of Preparation Of Medicated Lozenges[18]

Heating and congealing were the methods used. Heat the sugar, corn syrup, and water together. To this confectionery concoction, a medication is added. Colour, flavour, and other enhancements They poured the candy into the mould in the proper shape and size. In polyethylene warping, the candy is sealed and warped.

Materials: Karachi Pharmaceutical Laboratory generously contributed sodium bicarbonate, while sucrose and HPMC were purchased from Mercury Scientific Laboratory in Salem. In the department of pharmaceutics laboratory at Vinayaka mission's college of pharmacy in Salem, we tested glycerine and menthol.

Formulation of Sodium Bicarbonate lozenges.

The amount of active pharmaceutical ingredient (API) and excipients was precisely weighed (Table 1). Accurately weigh the required quantity of sucrose and water triturate it in a mortar to dissolve sucrose in water easily. Heat the solution by using a heating mantle. Add HPMC polymer, add two drops of glycerine as an opacifier, add menthol, heat the solution to a jelly-like consistency is formed, keep a side for a few minutes, and add drug and resonate mixture. The prepared jelly solution was poured into the mould to get the required shape lozenges.

Evaluation of Sodium Bicarbonate lozenges.

The following official and unofficial parameters were assessed on the made lozenges: organoleptic test, hardness, thickness, diameter, weight variation, friability, drug content, in vitro dissolution studies, etc. Diameter and Thickness test following steps. Vernier callipers were used to measure the diameter and thickness.Sodium bicarbonate standard calibration curve in 0.1 N HCL solution 100mg sodium bicarbonate was accurately weighed and deposited into 100 ml of the volumetric flask, followed by 5ml of 0.1N HCL to dissolve the medication and volume made up to the mark with water to achieve a concentration of 1000g/ml. The stock solution was diluted to 10, 20, 30, 40, 50, 60, and 70 g/ml, and the absorbance was measured at 310nm.

The size of the lozenges is a critical consideration in their production. The three lozenges were chosen at random from each formulation batch and measured for thickness and diameter. Lozenge average diameter and thickness were determined, and observation readings are listed in the table below. And hardness test value Using a Pfizer hardness tester, the hardness of each batch composition of 10 lozenges was determined. The mean and standard deviation of the data were calculated and published. weight variation test Twenty lozenges were chosen randomly from each batch composition and weighed together; the lozenges were then evaluated individually. If not more than two of the individual lozenge weights depart from the average weight by more than the percentage allowed by IP, the batch passes the weight variation test. A Roche friabilator was used to determine friability. Ten lozenges were weighed and placed in the Roche friabilator for each batch formulation, with all parameters set on the friabilator. For 4 minutes, the device was rotated at 25 rpm (100 rotations). The tablets were taken away and weighed anew after each revolution. The maximum mean weight loss in the samples is 1.0 percent. Lozenges are tested for stability under the following conditions: 2 months at 60° Celsius, 3-6 months at 45° Celsius, 9-12 months at 37° Celsius, 36-60 months at 25° Celsius The stability of lozenges in their final packets is tested under the following conditions: For 6-12 months, set the temperature to 25°C at 80% relative humidity (RH), 37°C at 80% RH for 3 months, and 25°C at 70% RH for 6-12 months. The disintegration time of lozenges was measured using a USP Disintegration equipment and recorded at 37°C in a pH 6.8 phosphate buffer containing 2% SLS.

RESULTS AND DISCUSSION

The Organoleptic Properties of drug samples were investigated for the drug's appearance, colour, and odour. (Table No:01). The shaking flask method introduced excess medication to methanol, phosphate buffer, and double distilled water separately during solubility studies. (Table No:2). Sodium bicarbonate standard calibration curve in 0.1 N HCL solution 100 mg sodium bicarbonate was accurately weighed and deposited into 100 ml of the volumetric flask,

followed by 5ml of 0.1N HCL to dissolve the medication and volume made up to the mark with water to achieve a concentration of 1000g/ml. The stock solution was diluted to 10, 20, 30, 40, 50, 60, and 70 g/ml, and the absorbance was measured at 310nm. (Table No: 3). Absorbance linearity graph of Sodium Bicarbonate. (Fig No:01) Disintegration profile of sodium bicarbonate lozenges: The disintegration time of lozenges were determined by USP Disintegration apparatus and disintegration time was noted in pH 6.8 phosphate buffer containing 2% SLS at 37ºC. (Table No 04). Stability studies of sodium bicarbonate lozenges for optimized formulation L2. (Table No 5).
lozenges In vitro percentage studies of sodium bicarbonate lozenges of Weight variation, friability, hardness, percentage of drug content, thickness, and diameter test values. (Table No:6).

CONCLUSION

The present study used sucrose, HPMC, glycerine, menthol, and water to create sodium bicarbonate lozenges successfully using the heating and congealing method. These lozenges are simple to use and helpful in treating antacid and heartburn. Compared to other sodium bicarbonate formulations on the market, the current formulation is simple in composition, straightforward to make, and cost-effective. This formulation will require more work to improve. In comparison to tablets, sodium bicarbonate lozenges are more effective, simple, and rapid to function.

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Table No: 01 organoleptic property of prepared lozenges

Parameters	Result
Shape	Round
Colour	Pale yellow White (HPMC k100)
Texture	Smooth
Taste	Sweetness

Table No:02 Solubility of sodium bicarbonate

Water	soluble,
Acetone	Slightly soluble
Methanol	Slightly soluble
Ethanol	Insoluble

Table No:03 Absorbance value of sodium bicarbonate

S.NO	CONCENTRATION(μg/ml)	ABSORBANCE
1	0	0
2	10	0.0989
3	20	0.2123
4	30	0.3021
5	40	0.4123
6	50	0.5033
7	60	0.5758

Table No:4 Disintegration studies of sodium bicarbonate lozenges

TIME (sec)	L1	L2	L3	L4	L5
0	0	**0**	0	0	0
10	38	**30**	27	42	22
30	52	**60**	41	60	38
60	70	**78**	58	65	52
90	88	**91**	78	77	70

Table No:05 Stability studies of sodium bicarbonate lozenges

Evaluation parameter	Initial O days	1st Month	2nd Month	3rd Month
Weight variation	0.750	0.750	0.750	0.750
Diameter	2.3±0.0cm	2.2±0.0cm	2.±0.0cm	2.3±0.0cm
Thickness	0.72 cm	0.72 cm	0.72 cm	0.71cm
Hardness	1.2	1.1	1	1
Friability	0.91	0.91	0.91	0.91
Drug content	91.2	91.2	91.1	91.1

Table No:6 *In vitro* percentage studies of sodium bicarbonate lozenges

Formulation	Weight variation	Diameter	Thickness	Hardness	friability	%drug content
L1	0.820	2.3±0.0cm	0.71 cm	1.7	0.87	88.6
L2	**0.750**	**2.3±0.0cm**	**0.72 cm**	**1.2**	**0.91**	**91.2**

L3	0.720	2.3±0.0cm	0.73 cm	2.1	0.85	82.6
L4	0.740	2.3±0.0cm	0.70 cm	0.7	0.52	83.5
L5	0.600	2.3±0.0cm	0.71 cm	1.3	0.84	89.3

*Formulation Code:
L1= Sodium bicarbonate lozenges formulation 1. L2 = Sodium bicarbonate lozenges formulation L2
L3 = Sodium bicarbonate lozenges formulation 3. L4 = Sodium bicarbonate lozenges formulation 4.
L5 = Sodium bicarbonate lozenges formulation 5.

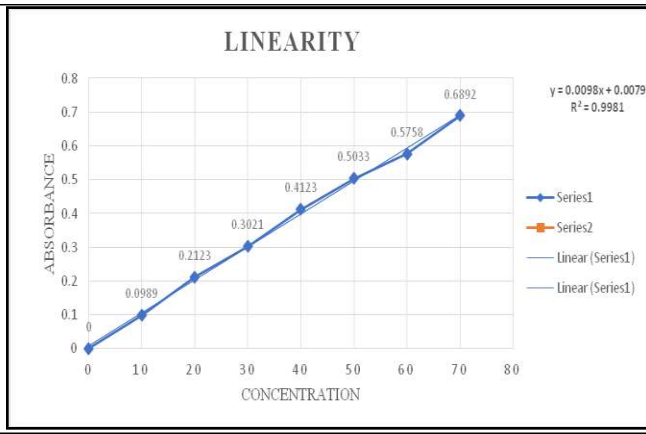

Fig No 01 Absorbance linearity graph of Sodium Bicarbonate

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RESEARCH ARTICLE

Formulation and Evaluation of Pomegranate Face Cream

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ABSTRACT

To formulate and evaluatea herbal face cream with pomegranate, water melon, aloe vera, and orange extracts to provide a moisturizing effect. Methods: Bee's wax, pomegranate, water melon, triethanolamine, distilled water, rose oil, Aloe Vera, and orange peel extracts were used to make the cream. The cream was made by blending all of the excipients and herbal extracts geometrically and homogeneously using the o/w emulsion process. F1, F2, F3, F4, F5 are the five batches of our herbal cream that we have developed. Different factors such as appearance, pH viscosity, spread ability, and washability were examined for all five formulations. Result: During the irritancy investigation, all five formulations showed good appearance, pH viscosity, and spread ability, as well as no redness, erythema, or irritation, and they were easily washable. The herbal compounds are all natural.

Keywords: pomegranate, water melon, orange, beeswax, formulation, evaluation

INTRODUCTION

A cream is one of the skin-care products that is applied to the skin. Creams are also used on mucus membranes including the vaginal and rectum[1]. Creams are both pharmaceuticals and cosmetics that are used to treat a variety of skin diseases[2]. Creams are a semi-solid mixture of oil and water. • W/O • O/W Small droplets of oil are spread in a continuous water phase in O/W creams[3]. The O/W kind is more pleasant and cosmetically acceptable since it is less oily and readily rinsed off with water[4].W/O Creams are made up of minute water droplets suspended in a continuous oil phase. W/O types are more difficult to work with, and they also require more moisturizing because they offer an oily barrier that prevents water loss via the stratum corneum[5]. USES: • Cleansing • Emollient Effect •

Moisture Retention (Without Creams) • Physical/Chemical Barrier (Sunscreen) The concept of beauty and cosmetics may be traced back to the dawn of humanity and civilization. Herbs from India and their significance are well-known around the world. Herbal cosmetics are in high demand on the global market and are a priceless gift from nature[6]. Herbal formulations have always piqued interest due to their high activity and, in comparison to synthetic medications, fewer or no negative effects[7]. Herbal cosmetics are defined as beauty products containing herbal ingredients that have desired physiological activities such as healing, smoothing appearance, enhancing, and conditioning qualities.The use of herbs in cosmeceutical production has greatly risen in recent years in the personal care system, and there is a high demand for herbal cosmetics. Cosmetics are substances that are applied to the human body with the purpose of cleansing, beautifying, increasing attractiveness, and changing appearance without harming the body's structure or functions. However, the use of synthetic items has been proven to be extremely detrimental to both young and the environment for a long time. Various synthetic substances, chemicals, dyes, and derivatives have been shown to induce a variety of skin illnesses with a variety of negative effects. As a result, we make extensive use of herbal cosmetics. The fundamental concept of skin care cosmetics can be found in the Rigveda, Yajurveda, Ayurveda, Unani, and Homeopathic medical production. Skin protection, sunscreen, antiacne, antiwrinkle, and antiaging compositions are created with a variety of natural and synthetic components for many sorts of skin disorders. Aloe barbadensis, Ocimum sanctum, Azadirachta indica, Curcuma longa, Cedro oil, Myristica fragrans, Oliumrosae(Rose Oil), Orange Oil, Prunus dulcis, Ocimum sanctum, Prunus dulcis, Ocimum sanctum, Prunus dulcis, Ocimum sanctum, these herbs Prunus dulcis have been chosen based on a conventional system and scientific rationale for modern applications[8]. When used frequently, a herbal lotion should provide efficient skin protection while remaining free of toxicity, harmful residue, or irritation. It should also be cosmetically attractive[9]. systems. Herbs are employed in the form of crude or extract in these goods. Antioxidant, anti-inflammatory, antiseptic, emollient, anti seborrheic. antikerolytic activity, and antibacterial qualities should all be present in these herbs. Cosmetics are designed to minimize wrinkles, combat acne, and regulate oil

MATERIALS AND METHODS

List Of Plant Materials
Pomegranate, water melon, orange, were collected from local market at Salem,(table no:2.1)

Formulation Of Cream
Heat l beeswax in a borosilicate glass beaker to 75°C and keep it there. (Phase of oil). Pomegranate peel powder, triethanolamine, orange peel powder, watermelon juice in distilled water in a separate beaker; heat to 75°C to dissolve the peel powders and triethanolamine and obtain a clear solution. (In the aqueous phase.) After that, slowly pour this watery phase into the heated oily phase. Then, add a measured amount of olive oil and argon oil, and aggressively whisk until a creamy cream develops. Then, as a finishing touch, add a few drops of rose oil as a scent. Place this cream on the slab and, if necessary, add a few drops of distilled water, then mix the cream in a geometric pattern on the slab to give it a smooth texture.

Oil/Water Emulsion Method
Emulsions of Oil-in-Water (o/w) Most moisturisers (both day and night creams) and topical steroid treatments contain o/w emulsions, which are made by suspending oil droplets in an aqueous phase. Despite being categorised as a food product, homogenised milk is one of the most well-known o/w emulsions. O/w-based creams are thicker than lotions and easier to apply than ointments, and they function by permeating the skin's stratum corneum wall to generate a local impact. (The result shown in the table no:1)

Evaluation of herbal cream
Quality control tests were done on the prepared formulations, including organoleptic and physicochemical characteristics such as pH, spread ability, and viscosity. , were also conducted to assure the quality of the goods. The results were compared to a commonly used herbal cream that was utilized as a reference.

Appearance

The formulated herbal face cream was visually evaluated for color, appearance, and transparency. The smoothness of the cream was stimulated by rubbing the formulation between the fingers to observe the smoothness.

Physical Evaluation

Physical parameters such as color, aroma, consistency, and formulation status were used to evaluate the herbal creams that had been created.

pH

A digital Ph meter was used to determine the pH of the produced herbal cream. 100 mL distilled water was used to make the cream solution, which was then set aside for two hours. The average value of Ph was estimated after measuring it three five for the solution.

Spread ability

The spread ability was measured by the time it took two slides to slip away from the cream, which was placed in between the slides, under a particular force. The time it takes to separate the two is shorter. Thespread ability of the slides is improved. Two sets of standard glass slides The dimensions were measured. Then one slide of appropriate size was added. The cream formulation was photographed and placed on the slide. ThenThe formulation was placed on top of another slide. Then there's a weight. Or a particular load was applied on the upper slide to prevent the cream from separating. Between the two slides, a thin layer was squeezed uniformly.The weight was then removed, and any excess formulation stuck on the slides was scraped away. The force of weight attached to the upper slide allowed it to glide off effortlessly. The time it takes for the upper to finish It was seen that the slide was slipping off.

spread ability = m x l/t

Were,

m= A standard weight attached to or put on top of the upper slide. (30g)

l = length of the glass slide (5cm)

t = the measurement of time in seconds

Wash ability

After applying a small amount of cream to the hand, it was washed with tap water.

Non-irritancy test

Mark the area (1cm2) on the left-hand dorsal surface. Then the cream was applied to that area and time was noted. Then it is checked for irritancy, erythema, and edema if any for an interval up to 24 h and reported

Viscosity

Viscosity of cream was done by using Brooke field viscometer at a temperature of 25oc using spindle no.63 at 2.5 RPM

Smoothness

Emollience, slipperiness, and the amount of residue left after applying the prescribed amount of cream were determined to be satisfactory.

Stability studies

Introductions

The time from the date of manufacture and packaging of the formulation until its chemical or biological activity is not less than a set level of labelled potency and its physical properties have not altered considerably or negatively can be characterized as the stability of a medicine. The stability of the active component must be a major consideration in selecting whether or not to accept or reject dosage forms for medications in any design or evaluation.

Objective of the study

Stability testing enables recommended storage settings, re-test intervals, and shelf-lives by predicting how the quality of a drug ingredient or drug product changes over time under the effect of various environmental elements such as temperature, humidity, and light. Observing the rate at which a product degrades under typical room temperature takes a lengthy period in most cases. The ideas of expedited stability investigations are used to avoid

this unfavorable delay. The stability test requirements are described in the International Conference on Harmonization (ICH) Guidelines under "stability testing of New Drug Substances and Products" (QIA).
The present work stability study was carried out for the optimized formulation at 40ºC±2ºC/75%RH±5%RH for one month.

RESULT AND DISCUSSION

Organoleptic properties
The color of the dried peel powder is brown color, indistinct odor and bitter taste. All formulation were brown color and aromatic odor. Physical appearance of all formulation are opaque in nature. Evaluation result of pomegranate herbal face cream best formulations F2 (The result shown in the table no:2)

ATR -FTIR Spectra Analysis
The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR- FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample holder.(The result shown in the fig no:1)

Compatability studies

Physical compatibility studies
The physical mixture of drag and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak Following a weak. The samples are examined for any physical changes such as discoloration, odor. Etc...

Chemical compatibility studies
These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wavenumber region of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded. ATR-FTIR spectroscopy was fixed at the range of 4000-400cm^{-1}.There is no interaction between the drugs and excipients. (The result shown in the fig no:2)

Evaluation of cream formulation

Appearance
The prepared cream was visually inspected for the appearance, colour, and texture. All the prepared formulation was white colour, with a smooth texture, and they were all homogenous with no signs of phase separation. To optimized formulation concentration of excipients which impact the hydrating, viscosity was selected beeswax, olive oil, triethanolamine concentration have been varied to the study the impact on viscosity and hydrating effect. Five trials were planned and executed in a way to study the impact of single excipient in each formulation by keeping one formulation (F2) optimized formulation.

Determination of pH
Using pH paper, the pH of a cleaner solution (10%w/v) in distilled water was tested at room temperature.The pH level was determined using pH-paper, and it was found to be 6.3, which is based in nature, making it skin friendly and causing no irritation. (The result shown in the fig no: 3, table no: 3)

Determination of Spread ability
The Spread ability of the cream was based upon the viscosity and it was evaluated form all the 4 formulations. F2 has better spread ability as compares to other formulation. The F2 having better consistency so the cream was easily spreadable by the small amount of shear. (The result shown in the table no: 4)

Washability Test
Washability test was carried out by applying a small amount of cream on the hand and then washing it with water. And the F1 and F2 are good but F3, F4, F5 are fair. (The result shown in the table no: 5)

Viscosity
The viscosity of the cream was determined by using Brookfield Viscometer LVDV Prime-I. The viscosity of cream was measured at room temperature. 30+2°C with varying rpm and torque. All five-cream showed comparable the

viscosity range. The viscosity range of herbal cream is listed in F2 was determine to be a 1529cps. (The result shown in the table no:6)

Skin Irritancy

Skin irritancy of cream can be checked by taking small amount of product on skin, after few minutes to check whether local irritation or any inflammatory reaction are produced or not. The one of the major evaluation factors in the cream preparation purpose of avoiding the skin irritation. (The result shown in table in 7)

Stability studies

A stability study was carried out for the optimized formulation according to ICH guidelines at 40°C/75 % RH for one month. The results showed no significant change in the physical and chemical parameters of the cream. Hence the formulation (F2) was found to be stable. (The result shown in the table no: 8)

CONCLUSION

The cream had a moisturizing effect due to the use of pomegranate, orange, and aloe vera, and all of these botanical constituents had distinct actions. The formulations F1, F2, F3, F4, and F5 were found to be stable at room temperature and can be safely used on the skin, based on the results and discussion.

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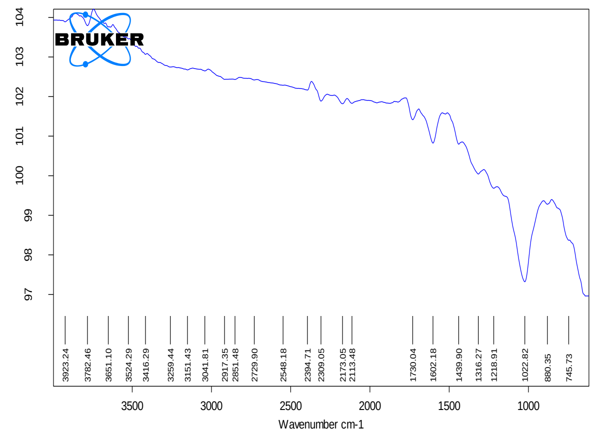

Figure no-1 ATR-FTIR of pomegranate pool powder

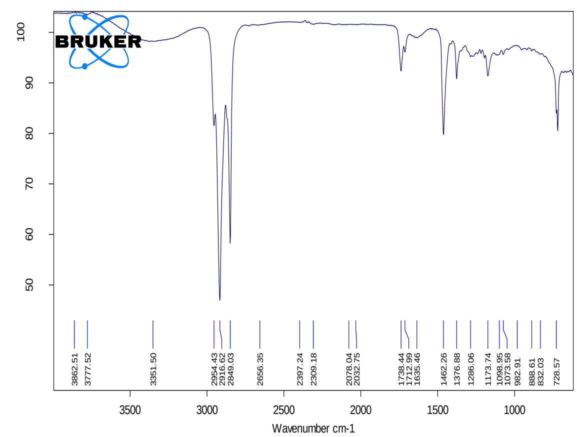

Figure.no-2 ATR-FTIR of pomegranate peel powder + water melon juice + bees wax + argon oil + rosemary oil

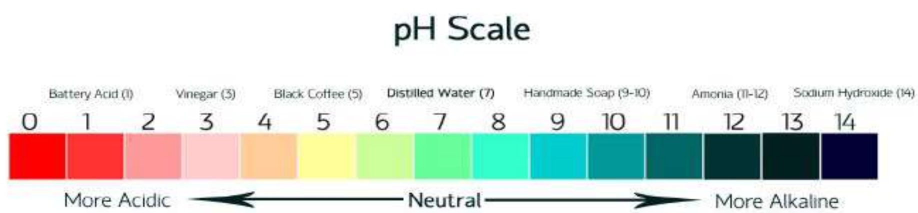

Figure no-3 pH Scale

Table no:1 Formulation of herbal cream

S NO	INGREDIENTS	F1	F2	F3	F4	F5
1	POMEGRANATE(POWDER)(gm)	5	5	5	5	5
2	WATER MELON (JUICE)(gm)	7	7	7	7	7
3	BEES WAX(gm)	10	15	20	25	30
4	ARGON OIL(gm)	2	2	2	2	2
5	ROSEMARY OIL(gm)	0.5	1	1.5	2.0	2.5
6	Oilve oil(gm)	10	10	10	10	10
7	Triethanolamine(gm)	1	2	3	4	5
8	Water (qs)	100	100	100	100	100

Table no:2 organoleptic properties

Color	Brown
Odour	Pleasant
Taste	Bitter
State	Semi solid
Consistency	Smooth

Table No: 3 Determination of PH

Formulation. No:	pH Range
F1	6.2
F2	6.3

F3	6.5
F4	6.5
F5	6.7

Table.no.4 Spread ability measurement

Formulation code	Spread ability (g.cm/sec)
F1	94.25
F2	92.45
F3	88.66
F4	85.03

Table.No:5 Wash ability test

Formulation No:	Wash ability
F1	Good
F2	Good
F3	Fair
F4	Fair
F5	Fair

Table.No:6 Determination of viscosity

Formulation No:	Viscosity
F1	1769cps
F2	1529cps
F3	2215cps
F4	4426cps
F5	4779cps

Table.No:7 Determination of skin irritancy

Formulation No:	Skin irritancy
F1	No irritation on skin
F2	No irritation on skin
F3	No irritation on skin
F4	No irritation on skin
F5	No irritation on skin

Table. No:8 Stability Parameter of selected formulation

Parameters	Initial	After one-month 40/75(°C/ RH)
Appearance	Light brown colour	light brown colour
Feel on Application	Smooth	Smooth
Ph	6.3	6.2
Viscosity	1529 cps	1524cps
Spread ability	92.45 g.cm/sec	90.21 g.cm/sec

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RESEARCH ARTICLE

Formulation and Evaluation of Kiwi Sunscreen Lotion by Primary Emulsion Method

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ABSTRACT

The aim of this research was to develop sunscreen lotion formulation with natural ingredients and calculated sun protection factor (SPF) for it. The sunscreen is prepared using water phase that include demineralised water as a main solvent, glycerine as a moisturizer, kiwi as a thickener and stearic acid as a preservative. The oil phase is composed of one of the followings: sunflower oil, wheat gram oil, carrot seed oil and emulsifying wax as emulsifier. Titanium dioxide are employed in sunscreen as inorganic physical sun blockers. The best lotion texture was obtained in the case of using emulsifying wax as emulsifier by 8%. The best solubility of sunscreen lotion is obtained using equal proportions of hexane and ethanol. An in vitro SPF (sun protection factor) of used samples is calculated according to Mansur's method. Moreover, Mansur's method calculates only SPF values of organic substances (triglycerides oils) but physical sun blockers cannot be calculated by Mansur's method. By comparing SPF values for triglycerides oils, the best protection value is obtained using wheat gram oil. These oils can be used in the formulation of sunscreens as emollient and sun blockers. This formulation of sunscreen lotion is focused on using, lotion texture and efficacy.

Keywords: Sun Protection Factor, Titanium dioxide, Wheat gram Oil, Kiwi extract powder.

INTRODUCTION

Sunscreen has a lengthy history in our daily lives, dating back over 6,000 years. Franz Greiter in 1938 and Benjamin Green in 1944 were the first to apply a combination of coco butter and red veterinary petroleum to protect their skin from the sun. Sunscreen (also known as Herbal sunblock, Herbal suntan lotion) is a lotion, spray, or other topical substance that protects the skin from the sun's ultraviolet (UV) radiation and decreases sunburn and other skin damage, with the purpose of decreasing the risk of skin cancer. Suntan lotion, on the other hand, is generally the polar opposite of sunscreen, referring to a moisturizer that maximizes UV exposure and tanning rather than blocking it. The use of ultraviolet (UV) radiation adds considerably to skin damage[1]. Melanoma incidence was also shown to be greater in populations where sunbathing is widespread, according to scientists. More in-depth investigations indicated that people who used sunscreen on a regular basis experienced much less skin damage. The causes of skin cancer have been further described, and UV rays have been identified as one of the major human carcinogens by several cancer authorities[2].

Application of Sunscreen:
Given differences in body habitus, a 2015 Canadian consensus conference determined that the question "apply sunscreen liberally" was the most acceptable. Figure 2 depicts an approximate estimate of the amount of sunscreen that a person of average weight should apply. Even when people are physically active, the stays on the skin at the required SPF for up to 8 hours after a single application, implying that the traditional advice to reapply sunscreen every 2-3 hours should be followed. When the likelihood of sunscreen being removed is high, such as after sweating, water immersion, friction from clothes, or sand exfoliation, reapplication is recommended[3].

Basis of sunscreen use:
Cosmetics are described as "materials meant to be rubbed, poured, sprinkled, or sprayed on the human body or any portion thereof for washing, beautifying, encouraging attractiveness, or modifying the look. These are formulations that are applied to the skin's surface to protect it against ultraviolet (UV) light's detrimental effects. Repeated skin exposure has been linked to an increased risk of acquiring skin cancer [4].. Melanoma may be avoided by learning about the negative effects of sunlight and how to shield oneself from its harmful beams. The American Academy of Dermatology advises that people of all skin kinds apply a sunscreen with an SPF of 15 or higher on a daily basis, despite the fact that skin malignancies are significantly more common in white people than in persons with darker complexion. Because of the potential danger of greater absorption of sunscreen chemicals due to higher body surface-to-volume ratios and thinner epidermis, Health Canada does not recommend the use of sunscreen for children less than 6 months[5].

MATERIALS AND METHOD

Chemical and equipment

SI.NO	INGERDIENTS	MANUFACTURER /SUPPLIER
1.	Emulsifying wax	Laveloute, pondy
2.	Stearic acid	Laveloute ,pondy
3.	Cetyl alcohol	Laveloute ,pondy
4.	Sunflower oil	Laveloute, pondy
5.	Wheat gram oil	Laveloute ,pondy
6.	Carrot seed oil	Laveloute ,pondy
7.	Arjuna bark extract	Laveloute ,pondy
8.	Kiwi extract powder	Laveloute ,pondy
9.	Lactic acid	Laveloute ,pondy
10.	Glycerine	Laveloute ,pondy
11.	Titanium dioxide	Laveloute ,pondy
12.	Demineralized water	Laveloute ,pondy
13.	Polypylene glycol	Laveloute ,pondy

METHODOLOGY

Preformulation Studies
Organoleptic properties
A natural substance's organoleptic quality refers to its appearance, odour,colour and taste. The study's initial stage is to characterise these characteristics, which aids in the primary identification of the natural substance as well as determining the like hood of patient acceptability of the raw materials aroma, taste and colour as well as its likely inclusion in the final dose form. Changes in the colour and odour of a formulation's raw materials ,might sometimes signal that the formulation's stability has deteriorated(under identical conditions)

ATR-FTIR Spectra Analysis
The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR-FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample holder

Drug and excipients compatibility studies

Chemical compatibility studies
These compatibility studies are conducted by using ATR-FTIR spectrophotometer and the spectrum was recorded in the wave number region of 4000 to 400 cm^{-1}. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded.

Preparation of sunscreen product formulation:
The sunscreen lotion was prepared on the basis of following procedure for the total weight of the sample (20ml).
Table No 10 - Formulation table

Preparation of aqueous phase
Kiwi extract, lactic acid, glycerine , titanium dioxide are weighed accurately and dissolved in demineralised water was added to swell using a homogenizer and heated up to 80^oC.

Preparation of oily phase
Emulsifying wax, stearic acid, cetyl alcohol and respective quantities are weighed accurately and add essential oils (sunflower oil, wheat gram oil, carrot seed oil) and heat up to 80^oC.

Mixing phase
Aqueous phase was added to oil phase at 80^oC with continousstrring for 20-25 min and then it was homogenized till uniform emulsion formed. It was poured into a wide mouth container and stored at temperature not exceeding 37^oC.

Authentication
This is to authenticate that the ***Kiwi fruit*** of family ***Actinidiaceae*** have been collected from ABS Botanical garden Kaaripatti, Salem Dt. T.N. and handed over to **Miss. P.ARUNDATHI** year B.Pharm for their project work

Evaluation of Formulation Product

Appearance
The formulated kiwi sunscreen lotion was visually evaluated for colour, appearance, and transparency. The smoothness of the lotion was stimulated by rubbing the formulation between the fingers to observe the smoothness, clumps, roughness and homogeneity.

pH Measurement

pH measurement of the sunscreen lotion was carried out using a digital Ph meter by dipping the glass electrode completely into the lotion system to cover the electrode. The measurement was carried out in triplicate and the average of the three readings was recorded

Viscosity

Brook field viscometer LVD was used to measure the viscosity of prepared creams using spindle S 94 at various speeds and shear rates. The measurements were made in 60 seconds between two successive speeds as equilibrium with shear rates ranging from 0.2. s^{-1} to 1.0 s^{-1} over a speed range of 10 , 20 , 30 , 40 50, rpm . the viscosity tests were carried out at room temperature.

Spread ability

Two sets of glass slides of standard dimensions were taken. The herbal lotion formulation was placed over one of the slides. The other slide was placed on the top of the lotion, such that the lotion was sandwiched between the two slides in an area occupied by a distance of 7.5 cm along the sides. Hundred 100g weight of lotion was placed on the upper slides so that the lotion was between the two slides was pressed uniformly to form a thin layer. The weight was position were fixed to a stand without slightest disturbance and in such a way that only upper slides to slip off freely by the force of weight tied on it. A 20g weight was tied to the upper side carefully.

The time taken for the upper slide to travel the distance of 7.5 cm and separated away from the lower slider under the influence of the weight was noted. The experiment was repeated for three times and mean time was taken for calculation.

Spread ability was calculated by using the following formula:

S=m×1/t

Where s= Spread ability, m- weight tied to upper slides, l- length of the glass slide, t-time taken in sec

Extrudability

The quantity in percentage sunscreen lotion extruded from tube on application of finger pressure was used as the basis for evaluating sunscreen lotion formulation for extrudability in the current study. Extrudability improved as the quantity extruded increased. The study formulation was placed in a clean, lacquered aluminium collapsible 5 gm tube with a 5 mm nasal tip opening, and pressure was applied to the tube using a finger. The amount of lotion extruded through the tip when a pressure was applied to a tube was then measured to assess tube extrudability.

Irritancy test

Mark an area (1sq.cm) on the left hand dorsal surface. The sunscreen lotion was applied to the specified area and time was noted. Irritancy, erythema, edema, was checked if any for regular intervals up to 24hrs and reported.

Preparation of Sunscreen Sample for SPF Measurement:

200mg of each sample was weighed, transferred to a 100ml volumetric flask, diluted to volume with 50% hexane in ethanol and followed by vigorous vortexting. Then, it is filtered through filter paper, rejecting the first 10ml. A 5 ml aliquot was transferred to 50 ml volumetric flask and diluted to volume with 50% hexane in ethanol. Then a 5 ml aliquot was transferred to a 50ml volumetric flask and the volume completed with 50% hexane in ethanol. Each diluted sample has a final concentration of 20ppm in 50 percent hexane and ethanol. The absorption spectra of samples in solution were obtained in the range of 290-320nm using 1cm quartz cell, and 50% hexane in ethanol as a blank. The absorption data were obtained in the range 290-320 (the range of UVB) every 5nm.

***In-vitro* release studies**

Kiescary chain instrument was used.2gms of cream kept in donor compartment. After the entire cellophane membrane is contact with the receptor compartment containing 22ml of Phosphate buffer pH 6.6.The receptor compartment is stirred continuously at (100rpm) using magnetic stirrer. The temperature maintained at 37± 1 degree centigrade. The surface area is calculated for Diffusion studies 3.14cm sq. for hours. The sample was withdrawn at

30min interval. Same volume was replaced with free Phosphate buffer. Sunscreen lotion containg kiwi extract powder is measured after dilution. Repeat the test for 3 times. Average values are noted. Sunscreen lotion applies on face and body surface applied topically surface tissue of the skin after application of substance. The skin is potentially appendages than through the matrix of stratum, corneum. Diffusion has been established. Dominant Diffusion mode properly into appendages. But occurs of the matrix of stratum, corneum. Penetration of remaining epidermal layer and corneum circulation via capillaries. This is carried by Agar Nutrient medium. Any concentration poured into petri dish a hole was made at the centre lotion was placed on it. Time taken for lotion to diffuse was noted.

Stability studies
Stability testing enables recommended storage settings, re-test intervals, and shelf-lives by predicting how the quality of a drug ingredient or drug product changes over time under the effect of various environmental elements such as temperature, humidity, and light. Observing the rate at which a product degrades under typical room temperature takes a lengthy period in most cases. The ideas of expedited stability investigations are used to avoid this unfavourable delay. The stability test requirements are described in the International Conference on Harmonization (ICH) Guidelines under "stability testing of New Drug Substances and Products" (QIA).

RESULT AND DISCUSSION

Physical analysis:
The prepared sunscreen lotion was visually inspected for the appearance, colour, and texture. All the prepared formulation was white colour, with a smoothness, and they were all homogenous with no signs of phase separation.
Colour : off-white
Odour : Minty
Smoothness :Smooth

pH measurement
pH is one of the major evaluation factors in the sunscreen lotion preparation purpose of avoiding the irritation of the skin upon the application. Using a pH metre, it was discovered that the pH ranges from 6.4 to 6.6, which is basic in nature. The pH should not be too acidic, as this might cause skin irritation, nor should it be too alkaline, as this can result in scaly skin. (The result shown in the Table No .2)

Viscosity
From the result shows viscosity of all the formulations range from (60340) to (68110) cps. F2 Shows a better consistency with viscosity level of 62930 cps.(The result shown in the Table No 3)

Determination of spread ability
The Spreadability of the sunscreen lotion was based upon the viscosity and it was evaluated form all the 5formulations.F2 has better spreadability as compares to other formulation .TheF2 having better consistency so sunscreen lotion was easily spreable by the amount of shear(Table No 4)

Determination of extrudability
The extrudability of the sunscreen lotion was based upon the viscosity, and it was evaluated from all the 5 formulations range from (3.759) to(0.965) gm. The formulation (F2) having better consistency of the cream. (The result shown in the Table No.5)

Irritancy test
From the above result,it was concluded that no irritancy was observed in all formulation.(The result shown in the Table No 9)

Calculations of Solar Protection Factor (SPF):
The absorbance of prepared solutions (20ppm in 50% hexane in ethanol) is measured in the range of 290-320nm, each time of wavelength range is changed by 5nm in each measurement. The Mansur mathematical equation (1) is used to calculate the SPF values of the samples (A-J).

$SPF = CF \times \sum^{320nm} EE(\lambda) \times l(\lambda) \times ABS(\lambda)$

Where: CF is the correction factor (=10), "EE", the erythemal effect of radiation at wavelength; "I", the intensity of the solar spectrum; and "ABS", the absorbance at wavelength 290-320nm. "EE", "I", "ABS" are values obtained or applied for every wavelength. The values for each of the [EE X l]..(The result shown in the Table No 6)

***In-vitro* Release Studies**
The diffusion studies of the formulation results are shown in the table no. 8.8 Drug release of the formulation(F3) after 4^{th} hour is 93.6%

Stability Study
A stability study was carried out for the optimized formulation according to ICH guidelines at 40°C/75 % RH for one month. The results showed no significant change in the physical and chemical parameters of the cream. Hence the formulation (F2) was found to be stable. (The result shown in the Table No 1)

Solubility Studies
Solubility studies were performed by shaking flask method with excess amount of drug added to Methanol, Hexane, Water separately. Solubility levels determined, using UV spectrometric method at 320 nm. The best solubility of sunscreen lotion is obtained using proportion of Hexane and Ethanol.(The result shown in the Table No 8)

CONCLUSION

From the above criteria of base and other excipients the formulation forms the effective, safe and stable preparation for topical administration. The sunscreen lotion formulation using kiwi extract may be effective, cost efficient and easily accessible way to prevent skin infection caused by microbes

ACKNOWLEDGEMENT

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Table.No.1 Formulation of sunscreen lotion

S.NO:	INGREDIENTS	F1	F2	F3	F4	F5
1	Kiwi extract	10gm	10gm	10gm	10gm	10gm
2	Polyphenylene sulphide	10gm	15gm	20gm	25gm	30gm
3	Glycerin	3gm	3gm	3gm	3gm	3gm
4	Wheatgerm oil	2gm	2gm	2gm	2gm	2gm
5	Emulsifying wax	5gm	7gm	9gm	11gm	13gm
6	Titanium dioxide	5gm	5gm	5gm	5gm	5gm
7	Lactic acid	3gm	3gm	3gm	3gm	3gm
8	Sunflower oil	1.5gm	1.5gm	1.5gm	1.5gm	1.5gm
9	Carrot seed oil	2gm	2gm	2gm	2gm	2gm
10	Aloe Vera perfume	1gm	1gm	1gm	1gm	1gm
11	Arjuna tree bark extract	2gm	2gm	2gm	2gm	2gm
12	Water	100	100	100	100	100

Table.No.2 Determination of ph

Formulation No.	P_H range
F1	6.4
F2	6.5
F3	6.4
F4	6.6
F5	6.3

Table. No. 3 Determination of viscosity

FORMULATION	VISCOSITY(CPS)
F1	60340 cps
F2	62930 cps
F3	65506 cps
F4	68110 cps
F5	692330 cps

Table.No.4 Determination of spread ability

Formulation code	spread ability (g.cm/sec)
F1	94.25
F2	90.45
F3	84.66
F4	81.03
F5	79.04

Table.No.5 Determination of extrudability

Formulation code	Extrudability (gm)
F1	3.759gm
F2	2.545gm
F3	1.350gm
F4	1.095gm
F5	0.965gm

Table. NO. 6 Determination of SPF

Wavelength (nm)		290	295	300	305	310	315	320
EE X I	F1	0.0150	0.0812	0.2874	0.3278	0.1864	0.0837	0.0180

Table.NO.7 Determination of In-vitro release drug

S.no	Time (mins)	F1	F2	F3	F4	F5
		% Of drug release				
1	0	0	0	0	0	0
2	15	42.12	40.13	20.15	21.15	15.15
3	30	56.13	57.15	30.55	40.32	26.15
4	45	66.12	67.16	55.15	61.15	38.15
5	60	78.55	75.13	65.19	65.98	56.15
6	120	81.30	84.15	75.13	75.12	65.12
7	240	85.12	89.12	76.70	77.31	74.12

Table. No.8 Determination of solubility studies

Si. No	Solvent Mixtures	Solvent Ratio	Observation
1.	Hexane: Ethanol	2.5:2.5	Good solubility
2.	Hexane: Methanol	2:3	Little solubility
3.	Ethanol: water	1:4	Very little solubility

Table.no.9 Irritancy test measurement

S.NO	FORMULATION CODE	IRRITANCY RESULT
1	F1	No irritancy
2	F2	No irritancy
3	F3	No irritancy
4	F4	No irritancy
5	F5	No irritancy

Table.No.10 Stability Studies

Study	Storage condition	Time period
Long term	24°C±2°C/60%RH±5RH OR 30°C±2°C/65%RH±5%RH	12 months
Intermediate	30°C±2°C/65%RH±5%RH	6 months
Accelerated	40°C±2°C/75%RH±5%RH	1 month

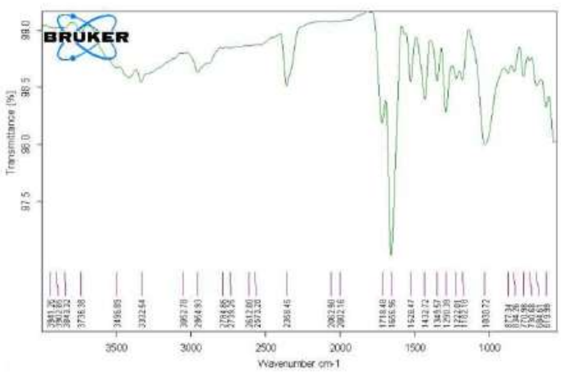

Fig.No.1 ATR-FTIR Spectrum of Kiwi extract

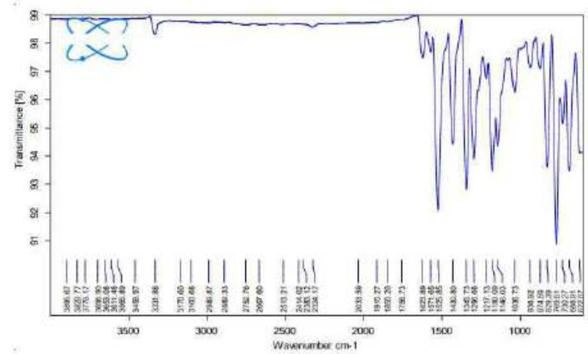

Fig. No. 2 ATR-FTIR Spectrum of sunscreen lotion using kiwi extract

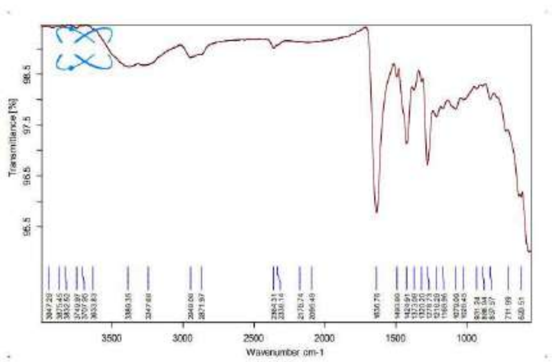

Fig.No.3 ATR-FTIR Spectrum of Glycerine

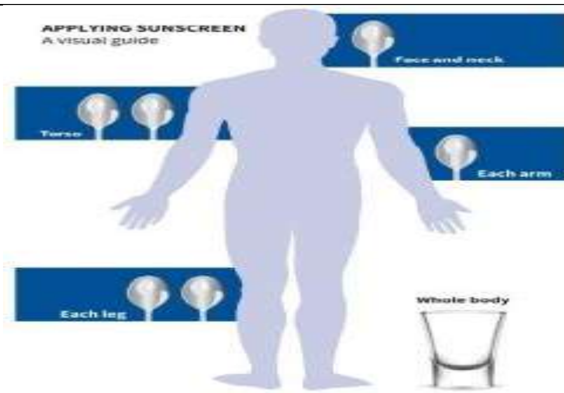

Fig.No.4 Application of sunscreen

RESEARCH ARTICLE

Formulation and Evaluation of Beta Vulgaris Lipstick by using Melt and Pour Method

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ABSTRACT

Colored lips have been bestowed across cultures during the analysis of a historical occurrence. From the past to the present, the need for these products to embellish and look more and more bewitching is increasing day by day. In today's market, the demand for herbal cosmetics is increasing, and people are avoiding less natural gifts. There is a vast array of natural cosmetic products available to meet the demands of women. Lipsticks are a type of cosmetic that is used to improve the appearance of the lips. Lipsticks help to save time and they are simple to apply, and are portable. Nowadays, people do not have a lot of free time. The Amaranthaceae family includes *Beta vulgaris,* a perennial plant. The shape is round and the color is crimson. Fruits are abundant in vitamins A and C, as well as calcium, iron, phosphorus, potassium, protein, and carbs. Beets also include a lot of folate, fibre, and antioxidants. Betalains with betacyanin, a pigment found in beets, are used to make dyes. Betalains are a mixture of a purple pigment (betacyanin) and a yellow pigment (betaphycocyanin) (betaxanthin).

Keywords: Herbal cosmetics, lipstick, natural pigments, formulation and evaluation.

INTRODUCTION

Herbal cosmetics:

Cosmetics are substances that are applied to the human body to improve its appearance. developing and developed countries, skin-care creams, lotions, powders, perfumes, lipsticks, fingernail and toe nail polish, eye and facial makeup, permanent waves, colored contact lenses, hair colors, hair sprays and gels, deodorants, baby products, bath nails, bubble baths, bath salts, butters, and a variety of other products are in high demand [1]. Herbal is a symbol of safety as opposed to synthetic, which has negative consequences for human health. Herbal preparations are such as herbal tablets, tonics, paste, shampoo, sindur, herbal contraceptives, and lipstick have become popular among consumers. Herbal medications are the fastest expanding segment for treating various disorders. Perhaps the vast scale of personal healthcare is unaffordable to many, and they turn to herbal medicine as a result of the increased negative effects of synthetic treatment [2]. Herbal cosmetics are a valuable natural gift that is in high demand all over the world. Herbal cosmetics come in a wide variety of formulations that are quite safe for the skin. Humans have been using herbs for many purposes, such as food, medicine, and enlightenment, but with the advent of science and technology, the usage of natural things such as plants has decreased, save for food, and vegetarians eat exclusively plants. Herbs are, nevertheless, making a comeback as drugs and cosmetics [3].

Dryness of lips:
Lip dryness can be caused by a variety of factors, including the weather, an allergic reaction too our lipstick or lip gloss, dehydration, and nearly anything else. Our lips will mend faster if we use a nice moisturizing lip stick. (Figure No: 1)

Lips chapped:
People get chapped lips for similar reasons as they get lip dryness.
Dehydration, the weather (cold, sitting in an air-conditioned environment for a long time), excessive lip licking (which removes the natural moisture from your lips, drying them out), and even Lips that have been exposed to too much sun might get chapped.(Figure No :2)

Different lip problems:
Lips dryness, cracking, discomfort, numbness, lesions, and swelling are all examples of lip problems. Lip symptoms can be caused by a variety of factors, and the severity of the symptoms varies greatly depending on the reason. Lip difficulties are caused by injuries to the lips, such as biting them or burning them with hot food. Lip symptoms can be caused by even a common infection. Symptoms involving the lips might be linked to diseases or disorders that affect the nerves and muscles, such as nerve injury or neuropathy. Cold and dry weather, infection, nutritional deficits, and pharmaceutical side effects can all cause lip problems. Locally acting on the lips, calming, anti-irritant agents, skin protectants, keratolytic agents, steroids, antibiotics, and anti-inflammatory agents are all good medication choices for medicated lipsticks.

Lipstick:
According to the D&C act of 1940 and rules of 1945, a cosmetic is any substance that is intended to be sprayed, poured, rubbed, or sprinkled on, or introduced into, or applied to the human body or any portion of it for cleansing, beautifying, promoting attractiveness, or altering the appearance. It also includes any articles designed to be used as a cosmetic component. Cosmetics are substances that are applied to the human body to improve its appearance. Herbal cosmetics are becoming increasingly popular on the global market, and they are unavoidable gifts from nature. (Figure No:3) Neutraceutical is cosmetic formulations can be used to treat skin problems while still providing a pleasing appearance. Lipsticks are cosmetic formulations for modifying or accentuating lip color that are made by molding a dispersion of colors in a waxy foundation and forming a stick or crayon form. Lipsticks are used more than any other product in the cosmetics preparation industry. Rather than declining in popularity, they are actually gaining in popularity. There hasn't been a substitute identified to take their place. Lipsticks are a convenient way to add color to your makeup or protect your lips from the effects of cold, dry weather, UV light, and wind. Dry lips, chafed, chapped, cracked lips, ulcers and lesions on lips, sunburn, and other lip disorders are all caused by infection or pollution. Locally acting on the lips are good pharmacological options for nutracuetical lipsticks. Smoothing, anti-irritant, anti-inflammatory and skin-protective agents. Lipsticks were used to make the lips appear more vibrant. Lipsticks, on the other hand, can be used to both color and treat infections of the lips. Because of its anti-irritating,

moisturizing, relaxing, and nontoxic capabilities, beetroot powder was chosen as a medicine of choice for the treatment of skin ulcers, wounds, skin eruptions, and fissures [4].

Lipstick is a cosmetic product used to enhance the appearance of women. Herbal lipsticks are used to provide the lips with a pleasing color, texture, and protection. Waxes, oils, pigments and dyes, alcohol, perfumes, preservatives, antioxidants, hues, and surfactants are all used in lipstick. These lipstick formulations cause no harm to our lips and have no negative side effects. They include color changes, gloss, and the smoothing out of creases and folds on the lips. It is a well-known cosmetic item that comes in a variety of forms, designs, and packaging. Because lipstick has so many benefits, it should be used to protect the lips from drying out and splitting. It hydrates our lips while also brightening our grin. It should be grittiness-free and non-drying, with the required plasticity. Many natural nutrients are present in herbal lipsticks that are good for the lips. It should be free of harmful chemicals such as paraffin, sulfate, phthalate, and others, which is why we use bees wax, beet root powder, olive oil, orange juice, and strawberry essence [5].

Advantages of lipstick:

- **Beauty**: You will instantly feel more gorgeous no matter what sort of lip color you choose (sharp, bold, and dramatic colors, or more natural and subtle shades that can be translucent). If you want to stand out in a crowd, be more gorgeous, or simply improve your confidence, lipstick is the fashion accessory for you.
- **Hydration:** Even though some older lipstick formulas contain chemicals that might drain moisture from your lips, the majority of they are hydration-conscious and designed to keep your lips in their natural state. Some hydrating ingredients, such as vitamin E or aloe vera are commonly featured in new lipsticks.
- **Sunscreen:** Even as early as the early twentieth century, chemists and fashion designers came to the conclusion that sunscreen protection is crucial and that most individuals leave their sensitive lips vulnerable to the sun, even if they protect the rest of their face. Sun protection components were later added to lipsticks, allowing you to protect your lips from the sun, drying, wind, and other harmful and ageing impacts.
- **Posture:** Several studies have found that women who wear lipstick on a daily basis have better posture in their senior years. Women between the ages of 65 and 85 have fewer problems with their posture and balance, thanks to a long and continuous history of standing in front of the mirror and maintaining a healthy posture and body shape [6]

Disadvantages of lipstick:

The following are some of the negative consequences of using low-quality lipsticks on a regular basis:

- **Heavy metal:** Heavy metal is a genre of music that is characterized by According to studies lipsticks have been shown to have high quantities of chromium, cadmium, and magnesium. As a result, you'll be more susceptible to hazardous infections and organ damage. Cadmium can be deposited in the kidneys, eventually leading to renal failure.
- **Lead:** The majority of lipsticks have been found to contain dangerously high levels of lead. Lead is a neurotoxin that has the potential to harm the nervous system. It can also harm the brain. One of the causes of hormone imbalance and infertility is this. Even if only a small amount is consumed, it can have a significant impact on the body.
- **Formaldehyde and Mineral Oil:** Formaldehyde is a preservative that can cause cancer in humans. Other formaldehyde side effects include wheezing, coughing, and eye and skin irritation. Mineral oil is another element used in lipstick that helps to close pores. These compounds are to blame for a lot of the negative consequences of lipsticks.
- **Bismuth oxy chloride and Parafens:** These are two additional substances used in the manufacture of lipsticks. The carcinogenic properties of these two chemicals cause lipsticks to be toxic. Parafens, like formaldehyde, serve as preservatives. Despite the fact that it is used to keep lipstick fresh, it is very hazardous to the human body. " [6]

Good lipsticks should have the following characteristics:

- It should not irritate the skin.
- Plastically, it should have been required.
- It should be stable in terms of both physical and chemical properties.
- It must be non-toxic.
- It should not dry out while being stored.
- It must be devoid of fine particles.
- It should keep the color of your lips for a longer period of time after application.
- It should have a lustrous, silky appearance that is devoid of sweat.
- It should have a pleasant aroma, flavor, and taste.
- It should not melt or harden within a reasonable temperature range [7].

Anatomy of lips:

In lip anatomy, the upper and lower lips are referred to as the labium superiusoris and labium inferiusoris, respectively. (Figure No: 4) The vermilion border is where the lips meet the surrounding skin of the mouth area, and the vermilion zone is the normally reddish area within the borders. Cupid's bow refers to the vermilion border on the top lip. The philtrum is a vertical groove that runs from the procheilon to the nasal septum. Lip skin is exceedingly thin, with only three to five cellular layers, compared to ordinary facial skin, which can last up to 16 years. The skin includes fewer melanocytes when it is light in color (cells that produce melanin pigment, which gives the skin its color). As a result, blood vessels appear through the skin of the lips, giving them a distinctive red tint. This effect is less noticeable with a darker complexion since the skin of the lips contains more melanin and so appears darker. The skin of the lip forms the boundary between the outside skin of the face and the interior mucous membrane of the inside of the mouth .The mandibular prominence, a branch of the first pharyngeal arch, gives rise to the lower lip. It is elevated by labisuperiorisand attached to the lower lip by the thin lip lining, which may be seen by opening your mouth wide in front of a mirror. Two of the facial characteristics of foetal alcohol syndrome, a permanent handicap caused by the intake of alcohol during pregnancy, are the thinned vermilion of the upper lip and the flattery of the philtrum [6]

MATERIALS AND METHODS

Collection of plant material:

The herbs used in the manufacture of herbal lipstick were collected in January 2022, and beetroot was purchased from a local market in Salem.

Powdering sample:

For 6-7 days, beet root slices were shade dried at room temperature. The dried slices were pulverized and stored in a tight container once the moisture content was fully removed.

Color pigment extraction:

Shade dried, closely powdered beet root slices (100g) were macerated separately for 6-7 days. After the extraction was finished, the extract was filtered using Whatman filter paper (No. 10) to eliminate any remaining contaminants. To minimize the amount of the extract, it was vacuum distilled and evaporated in a water bath. It was possible to obtain a dark reddish-brown extract. To eliminate the surplus moisture, the concentrated extract was placed in desiccators. For further research, the dried extract was sealed in an airtight container. Beta vulgaris can be used to make a coloring agent by pressing it separately, filtering and evaporating the juice, and then storing it in an airtight glass container for further research [8].

Pre-formulation studies

Organoleptic properties

The color of the dried plant powder is reddish brown color, aromatic odor and slightly sweet taste. All formulations were reddish brown color and aromatic odor. Physical appearance all of formulation are opaque in nature.

ATR-FTIR Spectra Analysis

The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR-FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample holder.

Compatability Studies

These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wave number region of 4000 to 400cm^{-1}. Drug and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavityof the sample holder and the spectrum was recorded. The study was performed for drug. physical mixture of drug and polymer, separately.

Formulation of herbal lipstick:

Procedure:

Weight all the ingredients individually that are required for the preparation of the herbal lipstick using a digital balance. To prepare the herbal lipstick by using the melt and pour method. In a porcelain dish, weigh all of the ingredients. Put the porcelain dish in water to melt both the bees' wax and the white soft paraffin. Olive oil is regularly mixed with bees' wax and white soft paraffin. Finally, add the acacia to the mixture. Color, antioxidants, and preservatives are also included, as well as orange juice and pigment. Lip moisturizers and white soft paraffin are used. Beetroot extract was used as a pigment. Then, as the new cells form and become smoother, vitamin E was added. As a preservative, strawberry essential oil is used. Then, for a pleasant odor, a perfume was added. Freeze for a few minutes. Remove the top layer with a sharp knife and the stick that came with the mould. Quickly pass the lipstick through the flame to add gloss to the top layer of the lipstick. Conducting an softening temperature test.
Place the lipstick container on the table [9] To optimized formulation concentration of excipient which impact the pH, skin irritation test and appearance was selected beetroot powder and concentration have been varied to the study the impact on pH, skin irritation test and appearance.Five trials were planned and executed in a way to study the impact of single excipients in each formulation by keeping one formulation (F2) optimized formulation. The result shown in the table no:1

Evaluation studies: [10]

In order to maintain a uniform standard for herbal lipstick, the formulated herbal lipsticks were tested for characteristics such as melting point, breaking force of application, and surface abnormalities, among others.

Physical appearance:

Color was checked by eyes against white background, the odor was smelled.

Determination of pH parameter:

The lipstick pH was observed with a digital pH meter by completely immersing the glass electrode in the lipstick to cover the electrode. The measurement was done in triplicate and the average of the three readings was taken.

Determination of Skin irritation test:

Apply he lipstick to the skin for 10 minutes and see what happens.

Determination of Melting point:

Take both ends of the glass capillary tubes and open them. Introduce a sufficient amount of lipstick into each of five capillary tubes, about 10 mm high, and allow the tubes to stand for the required duration, with the temperature in the capillary tube being taken as the melting point. Calculate the result after repeating the operation three times with the other four capillary tubes.

Determination of Breaking point:
The (10 gm) value at a 30seconds interval and the weight at which it breaks. The breaking point test is used to determine the strength of the lipstick. Place lipstick horizontally in a socket about an inch from the support's edge. The breaking point is reached when the weight is increased by a certain amount.

Determination of Force of Application:
This is a test that determines how much force should be used in an application. Keep a piece of coarse brown paper on a shadow graph balance and use a 45*C angle to apply lipstick to a 1 sq. inch area until it is completely coated. The application force is shown by the pressure lead.

Determination of Surface anomalies:
This test for identifying the surface identifies things like no crystal formation on surfaces, no mould or fungus contamination, and so on.

Determination of Perfume stability:
Perfume stability can also be determined by placing lipstick in a 40° oven and performing a pentode comparison with fresh lipstick.

Determination of Aging stability:
Store the product at 40 °C for 1 hour while monitoring variables such as application quality, wax crystallization on the surface, and bleeding.

Determination of short time stability studies:
Beetroot is loaded for stability determination at accelerated stability condition (40^0C/75% RH). It's taken and examined for appearance. pH and skin irritation tests after a certain amount of time (1months). All of these factors are compared to the initial sample and evaluated to see whether it meets the specifications. If itdose, the batch passes the test.

RESULT AND DISCUSSION

Pre-formulation studies:
Organoleptic properties:
In order to maintain a uniform standard for herbal lipstick, the formulated herbal lipsticks were tested for characteristics such as melting point, breaking point, force of application, and surface abnormalities, among others. Color was checked by eyes against white background, the odor was smelled. The result shown in the table no:2

ATR-FTIR Spectra Analysis:
The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR-FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample holder. The result shown in the fig no: 5

Compatability Studies:
These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wave number region of 4000 to 400cm^{-1}. Drug and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavityof the sample holder and the spectrum was recorded. The study was performed for drug. physical mixture of drug and polymer, separately. ATR-

FTIR spectroscopy was fixed at the range of 4000-400cm^{-1}. There is no interaction between drug and Excipients. The result shown in the fig no: 6

Evaluation studies

Physical appearance:

The prepared lipstick was visually inspected for the appearance, color and texture. All the prepared formulation was reddish brown color with smooth texture.

Determination of pH parameter:

The lipstick pH was observed with a digital pH meter by completely immersing the glass electrode in the lipstick to cover the electrode. The measurement was done in triplicate and the average of the three readings was taken. pH is one of the major evaluation factors in the lipstick preparation purpose of avoiding the irritation of the lips upon the application. Formulation of prepared lipstick which indicates the study result of pH ranging from 6.5to6.8. Among this studied formulation F1 TO F5 formulation F2 show pH value of 6.8 which was optimal range compare to rest of these formulation. The result shown in the table No: 3

Determination of Skin irritation test:

Apply he lipstick to the skin for 10 minutes and see what happens. From the above result, it was concluded that no irritation was observed in all formulation. The result shown in the table No: 4

Determination of Melting point: -

Take both ends of the glass capillary tubes and open them. Introduce a sufficient amount of lipstick into each of five capillary tubes, about 10 mm high, and allow the tubes to stand for the required duration, with the temperature in the capillary tube being taken as the melting point. Calculate the result after repeating the operation three times with the other five capillary tubes. The melting point temperature is not measured directly within the substance, but rather outside the capillary tube the results are dependent on the heating rate. All of the formulations suitable melting point for F2. (The result shown in the Table No: 5)

Determination of Breaking point:

A value (30 gm) at a 30 second interval and the weight at which it is breaks. The breaking point test is used to determine the strength of the lipstick. Place lipstick horizontally in a socket about an inch from the support's edge. The breaking point is reached when the weight is increased by a certain amount. The breaking point is not suitable for all formulations. These are one of the best breaking point for F2. (The result shown in the table No: 6)

Determination of Force of Application:

This is a test that determines how much force should be used in an application. Keep a piece of coarse brown paper on a shadow graph balance and use a 45*C angle to apply lipstick to a 1 sq. inch area until it is completely coated. The application force is shown by the pressure lead. The force on application of the lipstick was evaluated from all the 5 formulations F2 has better application on the lips as compare to other formulation. The F2 having better consistency so the lipstick was easily apply by small amount of shear. (The result shown in the table No: 7)

Determination of Surface anomalies:

This test for identifying the surface identifies things like no crystal formation on surfaces, no mould or fungus contamination, and so on. From the above result, it was concluded that no defects was observed in all formulation. (The result shown in the table No: 8)

Determination of Perfume stability:

Perfume stability can also be determined by placing lipstick in a 40° oven and performing a pentode comparison with fresh lipstick. After 30days checked for all formulations, F2 is best smell. (The result shown in the table No: 9)

Determination of Aging stability:

Store the product at 40 °C for 1 hour while monitoring variables such as application quality, wax crystallization on the surface, and bleeding. All of the formulations was checked, F2 is the best smooth on the lips. (The result shown in the table No: 10)

Determination of short time stability studies:

Beetroot is loaded for stability determination at accelerated stability condition (40^0C/75% RH). It's taken and examined for appearance. Force on application, pH and appearance tests after a certain amount of time (1month). All of these factors are compared to the initial sample and evaluated to see whether it meets the specifications. If it dose, the batch passes the test. (The result shown in the s Table No: 11)

CONCLUSION

- In the present study, an attempt was made to develop herbal lipstick to provide coloring for lips.
- The comparison of the ATR-FTIR spectra of beetroot powder and beetroot lipstick using beetroot powder was made F2 confirms that there is no disappearance of the existing peak. This result shows that no degradation or destruction of the betalains is the colored parts. Formulation of beetroot lipstick using beetroot powder which were tested for appearance, pH, melting point, breaking point, skin irritation test, aging stability test and perfume stability test according to ICH guidelines.
- There is no color change on physical compatibility studies and it can be concluded that all the excipients were compatible with beetroot lipstick.
- A stability study was carried out for the optimized formulation according to ICH guidelines at 40°C/75% RH for one month. The results showed no significant change in the physical and chemical parameters of the lipstick. Hence the formulation (F2) was found to be stable.
- From the above criteria of base and other excipients the formulation forms the effective, safe and stable preparation for lips.
- The lipstick formulation using beetroot powder may be effective, cost efficient and easily accessible way to prevent the lip problems.

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Table No: 1 - Formulation Of Herbal Lipstick

S .No	Ingredients	Quantity				
		F1	F2	F3	F4	F5
1.	Bees wax	9.2g	7.2g	8.6g	8.0g	9.0g
2.	White soft paraffin	7.5g	5.6g	7.1g	6.2g	7.6g
3.	Olive oil	10g	5g	8g	7g	6g
4.	Acacia	3g	1g	2g	3g	4g
5.	Beetroot extract	1.5g	1.5g	1.5g	1.5g	1.5g
6.	Orange juice	3g	1g	2g	3g	5g
7.	Vitamin E	3g	1g	2g	2g	3g
8.	Strawberry essence	3g	1g	2g	1g	2g
9.	Perfume	q.s	q.s	q.s	q.s	q.s

Table No: 2 (Organoleptic Properties)

ORGANOLEPTIC PROPERTIES	OBSERVATION
Color	Reddish brown
Odor	Aromatic
Taste	Slightly sweet

Table No: 3 (Determination Of Ph Parameter)

FORMULATION	pH range
F1	6.5
F2	6.8
F3	6.7
F4	6.6
F5	6.7

Table No: 4 (Determination of Skin Irritation Test)

FORMULATION	Skin irritation test
F1	No irritation
F2	No irritation
F3	No irritation
F4	No irritation
F5	No irritation

Table.No:5 (Determination Of Melting Point)

FORMULATION	**Melting point**
F1	59
F2	63
F3	66
F4	65
F5	67

Table.No:6 (Determination of Breaking Point)

FORMULATION	Breaking point
F1	30
F2	35
F3	36
F4	37
F5	36

Table.No:7 (Determination of Force Of Application)

FORMULATION	Force of application
F1	Good
F2	Good
F3	Good
F4	Good
F5	Good

Table.No:8 (Determination of Surface Anomalies)

FORMULATION	**Surface anamolies**
F1	No defects
F2	No defects
F3	No defects
F4	No defects
F5	No defects

Table.No:9 (Determination of Perfume Stability)

FORMULATION	**Perfume stability**
F1	++
F2	+++
F3	++
F4	+
F5	++

Table.No:10 (Determination of Aging Stability)

FORMULATION	Aging stability
F1	Slightly rough
F2	Smooth
F3	Smooth
F4	Smooth
F5	Slightly rough

Table No: 11 (Determination of Short Time Stability Studies)

S. No	Test	Initial	40^{0}c /75%RH for one month
1.	Appearance	Reddish brown	Reddish brown
2.	Force on application	Smooth	Smooth
3.	pH test	6.8	7.0

Figure No: 1

Figure No: 2

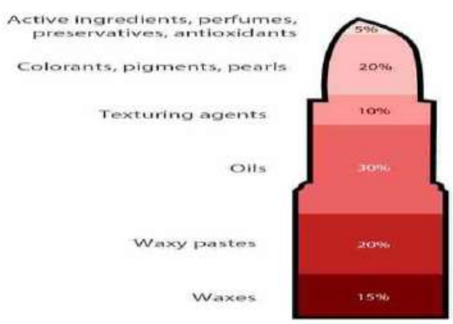


Figure No: 3

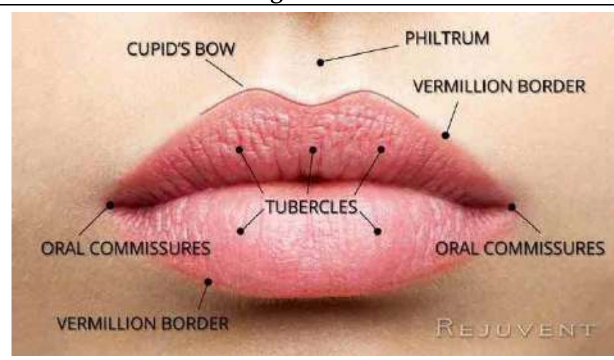
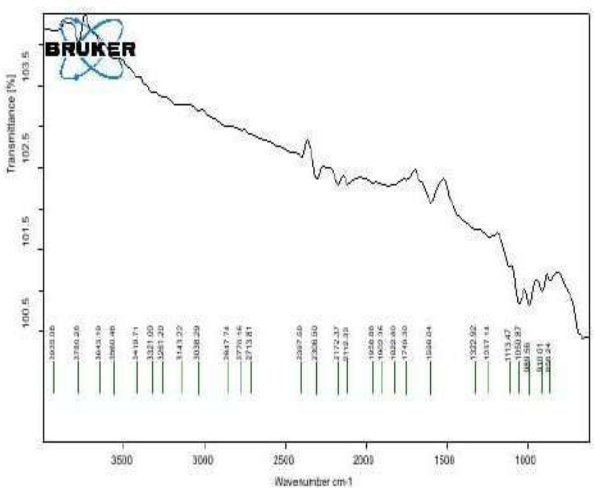
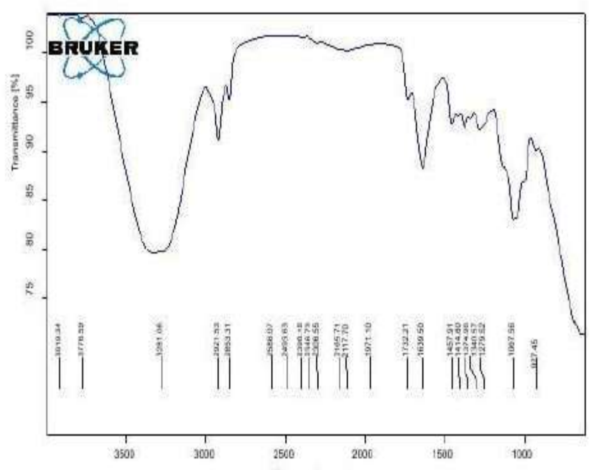


Figure No: 4



ATR-FTIR Beetroot powder (Figure No: 5)



ATR-FTIR of beetroot lipstick (Figure No: 6)

RESEARCH ARTICLE

Preparation and Evaluation of Transdermal Patch of Aspirin by Solvent Casting Method

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ABSTRACT

Transdermal drug delivery systems (TDDS) are dosage forms that involve drug delivery to the epidermal and dermal tissues of the skin for local therapeutic benefit. In contrast, a significant portion of the drug is transferred into the systemic blood circulation. The transdermal medication delivery system's adhesive is crucial to the product's safety, efficacy, and quality. Oral aspirin therapy is well-known for its effectiveness in preventing cardiovascular and cerebrovascular disease secondary. On the other hand, oral administration is frequently accompanied by stomach pain. Transdermal distribution, which avoids the stomach, may be more convenient and safer for aspirin administration, especially for long-term use. This study aimed to create and test transdermal patches by Solvent casting method using aspirin and hydroxy propyl methyl cellulose and ethyl cellulose act as a polymer, polyethylene glycol act as plasticizer, polypropylene glycol act as a penetration enhancer was used to make transdermal patches.

Keywords: Transdermal drug delivery system, Transdermal patch, aspirin, solvent casting method, Matrix-dispersion system, skin.

INTRODUCTION

Transdermal drug delivery systems (TDDS) are dosage forms that release a therapeutically effective amount of medicine through a patient's skin. The skin's full morphological, biophysical, and physicochemical features must be studied to transfer medicinal substances via the human skin for systemic effects. Transdermal administration has an advantage over injectables and oral methods because it improves patient compliance and avoids first-pass metabolism. A transdermal patch is a medicated adhesive patch placed on the skin to deliver a specific dose of medication through the skin and into the bloodstream. Drugs are delivered topically through transdermal patches, absorbed by the skin and absorbed into the bloodstream over time. The amount of medicine administered and the length of time it is worn varies from patch to patch.

Advantage of transdermal drug delivery

1. To begin with, there are biological benefits to drug delivery through the skin:
2. Transdermal administration avoids the stomach environment, where the medicine may degrade and become ineffective or where it may cause the patient to develop unpleasant gastrointestinal symptoms.
3. Transdermal delivery avoids the first-pass effect, in which active medication molecules can be transformed into inactive or even side-effect-causing molecules.
4. Consistent plasma levels are achieved with transdermal medication administration. When a patch is worn for 24 hours or even 7 days, the plasma levels remain constant once a steady state is attained since the rate of drug delivery from the patch is constant. When a medicine is given four times a day, or even once a day, the drug levels rise immediately after administration and gradually fall until the following administration, resulting in peaks and troughs throughout treatment.
5. Therapeutic failure or adverse effects frequently associated with intermittent dosing for chronic diseases can be avoided.
6. Self-administration and removal when required.
7. This non-invasive and safe transdermal route of drug delivery can overcome pain and inconvenience of injections.
8. If a transdermal delivery system is used in place of a needle, then the medical waste can also be decreased, decreasing healthcare costs.

Matrix-dispersion system

The medication is distributed uniformly in this type's hydrophilic or lipophilic polymer matrix. A drug-containing polymer disc is fixed to an occlusive base plate in a compartment made from a drug impermeable backing layer. Instead of placing adhesive on the front of the drug reservoir, a strip of the adhesive rim is formed by spreading it around the circumference.

MATERIALS AND METHODS

Materials

Aspirin was received from Oxford lab fine chem LLP, Maharashtra, HPMC, Ethylcellulose, Polyethylene glycol, Polypropylene glycol, Glycerine, Ethanol were purchased from mercury scientific laboratory salem and the department of a pharmaceutical laboratory, Vinayaka missions college of pharmacy, salem.

Methods

Drug-loaded matrix-type transdermal patches of aspirin were prepared by using solvent casting method. A petri dish with a total area of 10 cm^2 was used. Drugs were accurately weighed and dissolved in 10 ml of ethanol solution and kept aside to form a clear solution. Polymer hydroxypropyl methyl cellulose /ethylcellulose was dissolved in the above solution and mixed until clear solution was obtained. Polyethene glycol (30% W/W of total polymer) was used as plasticizer and propylene glycol (15% W/W of total polymer) was used as a permeation enhancer. 1ml of glycerine was added to the above solution. The resulted uniform solution was cast on the petri dish, which was lubricated with glycerine and dried at room temperature for 24 hours. The amount of drug and excipients used for the transdermal patches is shown in the Table. No:1

organoleptic properties of aspirin:

The organoleptic quality of a drug substance is identified by its appearance, odour, colour, taste, and solubility.
UV spectroscopy

Preparation of standard aspirin solutions:

To Prepare the standard solution of aspirin (1000μg/ml), accurately weighed 10mg of drugs were transferred in 10ml volumetric flasks, dissolved and diluted up to mark with distilled water; from these stock solutions, 1ml aliquots were transferred in 10ml volumetric flasks and were diluted up to mark with distilled water to get working standard solution having a concentration of aspirin 100μg/m.

Standard Calibration Curve For Aspirin

To check the linearity of the method, working standard solutions with a concentration of 20- 50μg/ml of ASPIRIN were prepared from the standard stock solutions of drugs. For this prepared aliquot of 2.0,2.5,3.0,3.5,4.0,4.5 and 5.0ml of standard stock aspirin solutions were transferred to a series of 10 ml volumetric flasks and diluted to mark with ethanol. The absorbance was measured at 221 nm Calibration curves were constructed by plotting absorbance vs concentration.

ATR-FTIR spectra analysis

ATR-FTIR of pure aspirin, Aspirin + HPMC + polyethylene glycol+ polypropylene glycol mixture, aspirin transdermal patches. The spectrum was recorded in the wavelength region of 4000 to 400cm^{-1}. A sample of the drug was directly filled into the cavity of the sample holder, and an IR spectrum was recorded using an ATR-FTIR spectrophotometer

Evaluation parameters of the transdermal patch

Physicochemical evaluation

1.Thickness

The thickness of the drug-loaded patch is measured at several points with a digital micrometre. The average thickness standard deviation is calculated to guarantee that the thickness of the prepared patch is consistent.

2. weight uniformity:

Before testing, the prepared patches must be dried at 60°C for 4 hours. A specified patch area must be cut into different areas and weighed in a digital balance. Individual weights will be used to establish the average weight and standard deviation.

3. percentage moisture content:

The prepared 2x2 films are to be weighed individually and kept in a desiccator containing fused calcium chloride at room temperature for 24 hrs. After 24 hours, reweigh the films and use the formula below to calculate the percentage moisture content.

Percentage moisture content = [Initial weight- Final weight/ Final weight] ×100

4. percentage moisture uptake:

The weighted 2X2 films must be stored in a desiccator at room temperature for 24 hours in a saturated potassium chloride solution. After 24 hours, the films must be reweighted and the percentage moisture uptake calculated using the formula below

Percentage moisture uptake = [Final weight- Initial weight/ initial weight] ×100.

5. folding endurance:

A strip of a certain area must be cut uniformly up to 2cm in length and repeatedly folded at the same location until it breaks. The value of the folding endurance was determined by the number of times the film could be folded in the same location without breaking.

6. percentage elongation break test:

The percentage elongation break is determined by measuring the length shortly before the breaking point and using the formula below to calculate the percentage elongation.

Elongation percentage = (Final length-initial length/ initial length) ×100

Where: L1 is the final length of each strip, and L2 is the initial length of each strip

7. *in vitro* diffusion test

Prepare acetic buffer solution at pH 5.5 and makeup to 1000 ml. Prepare the egg membrane by breaking the top of the egg, then dip the eggshell into hydrochloric acid. After 30 mins, take out the membrane from the acid and wash with distilled water. Fill the prepared patch into the membrane and tie it with thread. Hold and tie the membrane with thread to the double side open burette. Dip the double side open burette (membrane) into the 1000 ml beaker containing 900ml of acetic buffer solution and that is placed in a magnetic stirrer. Set 60rpm and maintain the temperature at 37° C. With the help of a magnetic stirrer, the buffer solution will rotate. Take a sample in a time interval of about 1 to 12 hours. The absorbance of the sample can be determined by using UV spectrometer at 221nm.

RESULT AND DISCUSSION

Organoleptic properties of aspirin: The Preformulation studies were carried out to determine the solubility of aspirin. The sample received for its organoleptic properties such as white crystalline, odor less, bitter taste, and crystalline appearance shows results that comply with reported literature standards. The solubility test showed that aspirin is water-insoluble but soluble in solvents like methanol, ethanol, chloroform and another polar solvent. UV spectroscopy: The results are shown in the Table. No.2 and fig no:1 UV spectral studies authenticate the spectra obtained standard pure drug gave the maximum absorption peak at 221nm and linearity with R2 value of 0.971. ATR-FTIR of pure aspirin, Aspirin +HPMC+ polyethylene glycol+ polypropylene glycol mixture, aspirin transdermal patches. The results are shown in the fig no:2,3 and 4. The comparison of ATR-FTIR spectra of aspirin and a mixture of drug and polymer confirms that there is no appearance of additional new peaks and disappearance of existing peaks from that of the drug. This indicates that there is no interaction between the drug and polymer.

Physicochemical Evaluation Result: The prepared patches was subjected to evaluate the percentage of moisture content, percentage moisture uptake, thickness, percentage elongation break test, folding endurance, *in-vitro* diffusion studies for up to 12 hours are studied. The result are shown in the Table No: 3. The percentage of prepared patches' moisture content ranged from 1.09 to 2.19 % by using HPMC polymer and 5.09 to 6.22% by using ethyl cellulose. The percentage of moisture uptake of prepared patches ranged from 1.78 to 4.34 % using HPMC polymer and 1.07 to 4.76% using ethyl cellulose. The percentage of Elongation break of prepared patches ranged from 42.85 to 56.52% using HPMC polymer and 51.94 to 55.55% using ethyl cellulose. The folding endurance of prepared patch ranged from 2 to 4 using HPMC polymer and 2 to 3 using ethyl cellulose polymer. *In vitro* drug release studies for best formulations –F-5: The result are shown in the Table No:4 and fig.no:2 In vitro release studies of transdermal patches of aspirin were performed formulations 5 in pH 5.5 acetic buffer by egg membrane diffusion method. From the results, in vitro release was found to be controlled in pH 5.5 acetic buffer. Formulations containing HPMC show a drug release 93.81. According to the above data, the drug-containing HPMC polymer shows maximum diffusion.

CONCLUSION

The prepared transdermal patch of aspirin using different grades of HPMC and ethyl cellulose had an HPMC polymer containing formulation shown good promising results for the all evaluated parameters.

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Table. No:1. Formulation of Aspirin Transdermal Patches

S.no	Aspirin (mg)	Hpmc (mg)	Ethyl Cellulose (mg)	Poly Ethylene Glycol (mg)	Poly Propylene Glycol (ml)	Glycerin (ml)	Ethanol (ml)
F-1	30	100	-	30	0.016	1	10
F-2	30	200	-	60	0.028	1	10
F-3	30	300	-	90	0.043	1	10
F-4	30	400	-	120	0.057	1	10
F-5	30	500	-	150	0.072	1	10
F-6	30	-	100	30	0.016	1	10
F-7	30	-	200	60	0.028	1	10
F-8	30	-	300	90	0.043	1	10
F-9	30	-	400	120	0.057	1	10
F-10	30	-	500	150	0.072	1	10

Table. No: 2 Standard Calibration curve data of ASPIRIN:

S.NO	CONCENTRATION (µg/ml)	Mean of Absorbance (At 221nm)
1	2	0.144
2	4	0.207
3	6	0.267
4	8	0.317
5	10	0.380
6	12	0.431
7	14	0.483

Table. No: 3 - Physicochemical Evaluation Result

F. Code	Thickness (MM)	Weight Uniformity (mg)	Percentage Moisture Uptake (%)	Percentage Moisture Content (%)	Percentage Elongation Break Test	Folding Endurance
F-1	0.10	0.10mg	1.78	1.09	42.85	03
F-2	0.11	0.11mg	2.65	2.11	48.71	03
F-3	0.11	0.12mg	3.50	2.33	50.00	02
F-4	0.12	0.12mg	4.34	2.25	53.48	02
F-5	0.12	0.13mg	3.84	2.19	56.52	04
F-6	0.10	0.10mg	1.07	5.09	51.94	03
F-7	0.11	0.11mg	1.87	5.50	51.70	02
F-8	0.11	0.11mg	3.25	6.09	53.48	02
F-9	0.12	0.12mg	3.82	5.72	55.55	03
F-10	0.12	0.11mg	4.76	6.22	55.44	02

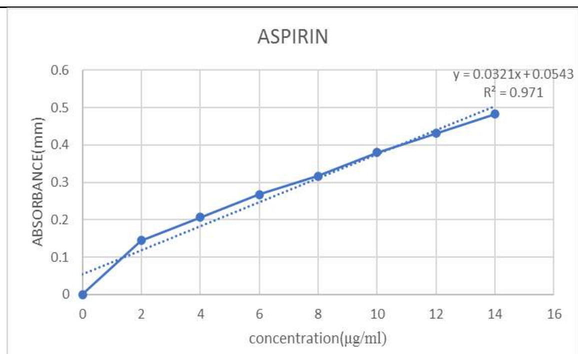

Fig. No: 1- linearity of aspirin:

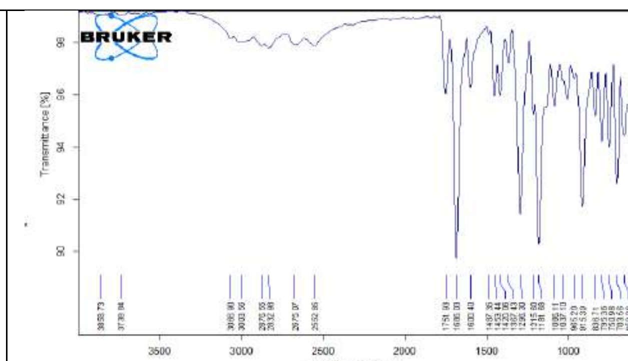

Fig. No: 2. ATR-FTIR of pure aspirin:

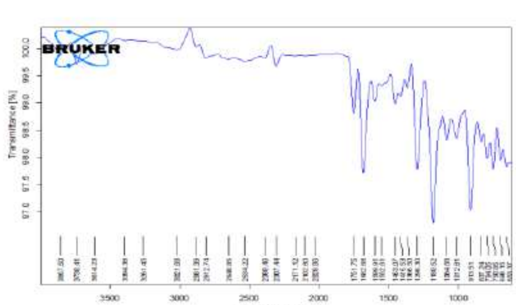

Fig. No: 3-ATR-FTIR of Aspirin +HPMC+ polyethylene glycol+ polypropylene glycol mixture

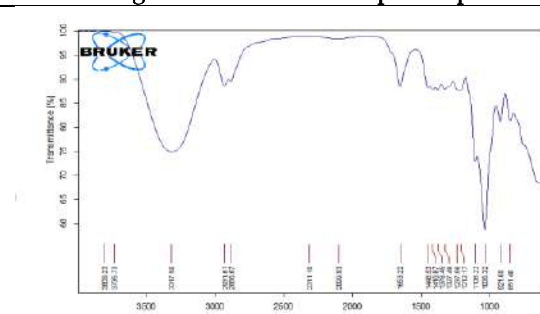

Fig. No: 4-ATR-FTIR of aspirin transdermal patches

RESEARCH ARTICLE

Formulation and Evaluation of Anti-Biotic Cream using Garlic Oil

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ABSTRACT

The primary goal of our study was to create a new cream formulation including garlic oil for the treatment of secondary skin infections. For skin infections, the topical approach is the best option. Because of the numerous advantages over traditional methods of drug administration, the development of topical drug delivery systems with systemic effects appears to be advantageous for a variety of medications. Garlic oil was used to create a new cream composition. In-vitro diffusion tests were performed on the formulation. The developed garlic oil cream was proven to be both safe and effective in the treatment of skin infections.

Keywords: garlic oil, anti-biotic cream ,Diallyl disulfide (DADS), Evaluation parameters.

INTRODUCTION

In recent decades, disease has been treated by administering medications to the human body through numerous routes, such as oral, sublingual, rectal, parental, topical, inhalation, and so on. Topical delivery is defined as the application of a drug-containing formulation to the skin to treat a cutaneous disorder or the cutaneous manifestations of a general disease (e.g., psoriasis) with the goal of containing the pharmacological or effect of the drug to the skin's surface or within the skin. Semisolid formulations in all their varieties dominate the system for topical delivery, but foams, sprays, and medicators are also used [1]. These Topical formulations are used to deliver medications. The underlying skin layer or tissue for localized impact is used as a layer Drugs are designed to be used. Topically, Creams are considered healthy items because they are made utilizing pharmaceutical industry tactics; each non-medicated and medicated cream is utilized to treat a variety of skin disorders. Ayurvedic, herbal, or medically aided lotions have been developed, and individuals utilize them to cure their skin problems. They are made up of one or more drug compounds that have been disseminated in a suitable phase [2] They are divided into two types

Oil-in-Water (O/W) creams

which are made up of small oil droplets spread in a continuous phase, while an oil-in-water (O/W) emulsion is one in which the oil is dispersed as droplets throughout the aqueous phase [3].

Water-in-Oil (W/O) creams

which are made up of microscopic water droplets that are scattered in an oily phase. The emulsion is of the water-in-oil (W/O) type when water is the dispersed phase and oil is the dispersion medium [4]. Since the Vedic era, mankind has used medicinal plant material to heal disease or provide a sufficient treatment for that ailment. It's as if it were said that there isn't a single plant on the planet that isn't medicinal in some way. This demonstrates the significance of a plant or a portion of a plant as a medication, i.e., herbal medicine [5]. The current study's goal is to investigate the medicinal properties of a plant, specifically garlic (Allium sativum). Garlic oil has a wide spectrum of antibacterial properties. Alliin is found in garlic oil, and when garlic cloves are crushed, the enzyme Alliinase converts alliin to allicine, which then generates a variety of sulphide compounds [6]. Allicin, alliin, ajoene, diallyl disulfide, dithiin, and Sallylcysteine are sulfur containing chemicals found in garlic oil. Garlic has a strong odour and flavour due to the enormous quantity of sulphur compounds present. Garlic contains diallyl disulfide, which is a potent antibacterial and antifungal chemical. Garlic is often used as a spice due to its distinct odour and flavour, and it also helps to lower blood pressure and heart problems. Dialyldisulphide is also a medication having broad-spectrum anti-cancer actions, according to study. It has the ability to stop the growth of a variety of tumour cells, including human colon cancer cells, human gastric cancer cells, and human breast cancer cells [7].

MATERIALS AND METHODS

Collection of plant sample

White bees wax, stearyl alcohol, cetyl alcohol, liquid paraffin, Vitamin E, garlic oil ,Propylene glycol, triethanolamine, propyl paraben was collected from the local market, salem

Preformulation studies

Organoleptic properties

A natural substance's organoleptic quality refers to its appearance, odour, colour, and taste. The study's initial stage is to characterise these characteristics, which aids in the primary identification of the Natural substance as well as determining the likelihood of patient acceptability of the raw materials' aroma, taste, and colour, as well as its likely inclusion in the final dose form. Changes in the colour and odour of a formulation's raw material might sometimes signal that the formulation's stability has deteriorated (under identical conditions).

IR Spectra Analysis

These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wave number region of 4000 to 400cm-1.

Drug and excipients compatibility studies

Physical compatibility studies

The physical mixture of drug and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak. Following a weak, the samples are examined for any physical changes such as discoloration, odour, etc.,

Chemical compatibility studies
These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wave number region of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded.

Procedure

Preparation of Cream Formulation
Preparation of oil phase
White bees wax, stearyl alcohol, cetyl alcohol and were melted in a China dish. To this liquid paraffin, Vitamin E and garlic oil were added and allowed to melt. Temperature should be maintained for an oil phase between 65 - 70^0C.(Table no:1)

Preparation of aqueous phase
Propylene glycol, triethanolamine, propyl paraben, water was added in beaker and the temperature of the phase was maintained at 65-70^oC .(table no :2) At 65-70°C, the oil component was gently added to the aqueous phase and mixed for 10 to 15 minutes. When the water and oil phases were at the same temperature, the aqueous phase was gradually added to the oil phase with moderate agitation and mixed until the temperature dropped to 40°C. To make a semisolid cream base, the emulsion was brought to room temperature. Keeping the pH of the cream between 4.5 and 6.4 is important(table no:3).

Evaluation of Formulated Cream

Appearance
The formulated garlic oil cream was visually evaluated for colour, appearance, and transparency. Observing the smoothness, clumping, roughness, and homogeneity of the cream was encouraged by rubbing it between the fingers.

pH Measurement
pH measurement of the cream was carried out using a digital pH meter by dipping the glass electrode completely into the cream system to cover the electrode. The measurement was done three times, with the average of the three measurements being recorded.

Viscosity
Brook field Viscometer LVD was used to measure the viscosity of prepared creams using spindle S 94 at various speeds and shear rates. The measurements were made in 60 seconds between two successive speeds as equilibration with shear rates ranging from 0.20 s1 to 1.0 s-1 over a speed range of 0.10, 0.20, 0.30, 0.40, and 0.50 rpm. The viscosity tests were carried out at room temperature.

Spread ability
Two sets of standard-sized glass slides were taken. One of the slides was covered with the garlic cream mixture. The cream was sandwiched between the two slides in an area filled by a distance of 7.5 cm along the sides after the other slide was placed on top of it. A 100g weight of cream was placed on the upper slides and squeezed uniformly between the two slides to form a thin coating. The weight was secured to a stand in such a way that only the upper slides were able to slip off freely due to the force of the weight linked to it. A 20g weight was carefully fastened to the upper side. The time taken for the upper slide to travel the distance of 7.5 cm and separated away from the lower slider under the influence of the weight was noted. The experiment was repeated for three times and mean time was taken for calculation.
Spread ability was calculated by using the following formula:
$S=m\times1/t$

Where s= Spread ability, m- weight tied to upper slides, l- length of the glass slide, ttime taken in sec.

Extrudability

The quantity in percentage cream extruded from tube on application of finger pressure was used as the basis for evaluating cream formulation for extrude ability in the current study. Extrude ability improved as the quantity extruded increased. The study formulation was placed in a clean, lacquered aluminium collapsible 5 gm tube with a 5 mm nasal tip opening, and pressure was applied to the tube using a finger. The amount of cream extruded through the tip when a pressure was applied to a tube was then measured to assess tube extrude ability.

Irritancy test

Mark an area (1sq.cm) on the left hand dorsal surface. The cream was applied to the specified area and time was noted. Irritancy, erythema, edema, was checked if any for regular intervals up to 24hrs and reported.

Removal

The ease of removal of the cream applied was examined by washing the applied part with tap

***In-vitro* Diffusion Studies**

Kiescary chain instrument was used.2gms of cream kept in donor compartment. After the entire cellophane membrane is contact with the receptor compartment containing 22ml of Phosphate buffer pH 6.6.The receptor compartment is stirred continuously at (100rpm) using magnetic stirrer. The temperature maintained at 37± 1 degree centigrade. The surface area is calculated for Diffusion studies 3.14cm sq. for hours. The sample was withdrawn at 30min interval. Same volume was replaced with free Phosphate buffer. Cream containing garlic oil is measured after dilution. Repeat the test for 3 times. Average values are noted. Cream applies on body surface applied topically surface tissue of the skin after application of substance. The skin is potentially appendages than through the matrix of stratum, corneum. Diffusion has been established. Dominant diffusion mode properly into appendages. But occurs of the matrix of stratum, corneum. Penetration of remaining epidermal layer and corneum circulation via capillaries. This is carried by Agar Nutrient medium. Any concentration poured into petri dish a hole was made at the centre cream was placed on it. Time taken for cream to diffuse was noted.

Stability studies

Introduction

The time from the date of manufacture and packaging of the formulation until its chemical or biological activity is not less than a set level of labelled potency and its physical properties have not altered considerably or negatively can be characterized as the stability of a medicine. The stability of the active component must be a major consideration in selecting whether or not to accept or reject dosage forms for medications in any design or evaluation.

Objectives of the study

Stability testing enables recommended storage settings, re-test intervals, and shelflives by predicting how the quality of a drug ingredient or drug product changes over time under the effect of various environmental elements such as temperature, humidity, and light. Observing the rate at which a product degrades under typical room temperature takes a lengthy period in most cases. The ideas of expedited stability investigations are used to avoid this unfavorable delay. The stability test requirements are described in the International Conference on Harmonization (ICH) Guidelines under "stability testing of New Drug Substances and Products" (QIA).

RESULT AND DISCUSSION

Pre-formulation studies

Organoleptic properties

The present study was carried out to develop Anti-microbial cream by using garlic oil. Assessment of the physical description /organoleptic property of the drug is the primary step for drug substance recognition. It helps to check the feasibility of drug for formulating into the intended dosage form. This also helps in assessing the patient acceptability factors such as colour, nature, odour, and taste which eventually leads to better patient compliance.

Garlic oil

Colour- brownish-yellow colour

Odor- pungent

Taste - bitter burnt garlic

The color, odor, nature and taste of the API were evaluated and it was observed as specified in the monograph. Based on the observation it was found satisfactory for the formulation of cream and no discomfort likely to arise in patient compliance.

IR- Spectra Analysis

ATR-FTIR spectrum of pure drug and prepared cream was compared to study of drug with the excipients and the spectrum was recorder in the wave number region of 4000 to 400cm^{-1}(fig no:1).

Compatibility Studies

Physical compatibility studies

From the study of physical compatible, it can be confirmed, there is no colour changes occurs in the physical mixture and it can be concluded that all the excipients were compatible with garlic oil. The compatibility study was performed at 40^{O}C/75%RH and found that excipients don't have interaction with garlic oil.

Chemical compatibility studies

ATR-FTIR spectrum of pure drug and prepared cream was compared to study of drug with the excipients and the spectrum was recorder in the wave number region of 4000 to 400cm^{-1}. According to functional category these excipients were mixed in garlic oil. This indicates that the drug is compatible with the formulation components. ATR-FTIR spectroscopy was fixed at the range of 4000-400cm^{-1}. There is no interaction between the drugs and excipients. physiochemical parameters evaluation of cream formulation. (The result shown in the fig no:2)

Appearance

The prepared cream was visually inspected for the appearance, colour, and texture. All the prepared formulation was white colour, with a smooth texture, and they were all homogenous with no signs of phase separation.

pH measurement

Using a digital pH meter, pH measurements of the prepared cream were taken by immersing the glass electrode entirely into the cream system and covering it. pH is one of the major evaluation factors in the cream preparation purpose of avoiding the irritation of the skin upon the application. Using a pH meter, it was discovered that the pH ranges from 6.4 to 6.6, which is basic in nature. The pH should not be too acidic, as this might cause skin irritation, nor should it be too alkaline, as this can result in scaly skin. (The result shown in the table no:4)

Determination of viscosity

The viscosity of formulated creams was measured by Brook field Viscometer LVD using spindle S 94 at varying speed and shear rates. The measurements were done over the range of speed setting from 0.10, 0.20, 0.30, 0.40 and 0.50 rpm in 60s between two successive speeds as equilibration with shear rate ranging from 0.20s-1 to 1.0 s-1. From the result shows viscosity of all the formulations range from (66500) to (68500) cps. F3 Shows a better consistency with viscosity level of 67506 cps. (The result shown in the table no:5)

Determination of Spread ability

The Spread ability of the cream was based upon the viscosity and it was evaluated form all the 4 formulations. F3 has better spread ability as compares to other formulation .The F3 having better consistency so the cream was easily spreadable by the small amount of shear. (The result shown in the table no:6)

Extrudability

The extrudability of the cream was based upon the viscosity, and it was evaluated from all the 5 formulations range from (1.759gm) to (2.545 gm) gm. The formulation (F3) having better consistency of the cream. (The result shown in the table no:7)

Irritancy test

Mark an area (1sq.cm) on the left-hand dorsal surface. The cream was applied to the specified area and time was noted. Irritancy, erythema, edema, was checked if any for regular intervals up to 24hrs and reported. From the above result, it was concluded that no irritancy was observed in all formulation. (The result shown in the table no:8)

Removal

The ease of removal of the cream applied was examined by washing the applied part with tap. All formulation was easily removed with normal water.

In-Vitro Diffusion Studies

The diffusion studies of the formulation results are shown in the table no. 8.6 Drug release of the formulation(F3) after 4^{th} hour is 92.7%

Stability Study

A stability study was carried out for the optimized formulation according to ICH guidelines at 40°C/75 % RH for one month. The results showed no significant change in the physical and chemical parameters of the cream. Hence the formulation (F3) was found to be stable

CONCLUSIONS

- In the present study, an attempt was made to develop anti-biotic cream to provide an effective treatment against microbes using garlic oil.
- The comparison of the ATR-FTIR spectra of garlic oil and antibiotic cream using garlic oil was made.F3 confirms that there is no disappearance of the existing peak. This result shows that no degradation or destruction of the phytoconstituents of Diallyl disulfide (DADS) which involves in anti-biotic activity.
- Formulation of Anti-biotic cream using garlic oil, which were tested for appearance, pH, viscosity, spreadability, extrudability, removal test, and stability according to ICH guidelines.
- There is no colour change on physical compatibility studies and it can be concluded that all the excipients were compatible with garlic oil.
- In-vitro drug release was found to be controlled in pH 7.4 phosphate buffer. Formulation (F3) shows drug release of 92.7%.On observation for 3months,no significant variation was observed and the formulation was clear.
- A stability study was carried out for the optimized formulation according to ICH guidelines at 40°C/75 % RH for one month. The results showed no significant change in the physical and chemical parameters of the cream. Hence the formulation (F3) was found to be stable.
- From the above criteria of base and other excipients the formulation forms the effective, safe and stable preparation for topical administration. The cream formulation using garlic oil may be effective, cost efficient and easily accessible way to prevent skin infection caused by microbes.

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Table.no:1 List of oily phase excipients

S.NO	INGREDIENTS	MANUFACTURER/SUPPLIER
1	White bees wax	VMCP, Salem
2	Ceta Stearyl alcohol	VMCP, Salem
3	Cetyl alcohol	VMCP, Salem
4	Liquid paraffin	VMCP, Salem
5	Vitamin E	Local market
6	Garlic oil	ALLIN EXPORTERS

Table.no:2 list of Aqueous phase excipients

S.NO	INGREDIENTS	MANUFACTURER/SUPPLIER
1	Propylene glycol	VMCP, Salem
2	Triethanolamine	VMCP, Salem
4	Propyl paraben	VMCP, Salem
5	Water	VMCP, Salem

Formulation development of anti-biotic cream using garlic oil

Table.no:3 composition of anti-biotic cream using garlic oil

S.NO	INGREDIENTS	F1	F2	F3	F4
1	Garlic oil	10ml	10ml	10ml	10ml
2	White bees wax	20mg	20mg	20mg	20mg
3	CetaStearyl alcohol	4mg	4mg	4mg	4mg
4	Cetyl alcohol	3mg	6mg	9mg	12mg
5	Paraffin	5ml	5ml	5ml	5ml

6	Vitamin E	0.3ml	0.3ml	0.3ml	0.3ml
7	Propylene glycol	7ml	7ml	7ml	7ml
8	Triethanolamine	0.50ml	1.0ml	1.5ml	2.0ml
9	Propyl paraben	0.5mg	0.5mg	0.5mg	0.5mg
10	Water	Upto 100	Upto 100	Upto 100	Upto 100

Table.no.4 pH measurement

FORMULATION	pH
F1	6.5
F2	6.6
F3	6.5
F4	6.4

Table.no.5 viscosity measurement

FORMULATION	VISCOSITY(CPS)
F1	60340 cps
F2	62930 cps
F3	67506 cps
F4	70110 cps

Table.no.6Spreadability measurement

Formulation code	Spreadability (g.cm/sec)
F1	94.25
F2	90.45
F3	88.66
F4	85.03

Table.no.7 Extrudability measurement

Formulation code	Extrudability (gm)
F1	1.759gm
F2	2.545gm
F3	2.350gm
F4	1.950gm

Table.no.8 Irritancy test measurement

S.NO	FORMULATION CODE	IRRITANCY RESULT
1	F1	No irritancy
2	F2	No irritancy
3	F3	No irritancy
4	F4	No irritancy

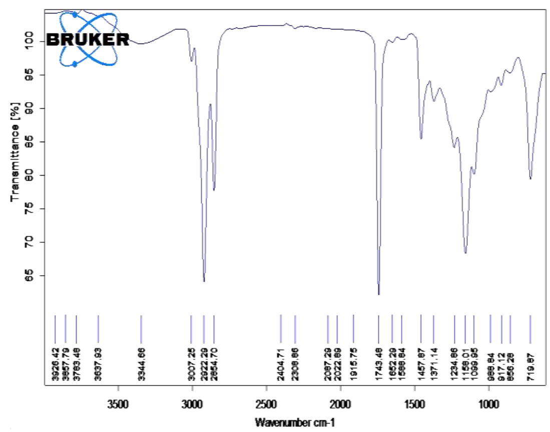

Fig.no:1 ATR-FTIR spectrum of garlic oil

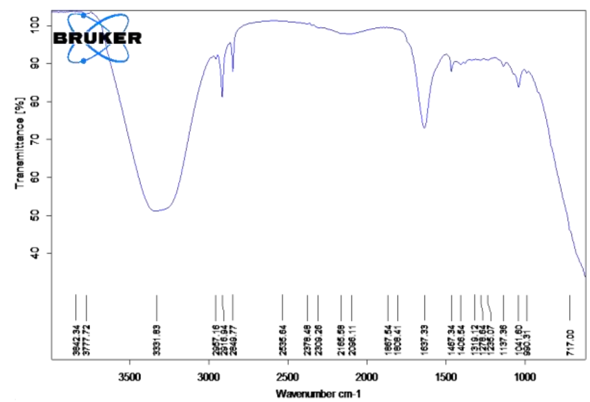

Fig.no:2 ATR-FTIR spectrum of anti-biotic cream using garlic oil

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RESEARCH ARTICLE

Formulation and Evaluation of Bombax Ceiba Gel for Acne Vulgaris

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ABSTRACT

The aim of the study is to formulate and evaluate Bombax ceiba gel containing bombax ceiba flower powder .The flower of bombax ceiba are traditionally used as home remedy in the treatment of jaundice and spleen enlargement ,acne ,skin whitening ,body weakness etc .Bombax ceiba gel was prepared by using Carbopol (Binding agent) and triethanolamine (Gelling agent),Tween 80 (stabilizer) as a major compound .These gel formulation of all batches were evaluated for physical appearance ,drug content ,pH ,viscosity ,in-vitro studies .The result of FTR analysis indicate that the characteristic peaks of the drug ,bombax ceiba are unaltered and hence it was concluded that the drug and excipient were compatible. The study indicates that bombax ceiba gel can effectively treat the acne vulgaris due to the presence of quercetin in the bombax ceiba flower which act as aAntioxidant, Anti-inflammatoryagent. these formulations also contain β sito sterol and kaempferol and trace of essential oil, which act as anti-aging properties

Keywords: Carbopol, Triethanolamine, Tween80, Bombaxceiba, formulation and evaluation

INTRODUCTION

Topical medication delivery is a popular way of treating both local and systemic inflammation, such as dermatological illnesses [1-3]. Topical administration has a number of advantages over traditional dosing forms, particularly in terms of avoiding major systemic side effects [4].The skin is the body's largest organ, consisting of fat, minerals, and protein, and accounts for roughly 15% of total adult body weight. It serves a variety of important roles, including physical protection include chemical and biologic agents, as well as the prevention of excessive water loss[5]. Gelare a semi-solid homogenous preparation that is more hydrophilic in nature, allowing for rapid release of the drug or active component. A gel is a two-part, three-dimensional cross-linked material with a substantial proportion of liquid medium that forms a stiff network that immobilises the liquid continuous phase [6,7]. Inorganic particles and organic macromolecules both are used to form a structural network of gel [8]. Acne vulgaris is a long-term skin disease that develops when the hair follicles become clogged with dead skin cells and oil released by the skin. Blackheads or whiteheads, pimples, and oily skin are all signs of this condition. Acne vulgaris is a complex skin disease that affects more than 85 percent of young people worldwide.Although acne is most common during puberty and worsens throughout adolescence, epidemiological studies suggest that it can occur at any age [9]. Acne is divided into two categories based on the type of lesion. They can be both inflammatory and non-inflammatory [10]. Bombax ceiba flower is crimson in colour and has bitter action, acrid culling, dry astringent to the bowel, anti-inflammatory action, removes bile and phlegm from the body, purifies the blood, is beneficial to the spleen, and has a good response to leucorrhoea. These flowers are also used for skin affections such as acne. The flower of the bombax ceiba contains important compounds such as β-sitosterol, kaempferol, quercertine, essentialoil[11] The flower of bombax ceiba are traditionally used as home remedy in the treatment of jaundice and spleen enlargement ,Anti proliferative agent[12].

MATERIALS AND METHODS

Preformulation studies:

Organoleptic Properties:

The organoleptic quality of a medicinal item refers to its appearance, odour, colour, and taste. The first stage of the study is to characterise these features, which aids in the primary identification of the drug ingredient as well as estimating the possibility of patient acceptability of the raw material's odour, taste, and colour, as well as its probable inclusion in the final dose form. Changes in the colour and odour of the raw material in the formulation may sometimes indicate changes in the formulation's stability (identical conditions).

IR Spectral Analysis :

In the wavelength range of 4000 to 400 cm-1, the spectrum was captured. An IR spectrum was obtained using an ATR-FTIR spectrophotometer by immediately pouring a sample of dried plant powder into the sample holder's cavity.

Compatibility Studies

The spectra were obtained in the wavenumber range of 4000 to 400 cm-1 in these compatibility investigations, which were conducted using an ATR-FTIR spectrophotometer. The spectrum was recorded after placing a gel containing Bombax ceiba powder in the sample holder's cavity.

Procedure

Preparation of gel containing Bombax ceiba

- Add 3 gm of drug to prepare for the oil drug phase.2.5gm of HPMC (polymer) and 0.1gm of tween 80 are used as stabilizers, and they are dissolved in glycerol.
- To prepare the aqueous phase, the phase has 3gm of Carbopol dissolved in 100ml of water with continuous stirring with heat. This drug-containing phase is sonicated in an ultrasonic bath sonicator.
- The drug phase is added drop by drop into the aqueous phase during homogenization to form an o/w emulsion.
- The emulsion is converted into droplets by homogenization. Homogenization was continued for one hour. Triethanolamine is added to form the gel with continuous stirring to form a gel.
- As a result, a gel containing Bombax ceiba was created. (The result shown in the table no:2)

Evaluation Of Bombax Ceiba Gel

Appearance:

The colour, look, and transparency of the prepared gel were all assessed visually. By rubbing the formulation between the fingers and observing the smoothness, clumping, and roughness, the smoothness of the gel was promoted.

pH Measurement

The pH of all formulations was measured using a digital pH metre at 25 + 0.5o C following calibration with standard buffer solutions of pH 4, 7, and 9, and the results were recorded

Viscosity Measurement:

Rheological tests were conducted using a Brookfield Synchro-Lectic Viscometer (Model RVT) with a Helipath Stand. The sample (50 g) was placed in a beaker and allowed to equilibrate for 5 minutes before using a T-D spindle to measure the dial reading at 10, 20, 30, 50, 60, and 100 rpm. The appropriate dial reading on the viscometer was noted at each speed. The spindle speed was gradually reduced, and the resulting dial reading was recorded. At room temperature, three measurements were taken in duplicate. The viscosity in centipoises was calculated by multiplying the dial readings by the variables listed in the Brookfield Viscometer catalogue (CPS).

Spreadability:

We chose two clean glass slides with conventional dimension 100 gm was placed upon the upper slid and gel between two slides is pressed uniformly in form a thin layer. the two slides in position were then fixed to a stand (atangle45) without any disturbance and in such a way that only the lower slide was held finally by the clamp allowing the upper slide to travel a distance of 0.5 cm under the direction of weight which was noticed. the weight was removed and excess of gel adhering to the slide was scrappedoff. The experiment was repeated and mean times taken for three such determination were calculated Spreadability was calculated by using the following formula

$S=m\times 1/t$

Where s= Spreadability, m- weight tied to upper slides, l- length of the glass slide, t-time taken in sec.

Extrudability:

The method used to assess the extrudability of gel formulations was based on the amount of gel extruded from the tube as a percentage when a specific load was applied. The greater the quantity extruded, the better the extrudability. The mixtures were placed in a clean, lacquered, one-ounce collapsible tube with a 5 mm aperture. After that, it was fastened in place between two glass slides. When a steady load of 1 kg was applied to the slides, the gel extruded was collected and weighed. Extrudability was measured by weighing the amount of gel extruded through the tip. It was computed how much gel was extruded. It is noted that the formulas have different extrudability.

***In vitro* studies**

The Kiescary chain instrument was employed in this study. In the donor compartment, 2 gm of gel are maintained. After the entire cellophane membrane has come into contact with the receptor compartment, which contains 22ml of phosphate buffer pH 6.6. Using a magnetic stirrer, the receptor compartment is continually swirled at (100rpm). The temperature was kept at 37 degrees Celsius. For diffusion investigations, the surface area is calculated to be 3.14cm sq. for hours. The samples were taken every 30 minutes. The free phosphate buffer was used to replenish the same volume. After dilution, bombax ceiba gel containing bombax ceiba flower powder is measured. Repeat the test three more times. The averages are noted. After applying the material, Bombax ceiba gel is applied topically to the skin's surface tissue on the face and body. Through the matrix, the skin has the capacity to become appendages. However, the stratum matrix, corneum, occurs. Capillary penetration of the residual epidermal layer and corneum circulation agar A nutrient medium is used to carry this out. A hole was cut in the centre of any concentration poured into a petri dish, and gel was applied to it. The time it took for the gel to disseminate was recorded.

Stability studies:

Stability testing predicts how the quality of a medication ingredient or drug product changes over time as a result of numerous environmental factors like temperature, humidity, and light. This allows for optimal storage settings, re-test intervals, and shelf-lives. In most circumstances, observing how quickly a product degrades at room temperature takes a long time. To avoid this unfavourable delay, the concept of rapid stability investigations is applied. The stability test requirements are detailed under "stability testing of new drug substances and products" in the International Conference on Harmonization (ICH) Guidelines (QIA) (Table no :02) The present work stability study was carried out for the optimized formulation at 40ºC±2ºC/75%RH±5%RH for one month

RESULT AND DISCUSSION

Result

Organoleptic properties

The goal of this research was to make a gel out of Bombax ceiba powder. The physical description or organoleptic property of the drug is the first stage in drug substance recognition. It assists in determining if a medicine can be formulated into the desired dose form. This also helps to determine patient acceptability characteristics, including colour, nature, aroma, and taste, which leads to better patient compliance. (Table.No:03)

IR- Spectra Analysis

The ATR-FTIR spectrum of the crude drug and the manufactured gel was compared to the study of the drug with excipients, and the spectrum was recorded in the wave number range of 4000 to 400 cm^{-1} (The result shown in the Figure.no:1)

Compatibility studies

To analyse crude drugs with excipients, the ATR-FTIR spectra of crude drugs and produced gel were compared, and the spectrum was recorded in the wave number range of 4000 to 400cm-1. The dried plant powder was combined according to functional category and showed no damage or deterioration with the excipients utilised. This means that the medicine is compatible with the other ingredients in the formulation. ATR-FTIR spectroscopy was fixed at the range of 4000-400cm-1. There is no interaction between the drugs and excipients. (The result shown in the Figure.no:2)

Composition of formulation table

To optimized formulation concentration of excipient which impact the stabilitythickening, gel forming capacity was selected Carbopol, HPMC,Triethanolamine concentration have been varied to the study the impact on stability, thickening, gel forming capacity. Four trials were planned and executed in a way to study the impact of single excipient in each formulation by keeping one formulation (F3) optimized formulation. (The result shown in the table no:1)

Evaluation studies

AppearanceThe look, colour, and texture of the prepared gel were all visually checked. All of the formulations were odourless and light brown in colour. All formulations have a hazy physical appearance.

Colour: Light brownish colour

Odour: Unpleasant odour

Smoothness: Good

Determination Of pH

After an appropriate dilution with distilled water, the pH of the four gels was evaluated using a pH metre. pH of all formulations was found to be between 5 to 6.0 that is within the range, which are presented in Table no: 8.2. The Ph of all formulations is basic in nature’s skin friendly that does not cause any irritation. (The result shown in the table no: 2)

Viscosity

A Brookfield viscometer was used to determine the viscosity of the F1, F2, and F3 and F4 gels. Viscosity of all the formulations was noted the result shows range from (0.110) to (0.870) cps. F3 Shows a better consistency with viscosity level of 0.894 cps. (The result shown in the table no: 3)

Spreadability

The spreadability of the gel was determined by its viscosity and was evaluated across all four formulations. When compared to other formulations, F3 has superior spreadability. Because the F3 had a better consistency, the gel could be easily spread with a small amount of shear. (The result shown in the table no: 4)

Determination Of Extrudability

(Table no: 08) Discussion: The extrudability of the gel was based upon the viscosity and it was evaluated from all the formulations.The formulation (F3) having better consistency of the gel formulation. (The result shown in the table no: 5)

***In vitro* diffusion studies**

The diffusion studies of the formulation results are shown in the table no.06 Drug release of the formulation(F2) after 4th hour is 91.3%. (The result shown in the table no: 6)

4.5.7- Stability StudiesThe optimised formulation was subjected to a one-month stability assessment at 40 °C and 75 percent RH in accordance with ICH requirements. The nanogel's physical and chemical properties did not alter considerably as a result of the research. As a result, it was determined that the formulation (F3) was stable. (The result shown in the table no: 7)

CONCLUSION

In the present research work an attempt was made to develop gel containing dried powder of *Bombax ceiba* in the base triethanolamine.involves in the antiacne thearpy. In this gel preparation Carbopol.triethanolamine tween 80, glycerin, HPMC. are used HPMC is used as polymer and emulsifying agent. carbopol is used as stabilizing agent and thickening agent. Triethanolamine is used as gelling agent. Tween 80 is used as surfactant, anti-oxident, buffer, anti-coagulant. Glycerol is used as a solvent stabiliser, ethanol is also a solvent The comparison of the ATR-FTIR spectra of *Bombax ceiba* Powder and mixture of power with polymer which confirms that there is none interaction between compounds and there is no disappearance of the existing peak. This result in no degradation or destruction of the phytoconstituents of Bombax ceiba.specifically, beta-sitosterol, quercertine, trace of essential oil kaempferol and on observation of fingerprint region which involves in Anti acne process. From the above criteria of base and other excipients the formulation forms the effective, safe and stable preparation for topical administration From these, it is concluded that gel containing *bombax ceiba.* in the form of powder achieves a stable, safe and harmless preparation which is usefull in the Anti acne therapy.

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The authors are thankful to Dr. B.Jaykar, Professor and Registrar, Vinayaka Mission's Research Foundation (Deemed to be University) and Vinayaka Mission's College of Pharmacy, Salem, Tamil Nadu for extending their support and facilities for this research.

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Table No:1 -Composition Of Formulation Table

COMPOSITION	F1	F2	F3	F4
Bombax ceiba	3 gm	3 gm	3 gm	3gm
HPMC	4.5gm	3.5 gm	2.5 gm	1.5 gm
Tween 80	0.1 gm	0.1 gm	0.1 gm	0.1 gm
Glycerol	5 gm	10 gm	15 gm	12 gm
Carbopol	8gm	6 gm	4 gm	2 gm
Triethanolamine	4 gm	3 gm	2 gm	1 gm
Water	100 gm	100 gm	100 gm	100 gm

Table.No:2 Bombax Ceiba Gel With pH

Formulation.No:	pHvalue
F1	5.2
F2	5.6
F3	6.0
F4	5.8

Table.No: 3 Bombax Ceiba Gel With Viscosity

BOMBAX CEIBAGEL	VISCOSITY
F1	0.110cps
F2	0.989 cps
F3	0.894 cps
F4	0.870 cps

Table No:4 Spreadability Of The Gel Preparation

Formulation code	Spreadability(g.cm/sec)
F1	81.22(g.cm/sec)
F2	85.42(g.cm/sec)

F3	89.34 (g cm/sec)
F4	95.62(g.cm/sec)

Table No: 5 Extrudability Measurement

Formulation code	Extrudability
F1	0.521 gm
F2	1.321 gm
F3	1.879 gm
F4	2.121 gm

Table No :6 In-Vitro Drug Release

S. NO	TIME (MINS)	FORMULATION CODE			
		F1	F2	F4	F5
		% Of Drug release			
1	0	0	0	0	0
2	15	23.5	26.3	30.1	40.2
3	30	28.3	30.1	38.9	55.3
4	45	36.2	38.9	46.3	58.1
5	60	40.1	49.2	58.3	66.3
6	90	53.2	55.2	66.9	70.1
7	120	64.2	68.9	75.9	80.2
8	150	72.6	78.2	83.8	89.2
9	180	86.3	88.2	91.5	91.3

Table. No:7 stability parameter of selected formulation

PARAMETERS	INITIAL	AFTER ONE MONTH 40/75(°C/ RH)
Appearance	Ligjt brown colour	light brown colour
Feel on Application	Smooth	Smooth
Ph	6.5	6.4
Viscosity	0.894cps	0.870cps
Spreadability	95.35(g.cm/sec	97.22 g.cm/sec
Extrudability	1.579	1.497

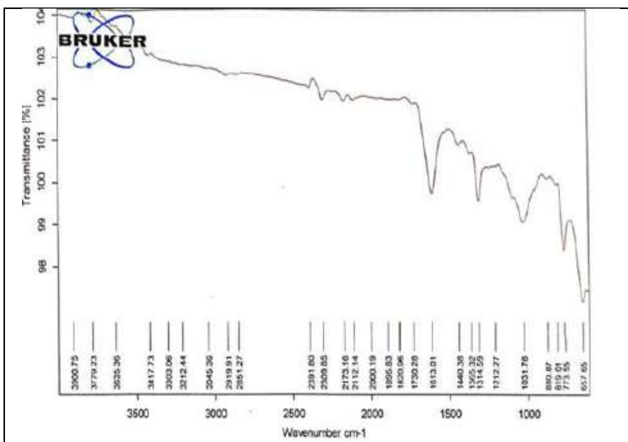

Fig no :01 ATR-FTIR of Bombax ceiba Flower powder

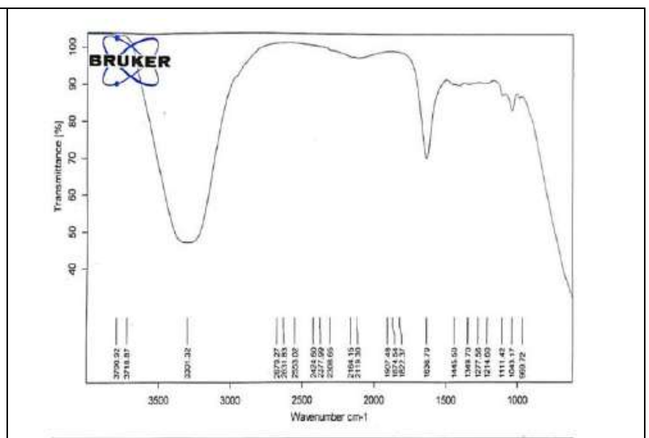

Fig no :02 ATR-FTIR of spectral analysis of formulation

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RESEARCH ARTICLE

Formulation and Evaluation of Poly Herbal Vanishing Cream

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ABSTRACT

The goal of this study was to come up with a formula for disappearing herbal cream and to assess it. Compared to conventional creams, herbal creams have a few benefits. The bulk of currently available creams, which are made from synthetic medications like acyclovir, triamcinolone, calcipotriene, and mometasone, provide fairness to the skin, but they also have various side effects including itching and allergic reactions. To begin, the oil phase was generated by melting a combination of stearic acid (17%), potassium hydroxide (0.5%), and sodium carbonate (0.5%) at 700°C. Second, an aqueous phase was made up of a mixture of alcoholic extracts of crude drugs, including rhizomes of kachora plant, fruits of nagarmotha, fruits of pimpali, fruits of nutmeg, seeds of Jawas plant, rhizomes of turmeric, wheat grains and cereals of urid and harbhara (4.5%), glycerin (6%), perfume (0.5%), and water (71%) heated at 70 The aqueous phase was then added to the oil phase at 70°C while stirring continuously. After the transfer was finished, the mixture was allowed to cool to room temperature while being agitated. Just before the finished product, the perfume was added. More research is needed to determine the effectiveness of this formulation.

Keywords: Kachora, Herb, Cream, Crude drug, Evaluation parameters.

INTRODUCTION

In recent decades, disease has been treated by administering medications to the human body through numerous routes, such as oral, sublingual, rectal, parental, topical, inhalation, and so on. Topical delivery is defined as the

application of a drug-containing formulation to the skin to treat a cutaneous disorder or the cutaneous manifestations of a general disease (e.g., psoriasis) with the goal of containing the pharmacological or effect of the drug to the skin's surface or within the skin. Semisolid formulations in all their varieties dominate the system for topical delivery, but foams, sprays, and medicators are also used [1]. These Topical formulations are used to deliver medications. The underlying skin layer or tissue for localized impact is used as a layer Drugs are designed to be used. Topically, Creams are considered healthy items because they are made utilizing pharmaceutical industry tactics; each non-medicated and medicated cream is utilized to treat a variety of skin disorders. Ayurvedic, herbal, or medically aided lotions have been developed, and individuals utilize them to cure their skin problems. They are made up of one or more drug compounds that have been disseminated in a suitable phase (2)
They are divided into two types

Oil-in-Water (O/W) creams

which are made up of small oil droplets spread in a continuous phase, while an oil-in-water (O/W) emulsion is one in which the oil is dispersed as droplets throughout the aqueous phase.(3)

Water-in-Oil (W/O) creams

which are made up of microscopic water droplets that are scattered in an oily phase. The emulsion is of the water-in-oil (W/O) type when water is the dispersed phase and oil is the dispersion medium.(4) Since the Vedic era, mankind has used medicinal plant material to heal disease or provide a sufficient treatment for that ailment. It's as if it were said that there isn't a single plant on the planet that isn't medicinal in some way. This demonstrates the significance of a plant or a portion of a plant as a medication, i.e., herbal medicine.(5) Because the latter approach relied on contemporary biology and chemistry for both discovery and treatment, it was quickly accepted by users, and it currently has a dominating position in the field of health care. Despite this, traditional medicines, which are often polyherbal, are growing in popularity due to the widespread perception that these items are safe, whereas single-molecule based contemporary pharmaceuticals utilised in the allopathic system can have serious side effects . The body's first line of protection against external exposure is the skin. The skin is where the indications of ageing are most obvious. Although ageing skin is not a health hazard, it can have a negative impact on a person's psychology.(6) Despite the fact that they were marketed as beauty creams, vanishing creams were also utilised as a foundation for face powders. Early loose powders didn't stick well to the skin, especially if it had been washed with soap and water . (7)

MATERIALS AND METHODS

Preformulation studies

Organoleptic properties

The organoleptic quality of a natural material relates to its appearance, odour, colour, and taste. The study's first step is to characterise these characteristics, which will help with the primary identification of the Natural substance, as well as determining the likelihood of patient acceptability of the raw materials' aroma, taste, and colour, as well as their likely inclusion in the final dose form. Color and odour changes in a formulation's raw material might sometimes indicate that the formulation's stability has worsened.

IR Spectra Analysis

The spectra was obtained in the wavenumber range of 4000 to 400cm-1 for these compatibility investigations, which were done using an ATR-FTIR spectrophotometer.

Drug and Excipients Compatibility Studies

Physical Compatibility Studies

The physical combination of medication and excipient was kept in a Petri dish and stored at normal and high temperatures for a weak in a stability chamber at 45°C/75 percent RH. After a weak, the samples are checked for physical changes such as discoloration, odour, and so on.

Chemical Compatibility Studies

The spectra was obtained in the wavenumber range of 4000 to 400cm-1 for these compatibility investigations, which were done using an ATR-FTIR spectrophotometer. The natural oils and excipients were thoroughly combined in the mortar until they were completely blended. The sample was then taken from the mortar and placed in the sample holder's cavity, where the spectrum was recorded.

Procedure

Preparation of poly herbal vanishing cream:

- All of the above-mentioned powdered Crude medicines, weighing 5 grammes each, were placed in a conical flask with 100 millilitres of water.
- Ethanol was added to it,
- After that, an aluminium foil cover was placed on top of the conical flask. After that, the mixture was macerated for 5 days.

Preparation of oil phase:

- Stearic acid (17%),
- potassium hydroxide (0.5%),
- sodium carbonate (0.5%)was placed in a single porcelain dish and melted at 70 degrees Celsius.

Preparation of aqueous phase:

- Alcoholic extract of crude drugs mentioned in step-1 (4.5%)
- Glycerin (6%),
- Water (71%)were placed in a second porcelain dish and heated to 70°C.

Addition of aqueous phase to oil phase:

- At 70°C, the aqueous phase was added to the oil phase while stirring continuously.
- After the transfer was complete, it was allowed to cool to room temperature while being stirred constantly.

Just before the final product was transferred to an appropriate container, perfume (0.5 percent) was applied last. The cream was then tested for a variety of physical properties. (The formulation of poly herbal vanishing cream shown in the table no:1)

Evaluation Of Formulated Cream

Appearance

The formulated garlic oil cream was visually evaluated for colour, appearance, and transparency. Observing the smoothness, clumping, roughness, and homogeneity of the cream was encouraged by rubbing it between the fingers.

pH Measurement

pH measurement of the cream was carried out using a digital pH meter by dipping the glass electrode completely into the cream system to cover the electrode. The measurement was done three times, with the average of the three measurements being recorded.

Viscosity

Brook field Viscometer LVD was used to measure the viscosity of prepared creams using spindle S 94 at various speeds and shear rates. The measurements were made in 60 seconds between two successive speeds as equilibration with shear rates ranging from 0.20 s1 to 1.0 s-1 over a speed range of 0.10, 0.20, 0.30, 0.40, and 0.50 rpm. The viscosity tests were carried out at room temperature.

Spreadability

Two sets of standard-sized glass slides were taken. One of the slides was covered with the garlic cream mixture. The cream was sandwiched between the two slides in an area filled by a distance of 7.5 cm along the sides after the other slide was placed on top of it. A 100g weight of cream was placed on the upper slides and squeezed uniformly between the two slides to form a thin coating. The weight was secured to a stand in such a way that only the upper slides were able to slip off freely due to the force of the weight linked to it. A 20g weight was carefully fastened to the upper side.The time taken for the upper slide to travel the distance of 7.5 cm and separated away from the lower slider under the influence of the weight was noted. The experiment was repeated for three times and mean time was taken for calculation.

Spreadability was calculated by using the following formula:

S=m×1/t

Where s= Spreadability, m- weight tied to upper slides, l- length of the glass slide, ttime taken in sec.

Extrudability

The quantity in percentage cream extruded from tube on application of finger pressure was used as the basis for evaluating cream formulation for extrudability in the current study. Extrudability improved as the quantity extruded increased. The study formulation was placed in a clean, lacquered aluminium collapsible 5 gm tube with a 5 mm nasal tip opening, and pressure was applied to the tube using a finger. The amount of cream extruded through the tip when a pressure was applied to a tube was then measured to assess tube extrudability.

Irritancy test

Mark an area (1sq.cm) on the left hand dorsal surface. The cream was applied to the specified area and time was noted. Irritancy, erythema, edema, was checked if any for regular intervals up to 24hrs and reported.

Removal

The ease of removal of the cream applied was examined by washing the applied part with tap

***In-vitro* diffusion studies**

Kiescary chain instrument was used.2gms of cream kept in donor compartment. After the entire cellophane membrane is contact with the receptor compartment containing 22ml of Phosphate buffer pH 6.6.The receptor compartment is stirred continuously at (100rpm) using magnetic stirrer. The temperature maintained at 37± 1 degree centigrade. The surface area is calculated for Diffusion studies 3.14cm sq. for hours. The sample was withdrawn at 30min interval. Same volume was replaced with free Phosphate buffer. Cream containing garlic oil is measured after dilution. Repeat the test for 3 times. Average values are noted. Cream applies on body surface applied topically surface tissue of the skin after application of substance. The skin is potentially appendages than through the matrix of stratum, corneum. Diffusion has been established. Dominant diffusion mode properly into appendages. But occurs of the matrix of stratum, corneum. Penetration of remaining epidermal layer and corneum circulation via capillaries. This is carried by Agar Nutrient medium. Any concentration poured into petri dish a hole was made at the centre cream was placed on it. Time taken for cream to diffuse was noted.

Stability studies

Introduction

The time from the date of manufacture and packaging of the formulation until its chemical or biological activity is not less than a set level of labelled potency and its physical properties have not altered considerably or negatively can be characterized as the stability of a medicine. The stability of the active component must be a major consideration in selecting whether or not to accept or reject dosage forms for medications in any design or evaluation.

Objectives of the study

Stability testing enables recommended storage settings, re-test intervals, and shelflives by predicting how the quality of a drug ingredient or drug product changes over time under the effect of various environmental elements such as temperature, humidity, and light. Observing the rate at which a product degrades under typical room temperature takes a lengthy period in most cases. The ideas of expedited stability investigations are used to avoid this unfavorable delay. The stability test requirements are described in the International Conference on Harmonization (ICH) Guidelines under "stability testing of New Drug Substances and Products" (QIA).

RESULT AND DISCUSSION

Pre-formulation studies

Organoleptic properties

The present study was carried out to develop poly herbal vanishing cream.The physical description/organoleptic quality of the drug is the first step in recognising the drug substance. It aids in determining the drug's suitability for formulation into the desired dosage form. This also aids in the evaluation of patient acceptability variables such as colour, nature, odour, and taste, which leads to improved patient compliance.

Poly herbal vanishing cream

- Colour- yellowish green color
- Odour-pleasant
- Taste -acidic and sour

The API's colour, odour, nature, and taste were examined, and it was noticed in accordance with the monograph. Based on the findings, it was determined that the cream formulation was adequate, and that no discomfort was anticipated to develop in patient compliance.

IR- Spectra Analysis

ATR-FTIR spectrum of pure drug and prepared cream was compared to study of drug with the excipients and the spectrum was recorder in the wave number region of 4000 to 400cm^{-1}. (The result shown in the fig no:1).

Compatibility studies

Physical compatibility studies

From the study of physical compatible, it can be confirmed, there is no colour changes occurs in the physical mixture and it can be concluded that all the excipients were compatible with herbal powder. The compatibility study was performed at 40^{O}C/75%RH and found that excipients don't have interaction with herbal powder.

Chemical compatibility studies

ATR-FTIR spectrum of pure drug and prepared cream was compared to study of drug with the excipients and the spectrum was recorder in the wave number region of 4000 to 400cm^{-1}. According to functional category these excipients were mixed in herbal powder. This indicates that the drug is compatible with the formulation (The result shown in the fig no:2)

Appearance

The look, colour, and texture of the made cream were examined visually. The developed formulations were all white in colour, smooth in texture, and homogeneous, with no evidence of phase separation.

Colour :yellowish green colour

Odour :pleasent

pH measurement

pH is one of the major evaluation factors in the cream preparation purpose of avoiding the irritation of the skin upon the application. Using a pH metre, it was discovered that the pH ranges from 6.2 to 6.7, which is basic in nature.
The pH should not be too acidic, as this might cause skin irritation, nor should it be too alkaline, as this can result in scaly skin. (The result shown in the table no: 2)

Determination of viscosity

From the result shows viscosity of all the formulations range from (12160) to (23230) cps.
F3 Shows a better consistency with viscosity level of 19930 cps. (The result shown in the table no: 3)

Determination of Spreadability

The Spreadability of the cream was based upon the viscosity and it was evaluated form all the 4 formulations.F3 has better spreadability as compares to other formulation .The F3 having better consistency so the cream was easily spreadable by the small amount of shear. (The result shown in the table no:4)

Extrudability

The extrudability of the cream was based upon the viscosity, and it was evaluated from all the 5 formulations range from (1.421gm) to(2.318gm) gm. The formulation (F3) having better consistency of the cream. (The result shown in the table no:5)

Irritancy test

From the above result,it was concluded that no irritancy was observed in all formulation. (The result shown in the table no:6)

***In-vitro* Diffusion Studies**

The diffusion studies of the formulation results are shown in the table no.7

Stability Study

A stability study was carried out for the optimized formulation according to ICH guidelines at 40°C/75 % RH for one month. The results showed no significant change in the physical and chemical parameters of the cream. Hence the formulation (F3) was found to be stable. (The result shown in the table no:8)

CONCLUSION

- In the present study, an attempt was made to develop anti-bacterial cream to provide an effective treatment against microbes using poly herbal vanishing cream
- The comparison of the ATR-FTIR spectra of poly herbal vanishing cream made.F3 confirms that there is no disappearance of the existing peak.
- There is no colour change on physical compatibility studies and it can be concluded that all the excipients were compatible with herbal powders.
- In-vitro drug release was found to be controlled in pH 7.4 phosphate buffer. Formulation(F3) shows drug release of 91.69%.On observation for 3months,no significant variation was observed and the formulation was clear.
- A stability study was carried out for the optimized formulation according to ICH guidelines at 40°C/75 % RH for one month. The results showed no significant change in the physical and chemical parameters of the cream. Hence the formulation (F3) was found to be stable.
- From the above criteria of base and other excipients the formulation forms the effective, safe and stable preparation for topical administration.
- The cream formulation using herbal powders may be effective, costefficient and easily accessible way to prevent skin infection caused by microbes.

ACKNOWLEDGEMENT

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Table.no:1 composition of poly herbal vanishing cream

S.NO	INGREDIENTS	F1	F2	F3	F4
1	Turmeric powder(gm)	1	1	1	1
2	Potassium hydroxide(ml)	0.5	0.5	0.5	0.5
3	Sodium carbonate(ml)	0.5	0.5	0.5	0.5
4	Ethanol(ml)	5	5	5	5
5	Glycerin(gm)	20ml	15ml	10ml	5ml
6	Stearic acid	10	8	6	4
7	Honey(gm)	1	1	1	1
8	Almond seed powder(gm)	1	1	1	1
9	Gram flour(gm)	8	6	4	2
10	Mustard powder(gm)	1	1	1	1
11	Water(ml)	Upto100	Upto100	Upto100	Upto100

Table.no:2 Information about ph measurement

FORMULATION	pH
F1	6.4
F2	6.2
F3	6.8
F4	6.7

Table.no.3 viscosity measurement

FORMULATION CODE	VISCOSITY(CPS)
F1	23230
F2	15200
F3	19930
F4	12160

Table.no.4 Spreadability measurement

Formulation code	Spreadability (g.cm/sec)
F1	92.43
F2	89.45
F3	87.36

Table.no.5 Extrudability measurement

Formulation code	Extrudability (gm)
F1	1.421gm
F2	2.318gm
F3	2.234gm
F4	1.456gm

Table.no.6 Irritancy test measurement

S.NO	FORMULATION CODE	IRRITANCY RESULT
1	F1	No irritancy
2	F2	No irritancy
3	F3	No irritancy
4	F4	No irritancy

Table no: 7 Diffusion study of cream preparation.

S.no	Time	F1	F2	F3	F4
		% Of drug release			
1	**15**	35.12	42.13	42.15	48.15
2	**30**	43.13	44.15	45.55	58.32
3	**45**	52.12	54.16	56.15	68.15
4	**60**	64.55	65.13	65.19	78.98
5	**120**	71.30	75.15	78.13	83.12
6	**240**	85.12	87.12	88.70	92.31
7	**280**	91.20	92.17	94.78	94.56

Table. No:8 Stability Parameter of selected formulation

Parameters	Initial	After one month 40/75(°C/ RH)
Appearance	Light yellow colour	light yellow colour
Feel on Application	Smooth	Smooth
pH	6.2	6.8
Viscosity	19930cps	23230cps
Spreadability	87g.cm/sec	85 g.cm/sec
Extrudability(gm)	2.234	2.142
In- Vitro drug release	91.20	94.56

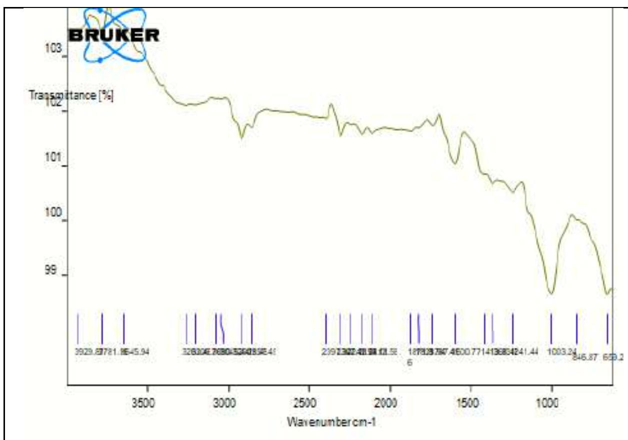

Fig.no:1 ATR-FTIR spectrum of herbal powder

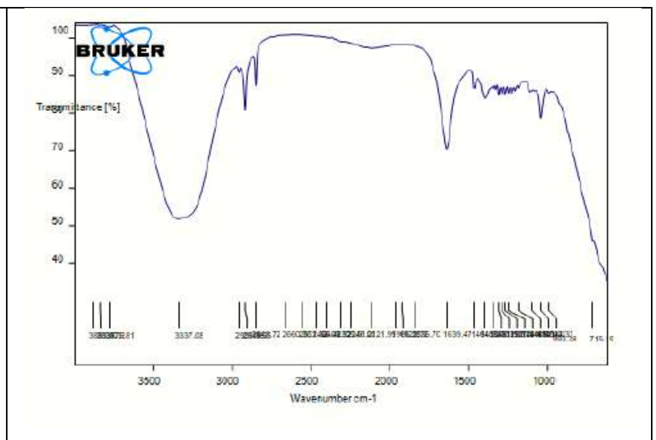

Fig.no:2 ATR-FTIR spectrum of poly herbal vanishing cream

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RESEARCH ARTICLE

Formulation, Development and Evaluation of Herbal Tooth Paste for Clove Powder

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ABSTRACT

The goal of this study was to develop and test herbal tooth paste with natural components, with a focus on safety and efficacy. It clears the gums for toothaches, dental treatment pain alleviation, and other dental issues. The clove powder was used to make the herbal clove tooth paste (active ingredient). Many physicochemical studies were conducted for visual pH, wash ability, and foam stability. The designed herbal toothpaste has a brown tint and has demonstrated high stability, pH, and conditioning activities. All of these qualities are great for a high-quality herbal clove toothpaste that can be used on a regular basis. However, more scientific inquiry is needed to confirm its overall quality.

Keywords: *Clove* Powder, *Amla* Powder, Stability, pH, Applications & Efficacy, Formulation Of Herbal *Clove* Tooth Paste

INTRODUCTION OF PASTE

Toothpaste is a paste or gel dentifrice that is applied to teeth with a toothbrush to clean and maintain their appearance and health [1]. Toothpaste is used to keep teeth clean. It's an abrasive that helps remove dental plaque and food from the teeth, reduces halitosis, and distributes active chemicals (most often fluoride) to help prevent tooth decay and gum disease (gingivitis) [2].

Clove Herbal Paste

Herbal and herbal-based toothpaste have been used for many years and are one of the most significant components of oral health[3]. Natural-ingredient formulations are more widely accepted because they are believed to be safer than manufactured medications. As a result, there has been a greater focus on incorporating natural substances into herbal dentrifrices [5]. The goal of the study was to manufacture a herbal base product, compare its efficacy to that of commercially available toothpaste, and evaluate several parameters such as colour, spreadability, foamability, extrudability, and antibacterial activity [6,7]. However, there is a plan in the works to develop a formulation for the commercial manufacture of herbal dental products that is also environmentally friendly.

Clove [8]

Cloves are the fragrant flower buds of the *Syzygiumaromaticum* tree, a *Myrtaceae*family member.

Clove Herbal Composition

Clove's herbal composition includes up to 18 percent essential oil concentration in the flower buds. Clove essential oil contains approximately 89 percent eugenol, with the remaining 5 to 15% being eugenol acetate and cariofileno [9,10].

Global *Clove* Production

Europe, Asia-Pacific, and Africa are the three regions in which the clove market is divided. Each segment will cover production (volume), consumption (value and volume), import (value and volume), export (value and volume), and price trend analysis. The study provides market estimates and forecasts in terms of both value (USD thousand) and volume (USD million) (metric ton).

- The study period is from 2017 to 2027.
- The year 2021 will be used as the starting point.
- Asia-Pacific is the fastest-growing market.
- Asia-Pacific is the largest market on the planet.
- CAGR (compound annual growth rate) is 3.5 percent.

The *clove* market is expected to grow at a CAGR of 3.5 percent between 2022 and 2027. Due to the high price of the commodity, customers' disposable money has been lowered as a result of unemployment, resulting in poor demand for herbal goods containing clove [11,12,13].

MATERIALS AND METHOD

Collection of Materials

Clove, *Amla* powder, *kadukkai* powder, *Cardamom*, Soap Nut (Soapberry). At a local market in Salem, cinnamon, neem leaf, crystal salt, Himalayan crystal rock salt, turmeric powder, honey, and coconut oil were purchased at a local market in Salem.

Apparatus

- A measuring cup made of glass, a bowl, and a handcrafted wooden mortar.
- A spoon
- Making a paste base for Clove Herbal Paste
- If desired, add products, color, and aroma to the mix.
- Digital balance.

Preformulation

Organoleptic Properties

The colour of the dried clove powder is dark-brown colour, indistinct odour and bitter taste. All formulations were brown colour and aromatic odour .physical appearance of all formulation are opaque in nature.

ATR-FTIR Spectra Analysis

The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR-FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample holder.

Compatibility studies:

Physical compatibility studies

Physical mixture of drug and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak. Following a weak, the samples are examined for any physical changes such as discoloration, odour, etc.,

Chemical compatibility studies

These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wave number region of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded.

Procedure for clove herbal paste

Crush a few cloves with equal parts of amla powder in a small mixing dish. To form a thick paste, add a few drops of water and roll a cotton swab through it to properly coat the surface. The beginning and obtained supplies are depicted. This method can be used for the DOUBLE BOILING METHOD.

Procedure

- Clove powder is used to make a herbal cleanser.
- Weghied all of the ingredients according to the instructions.
- In 20 minutes, combine Amla powder, Kadukkai powder, Turmeric powder , soapnut powder, and Cinnamon powder to heat.
- As a foaming agent, 1 gramme of soap nut (soapberry) is used, and honey is used as a sweetener.
- The mixture was triturated well, and 80 ml of Coconut oil was added to bring the total weight to 100gm.
- Titrate the clove sample for 30 seconds or until the solution becomes brown.
- On the burette, read and record the last volume.
- Calculate the quantity of calcium in cloves based on the results.

Evaluation of Studies for Prepared Formulations:

Quality control tests were done on the prepared formulations, including organoleptic and physicochemical characteristics such as pH, and viscosity. Specific tests for washability, such as, foam ability, moisture content, homogeneity, spreadability, stability was also conducted to assure the quality of the goods. The results were compared to a commonly used herbal clove paste that was utilised as a reference

Physical Appearance:

The physical appearance and ocular assessment of all samples were observed. The clarity, foam-producing capabilities, and fluidity of the prepared Formulations were assessed.

Determination of pH

Using pH paper, the pH of a cleaner solution (10%w/v) in distilled water was tested at room temperature.

Wash ability:

The formulation test was performed on the herbal clove paste and the ease with which it could be washed with water was tested.

Foam ability

For the determination of the herbal clove paste for its ability to foam about 0.1gm of herbal paste was taken and was dissolved in distilled water (about 50ml) in 100 ml graduated measuring cylinder. It the measuring cylinder was taken for about 10 min. Foam height was measured after 10 min. Record the observation for five consecutive experiment and the mean was taken.

Moister content

5 gm of formulation placed in a porcelain dish containing 6-8 cm in diameter and 2-4 cm depth in it. Dry the sample in a 105°C oven.

Calculation

$$\text{Moisture content (\%)} = \frac{w2 - w3}{w2 - w1} \times 100$$

were,

W1 = the weight of the container with the lid;
W2 = the combined weight of the container, lid, and sample before drying;
W3 = the combined weight of the container, lid, and sample after drying.

Homogeneity

At room temperature normal force was applied on the tube containing the paste at room temperature and observed if the paste extrude homogeneously from the tube.

Spread ability

The most extensively used method for evaluating and quantifying the spread ability of semisolid preparations is the parallel plate method. The method's benefits include its simplicity and comparatively low cost. Additionally, the assemblies may be developed and manufactured to meet specific data needs. The method, on the other hand, is less exact and sensitive, and the data it produces must be analysed and presented manually.

Tube extrudability

The prepared paste was put into a typical capped collapsible aluminium tube and crimped shut at the end in this fashion. The weights of the tubes were kept track of. The tubes were sandwiched between two glass slides and secured. After that, the cover was removed and 500g was put over the slides. The extruded paste was collected and weighed as a whole. The extruded paste percentage was determined.

Viscosity

Paste viscosity measurements were performed on a Brookfield digital viscometer (LV DV–II Ultras Programmable Remoter, USA) with spindle no. 3 and increasing shear rate values to indicate probable paste flow behaviour. All viscosity measurements were carried out at a constant temperature of 300 degrees Celsius.

Stability test:

Introduction

The time between the formulation's fabrication and packaging and its chemical or biological activity reaching a set level of labelled potency and effectiveness. Its physical features have not changed considerably or deleteriously is referred to as drug stability. The stability of the active component must be a major consideration in selecting whether or not to accept or reject dosage forms for medications in any design or evaluation.

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In the present work stability study was carried out for the optimized formulation (F4) at 400C ±2^{0}C/ 75% RH ± 5 % RH for one month. (Table no: 03)

RESULT AND DISCUSSION

RESULT

Determination of Organoleptic Characteristics:

The colour of the dried clove powder is dark-brown colour, indistinct odour and bitter taste. All formulations were brown colour and aromatic odour. physical appearance of all formulation is opaque in nature. (Table no: 01)

ATR -FTIR Spectra Analysis

An FTIR spectrum was used to identify and confirm the clove. The FTIR spectrum of clove is shown in (Figure No. 01). Clove's typical absorption peaks are well within pharmacopoeia limitations.(Fig.No. 01)

Compatability studies

Physical compatibility studies

The physical mixture of drag and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak Following a weak. The samples are examined for any physical changes such as discoloration, odour. Etc...

Chemical compatibility studies

These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wave number region of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded.(Fig.No: 02)

DISCUSSION

ATR-FTIR spectroscopy was fixed at the range of 4000-400cm^{-1}.There is no interaction between the drugs and excipients.

Composition of formulation table

To optimized formulation concentration of excipients which impact the hydrating, viscosity was selected *amla* powder, *kadukkai* powder, *cinnamon* have been varied to the study the impact on viscosity and hydrating effect. Five trials were planned and executed in a way to study the impact of single excipient in each formulation by keeping one formulation (F3) optimized formulation. (Tabel.No:02) Composition of formulation table

Determination of pH

Using pH paper, the pH of a cleaner solution (10%w/v) in distilled water was tested at room temperature. The pH level was determined using pH-paper, and it was found to be 5.6, which is based in nature, making it skin friendly and causing no irritation. (Table.no:04)

Wash ability

The formulation test was performed on the herbal clove paste and the ease with which it could be washed with water was tested. Washability test was carried out by applying a small amount of herbal toothpaste on the teeth and then washing it with water. And the F1, F2 and F3 are good. (The result shown in the table .no:05)

Foam ability

For the determination of the herbal paste for its ability to form foam about 1.0gm of paste was taken and was dissolved in distilled water (about 10ml) in 50ml graduated measuring cyclinder .It the measuring cyclinder was taken shaken for about 10 min .Foam height was measured after 10 minutes. Record the observation for five consecutive experiment and the mean was taken. Foam ability test was carried out by applying a small amount of herbal toothpaste on the mouth and then washing it with water. (The result shown in the table.no:06.)

Moisture Content %

5 gm of formulation placed in a porcelain dish containing 6-8 cm in diameter and 2-4 cm depth in it. Dry the sample in a 105°C oven. Moisture content simply refers to the amount of water present in a substance. The amount of weight lost after drying is commonly used to determine it. (The result shown in the table.no:07)

Homogeneity

At room temperature normal force was applied on the tube containing the paste at room temperature and observed if the paste extrudes homogeneously from the tube. Homogeneity is simply, but most frequently occurs in connection with samples from different populations which may or may not be identical. And the F1, F2 and F3 are pass. (The result shown in the table.no:08)

Spread ability

The Spread ability of the herbal toothpaste was based upon the viscosity and it was evaluated form all the 3 formulations. F3 has better spread ability as compares to other formulation. The F3 having better consistency so the herbal toothpaste was easily spreadable by the small amount of shear. (The result shown in the table.no:09)

Tube extrude ability

The prepared paste was put into a typical capped collapsible aluminium tube and crimped shut at the end in this fashion. The weights of the tubes were kept track of. The tubes were sandwiched between two glass slides and secured. After that, the cover was removed and 500g was put over the slides. The extruded paste was collected and weighed as a whole. The extruded paste percentage was determined. (The result shown in the table .no :10)

Discussion

A Tube Extrusion test consists of applying force to a product (herbal toothpaste) until it flows through an mouth, that may be in the F3 has better tube extrude ability as compares to other formulation

Viscosity

Paste viscosity measurements were performed on a Brookfield digital viscometer (LV DV–II Ultras Programmable Remoter, USA) with spindle no. 3 and increasing shear rate values to indicate probable paste flow behaviour. All viscosity measurements were carried out at a constant temperature of 300 degrees Celsius. All three herbal toothpaste showed comparable the viscosity range. The viscosity range of herbal cream is listed in F3 was determine to be a 35447± 334cps. (The result shown in the table .no :11)

Stability studies

A stability study was carried out for the optimized formulation according to ICH guidelines at 40°C/75 % RH for one month. The results showed no significant change in the physical and chemical parameters of the cream. Hence the formulation (F3) was found to be stable. (The result shown in the table.No:12)

CONCLUSION

- Herbal toothpaste is more widely acknowledged in dental research, and it is safer and has fewer side effects than synthetic preparations. Natural remedy research and public oral health indicate that the newly created herbal toothpaste has a promising future.
- *Clove* is considered to be a rich source for calcium and other excellent sources of micro nutrients.
- It can be concluded that *clove* powder is an appropriate and cheap source of Calcium for human nutrition.

- The paste of CHP was treated with demineralizing solution and results showed a statistically significant difference indicating the effectiveness of re-mineralizing effect of CHP on tooth surfaces. However, being natural products, CHP can be considered as an optimal alternative to the commercial ones.

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Table no: 01. Determination of organoleptic characteristic

Color	Brown
Odour	Pleasant
Taste	Astrigent

Table No: 02.Formulation of Clove Herbal Paste - (F3)

S.No	Ingredients in (gm)	F1 (gm)	F2 (gm)	F3 (gm)
1	Clove	2	2	2
2	Amla powder	20	20	20
3	Kadukkai powder	20	20	20
4	Cardamom	5	5	5
5	Soap Nut (Soapberry)	0.5	1	1.5
6	Cinnamon	0.75	0.75	0.75
7	Neem leaf	0.5	0.5	0.5
8	Crystal salt	0.5	0.5	0.5
9	Himalayan crystal rock salt	0.5	0.5	0.5
10	Turmeric powder	1	1	1
11	Honey	0.75	1.00	1.25
12	Coconut oil	2	4	6
13	Purified Water	q.s	q.s	q.s

Preparation of Clove herbal Paste = (50gm)

Table. No.03 ICH guidelines for stability study requirements

Study	Storage condition	Time period
Long term	25º C±2º C/60%RH±5RH OR 30º C±2º C/65%RH±5%RH	12 months
Intermediate	30º C±2º C/65%RH±5%RH	6 months
Accelerated	40º C±2º C/75%RH±5%RH	3month

Table.no:04.Determination of pH test

Formulation. No:	pH Range
F1	5.3
F2	5.5
F3	5.6

Table No.05 Determination of Washability Test:

Formulation. No	Wasability
F1	Good
F2	Good
F3	Good

Table No.06Determination of Foam ability

Formulation. No	Foam index
F1	20cm
F2	25cm
F3	16.5cm

Table No.07 Determination of MOISTURE CONTENT %

Formulation. No	MOISTURE CONTENT %
F1	31.02
F2	35.83
F3	32.56

Table No.08 Determination of HOMOGENEITY

Formulation. No	HOMOGENEITY
F1	Pass
F2	Pass
F3	Pass

Table No.09 Determination of SPREADIBILITY (cm)

Formulation. No	SPREADIBILITY (cm)
F1	6.2
F2	7.0
F3	7.2

Table No.10 Determination of TUBE EXTRUDABILITY (%)

Formulation. No	TUBE EXTRUDABILITY (%)
F1	89
F2	91.3
F3	91.5

Table No. 11 Determination of VISCOSITY

Formulation. No	VISCOSITY
F1	36447±38 7cps
F2	36477± 716 cps
F3	35447± 334cps

Table. No12 Determination of stability studies

Parameters	Initial	After 15 days	After 1 month
APPEARANCE	Brown	Brown	Brown
Ph	5.3	5.5	6.45.6
VISCOSITY	36447±38 7cps	36477± 716 cps	35447± 334cps
Washability	Good	Good	Good
MOISTURE CONTENT %	31.02	35.83	32.56
SPREADIBILITY (cm)	6.2	7.0	7.2

*Mean ± SD (n=6)

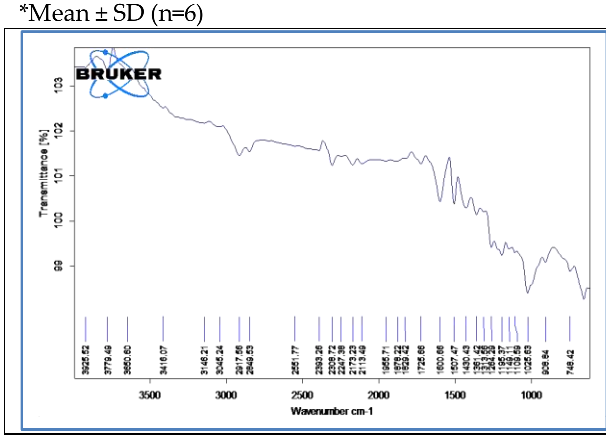

Fig.No. 01 ATR-FTIR Of clove powder

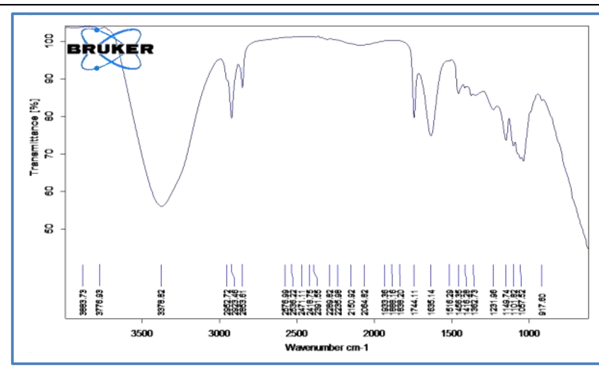

Fig. No: 02 FTIR Spectrum of clove powder + All excipient

RESEARCH ARTICLE

Comparative Study of Two Different Brands of Amoxicillin and Cephalexin Capsule

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ABSTRACT

Drugs are no more reliable for community because of substandard and poor quality medicines. Which causes various problems to human health and life. So it is important to check the quality of the approved medicines to assess the safety and efficiency of the drug .The study is to investigate the capsules by using clinical trials of In-vitro comparison of two brands of amoxicillin and cephalexin capsule. In- vitro parameters include dissolution test, weight variation test, disintegration test and moisture content test. The study reveals that selected brands of amoxicillin and cephalexin capsule lies within the pharmacopeia limit .The purpose of the study are to provide the information regarding the quality of the drug. The In vitro test include dissolution test , weight variation test , disintegration test , moisture content test were conducted to analysis between the drugs.

Keywords: amoxicillin, cephalexin, evaluation

INTRODUCTION

Capsules are defined as unit solid dosage form of medication available as small containers (shells) made up of gelatin enclosing accurately measured drug substances. The term capsule is derived from the Latin word capsule, meaning a small container.(1) Capsules are solid preparations in which drug substance and excipients are enclosed in either a soft or hard soluble shell. The sell is normally made from gelatin or other suitable polymeric material and results in a simple, tasteless, odorless, elegant, easy-to-swallow dosage form without the need for a secondary coating step. Gelatin has the property of disintegration when it's come in contact with water there by releasing the medicament completely .Instead of gelatin, denatured gelatin, methyl cellulose and polyvinyl alcohol can be used to make the capsule shell [2] Depending on the composition of the capsule shell, capsules may be classified as either hard or soft capsule, with soft capsules are of flexile, plasticized gelatin film while the hard capsule is composed of two pieces in the form of cylinders closed at one end; the shorter piece, called the cap‟ and the longer piece, called the body.(3]Capsules are made from aqueous solutions of gelling agents, such as animal protein (mainly gelatin) or plant polysaccharides or their derivatives (such as carrageenans and modified forms of starch and cellulose). Other ingredients can be added to the gelling agent solution including plasticizers such as glycerin or sorbitol to decrease the capsule's hardness.[4] Capsules may be filled with a range of formulation types including dry powders, semisolids, and other dosage forms such as beads, mini-tablets, and even mini capsules most of which are intended for oral administration. [5] There are also specialty applications such as capsules that can be loaded into dry-powdered inhalers, add reagents as part of a diagnostic kit, and occasionally soft-shell capsules intended for rectal or vaginal insertion as suppositories. There are different steps which involve in the manufacture of capsule include. Preparation of the gelatin solution, Dip coating the gelatin solution on to metal pins , Rotation of the dip coated pins , Drying of the gelatin coated pins , Stripping and trimming , Printing these are the different method used in the manufacture of the capsule .There are different evaluation parameters which are done to ensure the safety of capsule include dissolution test , weight variation test , disintegration test, moisture content test which are done according to the standard.

METHODOLOGY

Weight variation test

Procedure

Ten hard gelatin capsules are generally weighed independently and the contents are removed. The empty shells are separately weighed and the net weight of the contents is calculated by subtracting the weight of the shell from the respective gross weight. The content of active component in each capsule may be determined by calculation are done according to the percent drug content in the formulation.(The result is shown in table no: 1,2,3,4)

1. $$\text{Average weight of capsule} = \frac{\text{Total weight of 10 capsule}}{10}$$

2. $$\text{Deviation (\%)} = \frac{\text{Weight of each capsule} - \text{average weight of capsule}}{\text{Average weight of capsule}} \times 100$$

Disintegration test

Procedure

The capsules are placed in the basket-rack assembly, which is constantly lowered 30 times per minute into a thermostatically controlled bath of fluid at 37 ± 2 ˚C .And note down the time required for complete disintegration of capsule.

Moisture content test

Procedure

The produced transdermal films were weighted independently and maintained at room temperature for 24 hours in desiccator with fused calcium chloride. The film are again weighted after 24 hours .The produced Nano fiber patches are again weighted after 24 hours and the moisture was calculated using he procedure below

$$\text{Percentage moisture intake} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

Dissolution test

Procedure for Amoxicillin capsule

Dissolution test for amoxicillin capsules is carried out using 900 ml of water, freshly prepared by distillation, as the medium and rotating the paddle at 100 rpm for 30 minutes. Withdraw a suitable volume of the sample and filter promptly through a membrane filter disc having an average pore diameter not lesser than 1.0 µm, rejecting the first 1 ml of the filtrate. Measure the absorbance at about 272 nm. Also measure the absorbance of a standard solution of known concentration of amoxicillin RS at about 272 nm and calculate the content of $C_{16}H_{19}N_3O_5S$.(The result is shown in table no 5) Not lower than 80% of the standard amount of $C_{16}H_{19}N_3O_5S$

Procedure for Cephalexin capsule

Dissolution test for cephalexin capsule is carried out using 900 ml of water freshly prepared by distillation as media At the Speed of 100 rpm for 30 minutes .Withdraw a suitable volume of the medium and filter promptly through a membrane filter disc with an average pore diameter not lesser than 0.8 µm. Reject the first few ml of the filtrate and dilute a suitable volume of the filtrate with water. Measure the absorbance of the resulting solution at the maximum at about 261 nm (2.4.7). Calculate the content of $C_{16}H_{17}N_3O_4S$ taking 235 as the specific absorbance at 261 nm.(The result is shown in table no 6) Not greater than 75 % of the stated amount of$C_{16}H_{17}N_3O_4S$

RESULT

Weight variation test

Amoxicillin capsule

Ten hard gelatin capsules are generally weighed independently and the contents are removed. The empty shells are separately weighed and the net weight of the contents is calculated by subtracting the weight of the shell from the respective gross weight. The weight variation test for amoxicillin capsule was performed according to the standard procedure and the result obtained is shown In table no 1 & 2.

Cephalexin capsule

Ten hard gelatin capsules are generally weighed independently and the contents are removed. The empty shells are separately weighed and the net weight of the contents is calculated by subtracting the weight of the shell from the respective gross weight. The weight variation test was performed according to the standards and the result is shown in table no 3 & 4.

Moisture content test

Amoxicillin capsule

The produced transdermal films were weighted independently and maintained at room temperature for 24 hours in desiccator with fused calcium chloride. The film are again weighted after 24 hours .The produced Nano fiber patches are again weighted after 24 hours. The above procedure was performed and the result obtained is shown below.

Percentage of Moisture content for MOX capsules =2.4%

Percentage of Moisture content for ALMOX capsules =2.7%

Cephalexin capsule

Percentage of Moisture content for PHENIX capsules=2.2%

Percentage of Moisture content for CEPHADEX capsules=2.5%

Dissolution test

The dissolution test was been performed according to the standard procedure for both amoxicillin and cephalexin capsule and the absorbance was been was noted according to the time intervals. The result is shown in table no 5 & 6

Disintegration test

The capsules are placed in the basket-rack assembly, which is constantly lowered 30 times per minute into a thermostatically controlled bath of fluid at 37 ± 2 ˚C .And note down the time required for complete disintegration of capsule. The disintegration test was done performed according to the procedure and the result is shown below.

Amoxicillin capsule

1. Time required for total disintegration of mox capsule=30.21 mint
2. Time required for total disintegration of almox capsule=31.29 mint

Cephalexin capsule

1. Time required for total disintegration of phenix capsules = 30.41 mints
2. Time required for total disintegration of cephadex capsules =32.46 mints

RESULT AND DISCUSSION

Comparitive of In-*vitro* test profile of amoxicillin capsule

Different test were performed to analysis the different brands of Amoxicillin capsule. Dissolution test were conducted for 30 minutes. Disintegration test were performed and time was noted for each capsule until the capsule get fully disintegrate and moisture content test was conducted to analysis the percentage of moisture uptake by the capsule in 24 hours. The comparison between the two brands of amoxicillin capsule is shown in Table No 7. Dissolution test were conducted for 30 minutes which gives about 95.48% for mox 250 capsule and 93.78% for almox capsule .Disintegration test were perform to record the total disintegration of capsule which is record at 30.21 minutes for mox capsule and 31.29 minutes for almox capsule. Moisture content test was performed to analysis the percentage of moisture intake it is noted at 2.4% for mox capsule and 2.7% for almox capsule. From the analysis of the give result it is concluded that Mox capsule are better than Almox capsule.

Comparitive study of In-*vitro* test profile for cephalexin capsule

Different test were performed to analysis the different brands of cephalexin capsule. Dissolution test were conducted for 30 minutes. Disintegration test were performed and time was noted for each capsule until the capsule get fully disintegrate and moisture content test was conducted to analysis the percentage of moisture uptake by the capsule in 24 hours. The comparison between the two brands of cephalexin capsule is shown in Table No 8. Different test were conducted to analysis the two different brands of cephalexin capsule Dissolution test were conducted for 30 minutes which gives about 95,65% for phenix 250 capsule and 93.65% for Cephadex 250 capsule .Disintegration test were perform to record the total disintegration of capsule which is record at 30.41 minutes for Phenix capsule and 32.46 minutes for Cephadex capsule. Moisture content test was performed to analysis the percentage of moisture intake it is noted at 2.2% for Phenix capsule and 2.5% for Cephadex capsule. From the analysis of given result it is concluded that Phenix capsule are better than Cephadex capsule

CONCLUSION

Two brands of amoxicillin and cephalexin capsules have been subjected to analysis according to the monograph of BP and USP. The results suggest that all the tested brands satisfied the pharmacopoeial requirements. This study highlights among other things the need for constant surveillance on the retail drugs by the regulatory bodies with the view to ascertain bioequivalence and quality medicines, especially for drugs like amoxicillin and cephalexin for which there exists evidence of non-bioequivalence from different firms, resulting in efficacy issues. From this study and the various results obtained it can conclude that mox 250mg gives better effects than almox 250mg for amoxicillin capsule and phenix 250mg give better effects than cephadex 250mg for cephalexin capsule.

ACKNOWLEDGEMENT

The authors are thankful to Dr. B.Jaykar, Professor and Registrar, Vinayaka Mission's Research Foundation (Deemed to be University) and Vinayaka Mission's College of Pharmacy, Salem, Tamil Nadu for extending their support and facilities for this research.

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Table No.1 Almox 250 mg

SL.NO	INDIVIDUAL WEIGHT	AVERAGE	DIFFERENCE IN WEIGHT	%WEIGHT
1.	333	333	-1	-0.30030
2.	335	333	2	0.60060
3.	331	333	-2	-0.60060
4.	332	333	-1	-0.30030
5.	332	333	-1	-0.30030
6.	331	333	-2	-0.60060
7.	336	333	3	0.90090
8.	335	333	2	0.60060
9.	332	333	-1	-0.30030
10.	334	333	1	0.30030

Table No :2 Mox250 mg

SL.NO	**INDIVIDUAL WEIGHT**	**AVERAGE**	**DIFFERENCE IN WEIGHT**	**%WEIGHT**
1.	357	358.5	-1.5	-0.41841
2.	358	358.5	-0.5	-0.13947
3.	358	358.5	-0.5	-0.13947
4.	360	358.5	1.5	0.41841
5.	361	358.5	2.5	0.69735
6.	357	358.5	-1.5	-0.41841
7.	360	358.5	1.5	0.41841
8.	358	358.5	0.5	-0.13947
9.	359	358.5	0.5	0.13947
10.	357	358.5	-1.5	-0.41841

Table No:3 Phenix 250 mg

SL.NO	INDIVIDUAL WEIGHT	AVERAGE	DIFFERENCE IN WEIGHT	%WEIGHT
1.	332	332.6	-0.6	-0.18040
2.	334	332.6	1.4	0.42093
3.	332	332.6	-0.6	-0.18040
4.	333	332.6	0.4	0.12026
5.	333	332.6	0.4	0.12026
6.	334	332.6	1.4	0.42093
7.	331	332.6	-1.6	-0.48106
8.	332	332.6	-0.6	-0.18040
9.	334	332.6	1.4	0.42093
10.	331	332.6	-1.6	-0.48106

Table No: 4 Cephadex250 mg

SL,NO	INDIVIDUAL WEIGHT	AVERAGE	DIFFERENCE IN WEIGHT	%WEIGHT
1.	333	332.8	0.2	0.06010
2.	335	332.8	2.2	0.66106
3.	331	332.8	-1.8	-0.54087
4.	332	332.8	-0.8	-0.24038
5.	332	332.8	-0.8	-0.24038
6.	335	332.8	2.2	0.66106
7.	334	332.8	0.2	0.06061
8.	331	332.8	-1.8	-0.54087
9.	332	332.8	- 0.8	-0.24038
10.	334	332.8	1.2	0.36058

Table No:5Amoxicillin capsule

BRANDS	**TIME(minutes)**	**PERCENTAGE RELEASED (%)**
MOX	**5**	**82.28**
	10	**85.45**
	15	**87.74**
	20	**89.36**
	25	**92.62**
	30	**95.48**
ALMOX	**5**	**82,34**
	10	**86.65**
	15	**87.68**
	20	**89.54**
	25	**91,32**
	30	**93.78**

Table No:6Cephalexin capsule

BRANDS	**TIME(minutes)**	**PERCENTAGE RELEASED (%)**
PHENIX	**5**	**83.93**
	10	**86.73**

	15	**88.15**
	20	**90.72**
	25	**93.42**
	30	**95.65**
CEPHADEX	**5**	**81.97**
	10	**83.27**
	15	**85.85**
	20	**88.06**
	25	**90.22**
	30	**93.59**

Table No :7

Brands	Dissolution test (30 mints)	Disintegration test(mints)	Moisture content test (%)
Mox250mg	95.48%	30.21	2.4%
Almox250mg	93.78%	31.29	2.7%

Table No :8

Brands	Dissolution test(30 mints)	Disintegration test(mints)	Moisture content test (%)
Phenix	95.65%	30.41 min	2.2%
Cephadex	93.65%	32.46mint	2.5%

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RESEARCH ARTICLE

Formulation and Evaluation of Herbal Mouthwash against Oral Infections

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ABSTRACT

The goal of this study is to develop a formula and test its efficacy against bacteria found in the oral cavity. The goal of this study is to develop and test herbal mouthwash, as well as to determine its efficacy against oral microbial load. Water was removed from the plant materials that were collected. the plant components were collected and water soluble compounds were removed. The antibacterial activity and physicochemical properties of prepared mouthwash were also tested. The present mouthwash possesses a good antibacterial property. The findings of the stability research back up the effectiveness of the preparation. Mouthwash is currently a liquid preparation that usually comprises antibacterial and antiseptic ingredients. These treatments can be used to limit microbial growth in the mouth, but they can also be utilised for other reasons, such as analgesic, anti-inflammatory, or anti-fungal properties. The four herbs *Quercus infectoria*, *Eugenia caryophyllus, Glycyrrhiza glabra*, and *Cinnamomum zeylanicum* were chosen for mouthwash, and the final formulation was tested for antimicrobial activity against *Staphylococcus aureus* and *S. salivarius* cultures, as well as physical properties such as pH, colour, and stability. The presence of mouthwash has a strong antibacterial effect. Mouthwash is a liquid preparation that generally contains antibacterial and antiseptic compounds, and it is stable in a variety of temperatures. This solution can be used to minimise microbial growth in the mouth, as well as for other purposes such as analgesic, anti-inflammatory, or antifungal activities.

Keywords: Natural substance, colonization, analgesic, Natural oils.

INTRODUCTION

The importance of mouth and teeth cleanliness has been recognized From the dawn of civilisation to the twenty-first century, the importance of keeping one's mouth and teeth clean has been recognised. Patients and dentists are confronted with a plethora of mouthwash products comprising a variety of active and inactive components. Herbal mouthwashes are in high demand since they target oral infections, reduce pain quickly, and have fewer adverse effects. Chemical mouthwashes contain hydrogen peroxide, chlorine dioxide, and cetylpyridinium chloride, which act as an instant whitener, steriliser, and pain reliever for teeth. However, they can discolour teeth and cause side effects, but they are inexpensive. Although several popular herbal products have been shown to help decrease dental plaque and gingivitis, they have only been taken for a limited period of time and only as needed.Brushing and flossing are examples of other oral hygiene treatments. Dental caries and periodontal diseases are two of the most frequent infectious diseases that many people face. Periodontitis is a serious dental illness that can harm your teeth and gums.

Dental caries is common in children and adolescents in the beginning because they do not practise adequate oral hygiene. Oral infections develop from the contaminated tooth's root through the jawbones and into the crevices between the fascial planes of the surrounding soft tissue. Dental plaque is a complex biofilm that forms on the surface of teeth and contains over 500 bacteria. Initial colonization of bacteria in the salivary film of enamel produces dental plaque, which is followed by subsequent colonization via antibacterial adhesion. The supporting tissues of the teeth are affected by prenominal disorders. Inadequate dental hygiene is the most common cause of gingivitis, the mildest type of prenominal illness. Gingivitis is a condition in which the gums become inflamed and bleed. Plaque that accumulates on the surface of teeth and gums is the main cause of gingivitis. Mechanical plaque control techniques are employed as a mainstay of maintaining dental hygiene.

MATERIALS AND METHOD

Collection of Plant Sample
Aleppo oak

Apparatus:
- Sterile Petriplates
- Test tubes
- Conical flask
- Whattmann filter paper
- Incubator
- Autoclave
- Laminar air flow
- Pippetting device
- Hot air-oven

Pre-Formulation
Organoleptic Properties
The organoleptic quality of a Natural substance refers to its appearance, odour, colour, and taste. The study's first stage is to characterize these features, which assists in the primary identification of the Natural substance as well as estimating the probability of patient acceptability of the raw materials odour, taste, and colour, as well as its probable inclusion in the final dose form. Changes in the colour and odour of the raw material in the formulation might sometimes indicate changes in the formulation's stability (under identical conditions).

Solubilities
Solubility is defined as the ability of the substance to soluble in a solvent. One gram of the powder is weighed accurately and transferred into a beaker containing 100 ml of water. This was shaken well and warmed to increase the solubility. Then cooled and filter it, the residue obtained is weighed and noted.

ATR-FTIR Spectra Analysis
The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR-FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample holder.

Compatibility Studies

Physical Compatibility Studies
The physical mixture of drug and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak. Following a weak, the samples are examined for any physical changes such as discoloration, odour, etc.,

Chemical Compatibility Studies
These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wavenumber region of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded.

Procedure For Mouthwash

Procedure
Weighted quantity of each ingredient will be taken. Extract were taken mixed thoroughly in mortar and pestle properly with small quantity of water. All other remaining ingredient will be gradually added with good mixing. Drop by drop clove oil will be added and mixed properly taking care to avoid lump formation. PEG 40 and Glycerol will then be added drop by drop and mixed well. Finally, water added to make volume and preservative will be added and the product will be packed in an attractive, well closed container. The composition of herbal mouth wash shown in the table no:1

Evaluation Of Studies for Prepared Formulations

Various physicochemical parameters which are mentioned below were performed to establish quality of the prepared formulations.(12-19)

Determination of pH test
The pH of all the prepared formulations was determined by using Digital pH Meter. The formulations were dissolved in 100 ml of distilled water and stored for two hours. The measurement pH of formulation was done in previously calibrated pH meter.(12-19)

Irritancy test:
The irritancy test was performed on the herbal formulation .There is no redness or irritancy in the preparation .The condition was seen for 24 hrs.

Washabilty
The formulation test was performed on the herbal and the ease with which it could be washed with water was tested.

Foam ability
For the determination of the herbal for its ability to form foam about 1.0gm of mouthwash was taken and was dissolved in distilled water (about 50ml) in 100ml graduated measuring cyclinder .It the measuring cylinder was taken shaken for about 10 min .Foam height was measured after 10 minutes. Record the observation for five consecutive experiments and the mean was taken.

Stability test

Introductions
Stability of a drug can be define as the time from the date of manufacture and the packaging of the formulation, until its chemical or biological activity is not less than a predetermined level of labeled potency and its physical

characteristics have not changed appreciably or deleteriously. In any design and evaluation of dosage forms for drugs, the stability of the active component must be a major criterion in determining their acceptance or rejection.

Objective of the study

The purpose of stability testing is to predict the quality of drug substance or drug product varies with time under the influence of a variety of environmental factors such as temperature, humidity and light, enabling recommended storage condition, re-test periods and shelf-lives. Generally, he observation of the rate at which the product degrades under normal room temperature requires a long time. To avoid this undesirable delay, the principles of accelerated stability studies are adopted. The international Conference on Harmonization (ICH) Guidelines titled "stability testing of New Drug substance and products" (QIA) describes the stability test requirements. In the present work stability study was carried out for the optimized formulation at 40ºC±2ºC/75%RH±5%RH for one month

RESULT AND DISCUSSION

Determination of Organoleptic Characteristics:

The organoleptic quality of a Natural substance refers to its appearance. odour, colour. and taste. The study's first stage is to characterize these features, which assists in the primary identification of the Natural substance as well as estimating the probability of patient acceptability of the raw materials odour, taste and colour as well as its probable inclusion in the final dose form. Changes in the colour and odour of the raw material in the formulation might sometimes indicate changes in the formulation's stability (ander identical conditions).Therefore a soap containing a combination of surfactant is necessary.

Solubility

Solubility is defined as the ability of the substance to soluble in a solvent. One gram of the powder is weighed accurately and transferred into a beaker containing 100 ml of water. This was shaken well and warmed to increase the solubility. Then cooled and filter it, the residue obtained is weighed and noted

ATR -FTIR Sprctra Analysis

The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR- FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample holder. The result shown in the fig no: 1

Compatability studies

Physical compatibility studies

The physical mixture of drag and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak Following a weak. the samples are examined for any physical changes such as discoloration, odour. etc..

Chemical compatibility studies

These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wavenumber ragion of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded. The result shown in the fig no: 2

Determination of pH test :

The pH of all the prepared formulations was determined by using Digital pH Meter. The formulations were dissolved in 100 ml of distilled water and stored for two hours. The measurement pH of formulation was done in previously calibrated ph meter. The result shown in the table no: 2

Irritancy:

The skin irritancy test was performed on the herbal formulation .There is no redness or irritancy in the preparation .The condition was seen for 24 hrs. The result shown in the table no: 3

Foam ability:

For the determination of the herbal for its ability to form foam about 1.0gm of mouthwash was taken and was dissolved in distilled water (about 50ml) in 100ml graduated measuring cyclinder. The result shown in the table no: 4

Retention time of foaming

Foam retention time refers to the time for which the foam produced by the soap retains. The above procedure was repeated and the foam internal was measured for about 5-10 minutes. The result shown in the table no: 5

Stability studies

Stability studies were performed in accordance with ICH guidelines for accelerated testing with required modifications. The sample taken formulation was taken and kept at room temperature (30± 2°C) as well as refrigerator (4+2°C) for duration of one month. The samples were tested for their physical appearance, pH, viscosity,% cleaning action. The result shown in the table no: 6

CONCLUSION

Herbal formulations are also safe to use as a gargle because their systemic availability in trace amounts has no negative consequences. The current liquid herbal mouthwash can go a long way toward assisting folks in overcoming foul breath and a variety of dental ailments. Furthermore, we may rest confident and take comfort in the fact that this meal contains no unhealthy substances. The findings of the physicochemical examination show that the colour and odour of the current herbal formulation are acceptable, with a pleasant odour and better after effects. The zone of inhibition data also revealed that this herbal mouth rinse was proven to be an effective plaque inhibitor, and that the patients favoured it because of its taste, ease of use, and test duration in their mouth after rinsing. As a result, these can be utilised in conjunction with mechanical therapy to cure plaque.The current study has a significant impact on the development of an effective and low-cost herbal oral health intervention for low-income areas. However, because this was a short-term study, longer trials with larger samples are required. The natural herbs included in this formulation have been shown to help with oral hygiene. These herbs have been proven to work miracles for years and decades, as evidenced by several research findings. This herbal mouthwash can be used to quickly rinse one's mouth and keep one's mouth free of a variety of oral health disorders.

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Tabel.No: 1 Composition of formulation table

INGREDIENTS	FORMULATION CODE				
	F1	F2	F3	F4	F5
Aleppo oak	10gm	10 gm	10gm	10gm	10gm
Clove	5gm	5gm	5gm	5gm	5gm
Cinnamon	2 gm	2gm	2m	2gm	2gm
Liquorice	5gm	5gm	5m	5gm	5gm

Table.no: 2Determination of pH test

Formulation.No:	pH Range
F1	5.1
F2	5.3
F3	5.5
F4	5.4
F5	5.6

Table .no: 3Determination of irritant

Formulation.No:	Skin irritant
F1	Non-irritant
F2	Non-irritant
F3	Non-irritant
F4	Non-irritant
F5	Non –irritant

Table.no : 4 Determination Foam forming ability

Formulation.No:	Foam index
F1	25cm
F2	20cm
F3	16.5cm
F4	10cm
F5	8cm

Table.no :5 Determination of Retension time of foam

Formulation.No:	Retension time
F1	15 minutes
F2	13minutes
F3	10 minutes
F4	6minutes
F5	5minutes

Table.No: 6 Determination of stability studies

Parameters	Initial	After one month 40/75(⁰c/RH)
Apperaence	Penny brown	Penny brown
pH	5.5	5.6
Foam index	16.5cm	15cm
Foam retension time	10mins	8mins
irritant	Non irritant	Non irritant

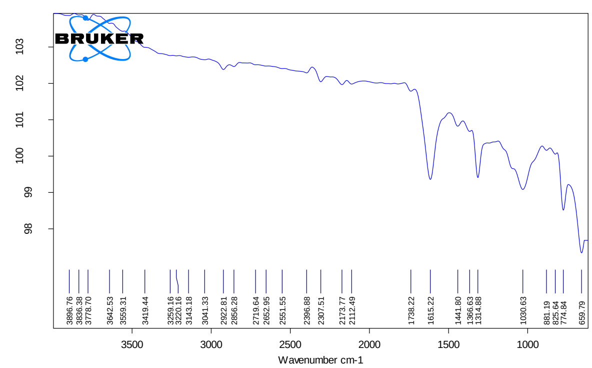

Fig.No. 1 ATR-FTIR spectrum of *Aleppo oak*

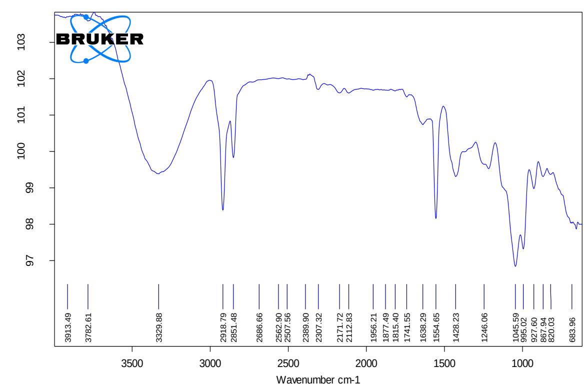

Fig.No.2 ATR-FTIR spectrum of herbal mouthwash formulation

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RESEARCH ARTICLE

Formulation and Evaluation of Herbal Mosquito Repellent Gel by using Natural Oils

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ABSTRACT

DEET-based insect repellents have been discovered to be particularly dangerous to people with urea cycle diseases, such as ornithine transcarbamylase (OTD) deficiency, and are hence contraindicated in these people. These circumstances have prompted the development of natural mosquito repellents that are low-cost, effective, non-toxic, environmentally benign, and biodegradable. A carbopol 940 based mosquito repellent gel formulation was created using the essential oils of *Cymbopogon citratus*, *Szygium aromaticum*, and *Azadirachta indica*, and then evaluated for appearance, pH, viscosity, spreadability, extrudability, Mosquito repellency cage test and accelerated stability testing. The mosquito repellent potential was assessed. In several developing countries where the majority of people lack access to mosquito nets, high-cost mosquito repellant creams, and other physical methods, this gel formulation could be an effective, inexpensive, and easily accessible way to protect the poor from mosquito-borne diseases such as malaria and dengue fever.

Keywords: OTD, Mosquito repellency, *Cymbopogon citratus*, *Szygium aromaticum*, *Azadirachta indica*,

INTRODUCTION

Mosquito Repellent Gel

Mosquitoes are flies that belong to the Culicidae family of insects. There are about 3000 mosquito species worldwide. The World Health Organization estimates that mosquito-borne diseases kill 725,000 people per year. A staggering

200 million people are affected by malaria, with 600,000 dying. Dengue fever and yellow fever are both mosquito-borne diseases that can be fatal [1].

Mosquito undergoes complete metamorphosis consisting of four stages as follows

100-250 eggs are laid on the water's surface. This level is available for 1-2 days. The larva is a free-swimming creature with an elongated body that is divided into three sections: head, thorax, and abdomen, as well as a voracious feeder. Larvae go through four phases of development called "instars," with molting in between. This period lasts for about 5-7 days. The presence or absence of a syphon tube depends on the larva's species. (respiratory tube) The pupa is comma-shaped in form, with a wide rounded cephalothorax and a small abdomen. It depicts the mosquito's resting stage in its life cycle; it does not feed, and respiratory tubes or trumpets protrude from the thorax's upper surface. Its pupal stage lasts about a day and a half. The pupal skin breaks along the back when the development is finished, revealing the adult mosquito, or imago. After resetting for a while, it flies away on the pupal skin to allow its wings to develop and stiffen. Adult mosquitos have a lifespan of around two weeks. Males have a shorter lifespan than females. The life cycle from egg to adult can be completed in 7-10 days2 at ideal temperature and feeding conditions [2].

What Is Mosquito Repellent?

A mosquito repellent is a substance designed to keep away mosquitoes, thereby preventing them from biting humans and feeding on human blood. It typically contains an active ingredient to the desired concentration and helps in releasing the active ingredient when needed. Mosquito repellents are available as creams, lotions, and sticks, applied directly on the skin [3].

Repelling Action

Mosquito repellents work by interfering with insects' homing system. This homing system, located in the antennae, consists of chemical receptors are stimulated by lactic acid that naturally evaporates from the skin of warm-blooded animals. When a repellent ingredient is applied to the skin. The mosquito, therefore, is unable to "find" the person to bite [4].

Topical Drug Delivery System

A topical drug delivery system (TDDS) is a method of delivering medications to the skin for topical therapeutic effects. Pharmacists use the skin to deliver various medications because it is one of the largest and most superficial organs in the human body. This system usually has a local influence on specific body postures. In ancient times, people used herbs to wounds to reduce inflammation or as pain relievers. Topical drug delivery systems are now used for a variety of purposes, ranging from smoking cessation to cosmetic enhancement. There are a variety of topically applied dose forms available today, including creams, ointments, lotions, patches, dusting powder, and more.This drug delivery technique has a number of advantages, including avoiding first-pass metabolism, which can boost bioavailability, being convenient and quick to apply to a large region, being simple to stop the treatment, and avoiding gastro-intestinal irritations. All of these factors have the potential to improve patient compliance [5].

Gels

Gels are semisolid compositions containing small inorganic particles or big organic molecules that are interspersed with liquid. Aqueous, hydroalcoholic, alcohol-based, or nonaqueous vehicles are all possibilities. A natural or synthetic polymer forms a three-dimensional matrix throughout a hydrophilic liquid in a typical polar gel.Gels are appealing drug delivery methods because they are easy to make and can be used to provide medications via the cutaneous, oral, buccal, ocular, nasal, otic, and vaginal routes.Depending on the type of gelling agent employed, gels might seem transparent or turbid.Gelling agents are compounds that, when added to an aqueous mixture, improve its viscosity without significantly altering its other attributes, such as flavour[6].

Advantages

- To ensure optimal cutaneous and percutaneous medication administration, gels are employed.
- They can avoid gastrointestinal medicine absorption problems caused by a low pH in the intestine.
- Gels have the ability to prevent enzymatic activity as well as medication interactions with food and beverages.
- They can be used to replace oral medicine administration when the route is not suited[7].

Disadvantages

- Gels have the potential to cause allergic responses.
- An enzyme in the epidermis has the potential to denature the medicines in gels.
- Drugs with a bigger particle size do not pass through the skin and are not absorbed.
- Some medications have a low permeability through the skin in them.
- Choosing an area that will be thoroughly investigated during the application of gels [8].

MATERIALS AND METHODS

Procedure

- Weight, the amount of carbopol, was soaking for 3 hours in a 100ml distilled water
- Carbopol +Water was homogenized in a mechanical stirrer for 30mins
- Take a 50ml beaker to add 5mg of sodium benzoate dissolved in ethanol. Added the above mixture of Carbopol.
- Mix other ingredients like lemongrass oil, clove oil, neem oil dissolved in ethanol.
- They added the above mixture of homogenized carbopol for continued stirring. Then add the requirement of triethanolamine.
- Then homogenize the above mixture, add a flavoring agent and formulation of gel.

Organoleptic properties

A natural substance's organoleptic quality refers to its appearance, odor, color, and taste. The initial stage of the study is to characterize these properties, which aids in the primary identification of the Natural substance and determining the likelihood of patient acceptability of the raw materials' aroma, taste, and color, as well as their possible inclusion in the final dose form. Changes in the colour and odour of a formulation's raw material might sometimes signal that the formulation's stability has deteriorated (under identical conditions).Compatibility studies.

Physical compatibility studies: The physical mixture of medication and excipient was kept in a Petri dish and stored at normal and high temperatures for a weak in a stability chamber at 45°C/75 percent RH. After a soft, the samples are checked for physical changes such as discoloration, odour, and so forth.

Chemical compatibility studies: These compatibility tests were carried out with an ATR-FTIR spectrophotometer, and the spectra was obtained in the 4000 to 400cm-1 wavenumber range. The natural oils and excipients were thoroughly combined in the mortar until they were completely mixed. The sample was then taken from the mortar and placed in the sample holder's cavity, where the spectrum was recorded.

Evaluation of Formulated Gel

Appearance

The colour, look, and clarity of the mosquito repellent gel formulation were assessed visually. Rubbing the formulation between the fingertips to check for smoothness, clumping, roughness, and uniformity enhanced the smoothness of the gel.

Washability

The washability of formulations was tested by first putting the gel to the skin and then assessing the ease and extent of washing it with distilled water while manually observing the effect.

Measurement of pH

A digital pH metre was used to measure the pH of the gel by dipping the glass electrode entirely into the gel system to cover the electrode. The test was repeated three times, with the average of the three readings recorded.

Viscosity

The viscosity of the gel was measured with a Brookfield viscometer (s-62, model LVDV-E) at 25°C and a viscometer spindle speed of 12rpm.

Spread ability

Two sets of standard-sized glass slides were taken. One of the slides was covered with the herbal gel mixture. The gel was sandwiched between the two slides in an area occupied by a distance of 7.5 cm along the sides after the other slide was placed on top of it. A 100g weight of gel was placed on the upper slides, and the gel was pushed uniformly between the two slides to form a thin layer. The excess gel adhering to the slides was scraped off, and the weight was removed. Only the upper slides were allowed to fall off freely by the force of weight tied on them since the two slides in position were fixed to a platform without the least disruption. A 20g weight was carefully fastened to the upper side. Under the impact of the weight, the time it took for the upper slide to travel 7.5 cm and separate from the lower slider was recorded. The experiment was done three times, with the average time used to calculate the result. spreadability was calculated by using the following formula:

$S=m\times 1/t$

Where s= spreadability, m- weight tied to upper slides, l- length of the glass slide, t-time taken in sec.

Extrude ability

A clamp was placed to prevent any rollback when a closed collapsible tube carrying around 20g of gel was squeezed strongly at the tip. The gel was extruded after the cap was removed. The extruded gel's volume was computed.

Mosquito repellency Test

Cage Test

The Cage test can be used to swiftly and effectively examine the viability of mosquito repellent chemicals for sprays and adsorbed materials. Its goal is to watch mosquitos landing in the cage on untreated and treated fabric. This method shows the human the actual situation of mosquito probing and biting, as well as direct observation of mosquito behaviour toward treated items. Some investigations employed a cage that was 18 X 18 X 18 cm in size, a cage that was 30 X 30 X 30 cm in size, a cage that was 34 X 32 X 32 cm in size, and a cage that was 35 X 35 X 35 cm in size. Two more experiments used cages that were 40 X 30 X 30 cm and 45 X 45 X 45 cm in size, respectively. Transparent mosquito netting are used to conceal the cage and keep mosquitoes out. It features arm access slots that are likewise covered with netting. Fill the cage with 20-30 mosquitos that have been famished overnight and fed just sucrose solution. Updated standards utilise fewer mosquitoes in the cage (as few as 30), as a lower density provides more accuracy, better replicates the actual biting environment seen during most indoor and outdoor activities, and provides a more comfortable atmosphere for volunteers. For the course of the study, volunteers should not smoke or use scent or repellent items. This element may change a person's appeal to mosquitoes, changing the outcome of the repellency test. The right arm was utilised to test the therapies, while the left arm served as a control. Both untreated and treated forearms will be exposed to the mosquito population for three minutes at the same time. If at least two mosquitos land or bite during the first three minutes, the test will continue. The hand will withdraw from the cage after 3 minutes if no mosquitos have been landed. Fig.No.1.2 For an accurate result, the number of mosquitos landing will be counted separately using a digital camera. For the next 8 hours, or until the repellency is gone, the exposition is repeated every 30 minutes.

Mosquito repellency T

Stability Studies

Introductions

The time from the date of manufacture and packaging of the formulation until its chemical or biological activity is not less than a set level of labelled potency and its physical properties have not altered considerably or negatively can be characterised as the stability of a medicine. The stability of the active component must be a major consideration in selecting whether or not to accept or reject dosage forms for medications in any design or evaluation.

Objective of the Study

Stability testing enables recommended storage settings, re-test intervals, and shelf-lives by predicting how the quality of a drug ingredient or drug product changes over time under the effect of various environmental elements such as temperature, humidity, and light. Observing the rate at which a product degrades under typical room temperature takes a lengthy period in most cases. The ideas of expedited stability investigations are used to avoid this unfavourable delay. The stability test requirements are described in the International Conference on Harmonization (ICH) Guidelines under "stability testing of New Drug Substances and Products" (QIA).

RESULT AND DISCUSSION

Pre-formulation studies

Organoleptic properties

The goal of this project was to create a mosquito repellent gel utilising natural oils. The physical description / organoleptic quality of the drug is the first step in recognising the drug substance. It aids in determining the drug's suitability for formulation into the desired dosage form. This also aids in the evaluation of patient acceptability variables such as colour, nature, odour, and taste, which leads to improved patient compliance.

Lemongrass oil

Colour-yellow
Odour- lemony& grassy
Taste- lemon with hints of ginger

Clove oil

Colour- pale yellow
Odour-strong & warm
Taste- sweet& spicy

Neem oil

Colour-pale green
Odour-garlic or Sulphur
Taste-bitter

The API's colour, odour, nature, and taste were assessed, and it was observed in accordance with the monograph. Based on the observations, it was determined that formulating the desired gel dosage form was satisfactory, and that patient compliance was unlikely to be affected.

Compatibility studies

Physical compatibility studies

It can be established by the physical compatibility study that there are no colour changes in the physical mixture, and that all of the excipients are compatible with natural oil. Excipients have no interaction with natural oil, according to the compatibility research, which was conducted at 400 degrees Fahrenheit and 75% relative humidity.

Chemical compatibility studies

The ATR-FTIR spectra of pure drug and produced gel was compared to a study of drug with excipients, and the spectrum was collected in the 4000 to 400cm-1 wavenumber range. These excipients were blended in natural oils according to their functional category. This indicates that the drug is compatible with the formulation components and the results shown in the fig no: 1,2,3&4

Discussion: ATR-FTIR spectroscopy was fixed at the range of 4000-400cm^{-1}. There is no interaction between the drugs and excipients.

Physiochemical parameters evaluation of gel formulation

Appearance

The look, colour, and texture of the produced gel were examined visually. The prepared formulation was light yellow in colour, with a smooth fluid liquid surface and a nice consistency free of lumps.

Washability

All formulation was easily washed with normal water.

pH Measurement

pH readings of the produced gel were taken with a digital pH metre by immersing the glass electrode completely in the gel system and covering it.The following is a summary of the study results shown in table no: 3

Discussion: pH is one of the major evaluation factors in the gel preparation purpose of avoiding the irritation of the skin upon the application.

Determination of Viscosity

The viscosities of formulation F1, F2, F3, F4, F5 mosquito replant gels (model L2MDV-100, RV-7 spindle at 20 revolutions per minute) were determined using a rotational viscometer (model L2MDV-100, RV-7 spindle at 20 revolutions per minute). To take readings for all of the formulations, 100gm of gel was poured in a beaker, and the spindle was immersed in it and rotated for 5 minutes. The results of all the formulations are shown in table no:4

Discussion: The above result shows the viscosity of all the formulations ranging from (3850) to (3867),cps.

The viscosity of gel depends upon the reduction of gelling agent that shows better consistency of (0.3882) cps in (F3) formulation.

Determination of Spreadability:

The formula was used to determine the spreadability. S= sML / T

Discussion: The spreadability of the gel was based upon the viscosity, and it was evaluated from all five formulations range from. The formulation had better consistency, so the gel was easily spreadable by the small amount of shear.

Extrudability:

The Extrudability of the gel was based upon the viscosity, and it was evaluated from all the 5 formulations range from (1.245gm) to(0.208gm) gm. The formulation (F3) has better consistency of the gel.

Stability Study

A stability study was carried out for the optimized formulation according to ICH guidelines at 40°C/75 % RH for one month. The results showed no significant change in the physical and chemical parameters of the gel. Hence the formulation (F3) was found to be stable.

Cage Test Result of Mosquito Repellent

The percentage of mosquito repellency was calculated by using the formula;

Percentage of mosquito repellency = C-T/C

C = No of mosquitos Bites on Control
T= No of mosquitos bites on test (when prepared formulation is applied)

Observation

This indicates that the mosquito bites on the left arm, and while inserting the gel-treated hand, the mosquito gets repelled away. This shows the repellency of the prepared formulation.

SUMMARY AND CONCLUSION

- In the present study, an attempt was made to develop herbal mosquito repellent gel to provide safe and non-toxic to humans using natural oils.
- The physicochemical properties of the drug such as ATR-FITR spectroscopy, organoleptic properties, drug compatibility studies were investigated and confirmed
- Essential oils such as lemongrass, clove, and neem were used to make Carbopol 940-based gel formulations, which were then tested for appearance, PH, viscosity, spreadability, extrudability, and stability according to ICH requirements.
- The mosquito repellent potential was evaluated
- The gel formulation may be an effective, inexpensive, and easily accessible way to prevent mosquito born-disease like malaria, dengue, etc.

ACKNOWLEDGEMENT

The authors are thankful to Dr. B.Jaykar, Professor and Registrar, Vinayaka Mission's Research Foundation (Deemed to be University) and Vinayaka Mission's College of Pharmacy, Salem, Tamil Nadu for extending their support and facilities for this research.

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Table. No: 1 List of excipients

S. No	Materials	Manufactures / Suppliers
1.	Lemongrass oil	VMCP, Salem

2.	Clove oil	VMCP, Salem
3.	Neem oil	VMCP, Salem
4.	Rose oil	VMCP, Salem
5.	Carbopol	VMCP, Salem
6.	Triethanolamine	VMCP, Salem
7.	Ethanol	VMCP, Salem
8.	Sodium benzoate	VMCP, Salem
9.	Purified water	VMCP, Salem

Table. No: 2 Composition of mosquito repellent gel

S. No	Ingredients	F1	F2	F3	F4	F5
1	Lemongrass oil(mg)	2	2	2	2	2
2	Clove oil(mg)	2	2	2	2	2
3	Neem oil(mg)	2	2	2	2	2
4	Carbopol(mg)	0.5	1	1.5	2	2.5
5	Sodium benzoate(mg)	5	5	5	5	5
6	Triethanolamine(mg)	200	400	600	800	1000
7	Ethanol(ml)	10	10	10	10	10
8	Flavouring(qs)	1	1	1	1	1
9	Distilled water(qs)	100	100	100	100	100

Table.no: 3 pH Measurement

Formulation	Ph
F1	7.57
F2	7.57
F3	7.60
F4	7.62
F5	7.60

Table. No: 4 Viscosity measurement

Formulation	Viscosity(cps)
F1	3850
F2	3862
F3	3882
F4	3891
F5	3867

Table .No: 5 Spreadability measurement

Formulation Code	Spreadability (g.cm/sec)
F1	16.38
F2	13.74

F3	10.00
F4	8.05
F5	5.39

Table No: 6 Extrudability measurement

Formulation Code	Extrudability (gm)
F1	1.245gm
F2	1.268gm
F3	0.536gm
F4	0.215gm
F5	0.208gm

Table. No:7 Stability Parameter of selected formulation

Parameters	Initial	After one month 40/75(°C/ RH)
Appearance	light yellow colored	light yellow colored
	Smooth	Smooth
Ph	7.60	7.62
Viscosity	3882	3920
Spreadability	10.00g	9.89 g
Extrudability	0.536g	0.511g

Times of testing	No of Mosquitos Bites on Control	(Left Arm) No of Mosquito Bites on Test	(Right Arm)Percentage of Mosquito Repellency
1	7	0	97%
2	10	4	96%
3	8	0	100%
4	9	0	100%

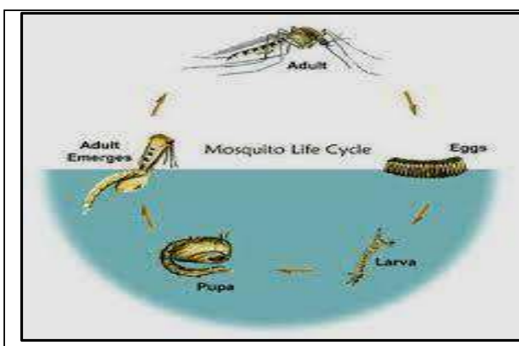
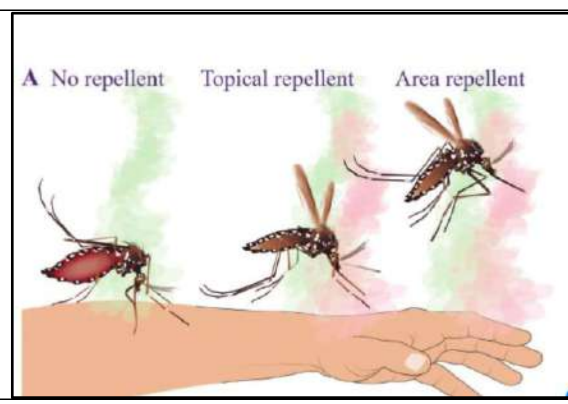


Fig. No.1 Mosquito life cycle



Repelling Action

Mosquito repellency Test - Cage Test

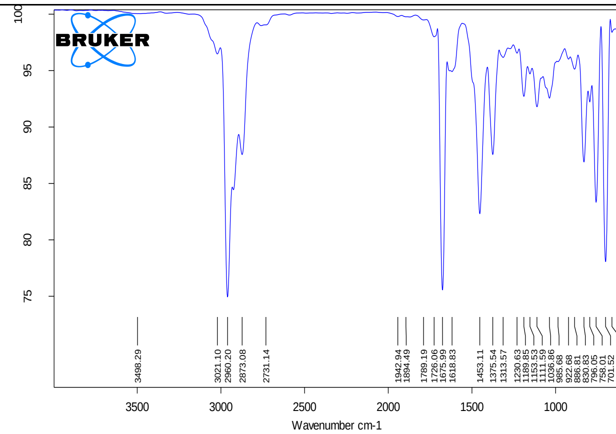


Fig. No:1 ATR-FTIR spectrum of Lemongrass oil

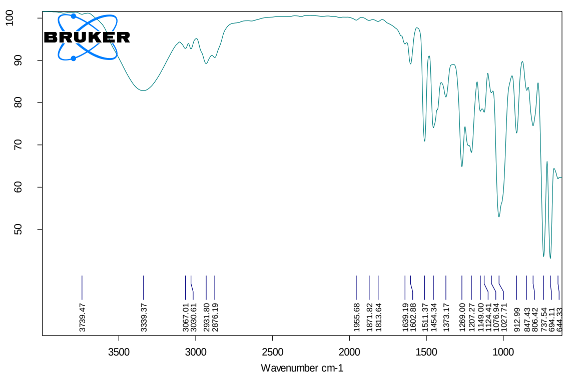


Fig. No:2 ATR-FTIR spectrum of clove oil

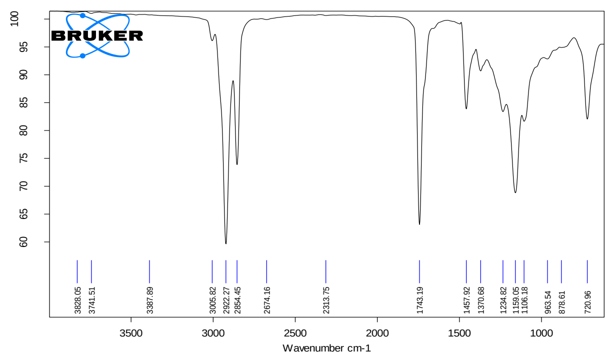


Fig. No: 3 ATR-FTIR spectrum of neem oil

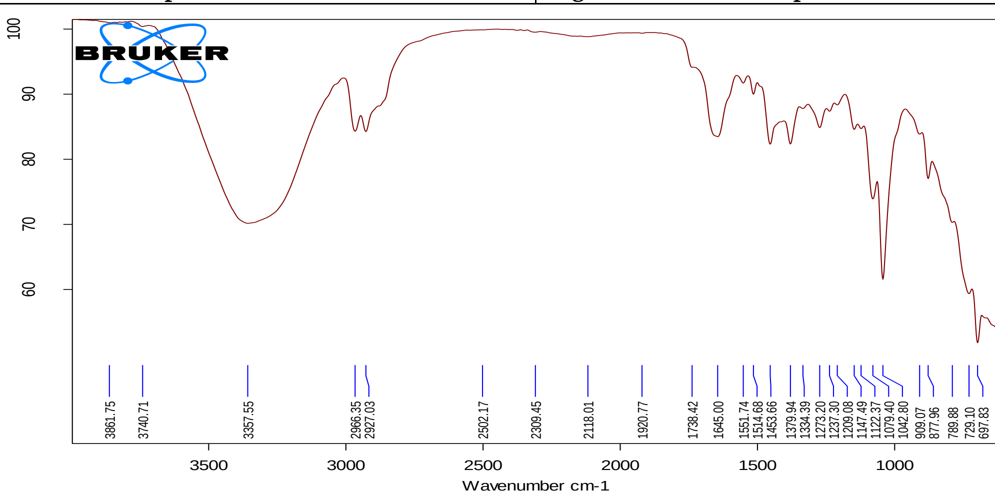


Fig.No: 4 ATR-FTIR spectrum of lemon grass oil+ clove oil+ Neem oil+ Sodium benzoate+ Triethanolamine+ Ethanol+ Flavouring+ Distilled water

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RESEARCH ARTICLE

Formulation and Evaluation of Avocado Herbal Shampoo by using Primary Emulsion Method

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ABSTRACT

The aim of the present study was to formulate and evaluate herbal shampoo containing natural ingredients with an emphasis on safety and efficacy. It clears dirt, dandruff, promotes hair growth, lustre, strengthens and darkens the hair. The cleanser was prepared by taking the avocado seed powder (active ingredient),Aloe vera, and soap nut in different proportions. Several physicochemical tests were performed for visual assessment, wetting time, pH, assurance of solid contents, conditioning performance, foam stability. The formulated herbal cleanser is black in color with demonstrable good froth stability,good cleansing, optimum pH and conditioning activity. Dirt dispersion of herbal shampoo is light along with 25ml foam height. All these are the ideal characters for good quality of the herbal shampoo to be used in daily life. However, further scientific investigation is required for validation of its overall quality.

Keywords: Herbal shampoo, efficacy, avocado seed powder, stability, pH

INTRODUCTION

A shampoo is a cosmetic preparation for washing the hair and scalp that is packaged in an easy-to-use container. Its principal role is to remove accumulated sebum, scalp debris, and hair-grooming preparation residues from the hair. shampoo has other functions such as lubrication, conditioning, bodybuilding, static charge avoidance, medicine, and so forth. Finally, for long-term use, the entire shampoo recipe must be medically safe. Many synthetic shampoo, both medicated and non-medicated, are available on the market today; however, herbal shampoo has become popular owing to its natural origin, which is safer, improves customer demand, and is devoid of side effects. Surfactants (synthetic) are added to synthetic shampoo for their cleaning and foaming properties, but long-term usage causes major side effects such as eye irritation, scalp irritation, hair loss, and hair dryness. shampoo containing natural herbals can be used as an alternative to synthetic shampoo. Formulating cosmetics with entirely natural ingredients, on the other hand, is extremely difficult. A variety of medicinal herbs with possible hair benefits have been utilised for centuries across the world and are now integrated into shampoo formulations. To develop a shampoo containing an only one natural substance which would be safer with milder effect, then the synthetic shampoo is difficult and also it should possess good foaming, detergency, and solid content as such synthetic shampoo. Hence, we considered in detailing an unadulterated natural cleanser utilizing conventional technique using regularly utilized plant material for hair washing. In the present study, herbal shampoo was formulated containing suitable ingredient such as English (butter fruit,avocado,avocado-pear,alligator pear) **fenugreek, (Trigonella foenum-graecum),** rosemary comes from the Latin ros marinus, Acacia concinna, Sapindusindica, Ecliptaprostrata, Aloe barbadensis various amounts.

MATERIAL AND METHODS

Collection And Authentication Of Plant Material

The fruit of persea-americana. L.plant of were collected from foot of hill yercaud salem, Tamilnadu. The plant was then authenticated by ABS Botanical conservation,Research&Training center,kaaripatti,salem-636106

Apparatus :

- A glass measuring cup, a microwave, and a water bath
- Spoon
- Container for shampoo
- Avacado powder.
- Optionally, add goods, color, and aroma to the mix.
- Digital balance.(Table.No.01)

Procedure

- Avocado powder is used to make a herbal shampoo.
- Weghied all of the ingredients according to the instructions.
- In 20 minutes, combine aloe vera, avocado powder, banana leaf powder, soapnut powder, and penugreek powder to gel and heat.
- Filter it using muslin cloth. Get the filtrate.
- The cleanser contains lavender and rosemary oils as flavouring agents.
- To combine the aforementioned filtrate, continuous stirring was used.
- Finally, mixed xantham gum was utilised as a thickening agent, as well as semisolid nature preservatives and perfumes, to keep the herbal shampoos consistency.(Table.No.02)
- Primary emulsion method
- Combine the avocado seed powder, oil, and dry mortar in a mixing bowl. After adding water, rapidly stir until the primary emulsion forms in the mortar.
- As needed, add more water until the primary emulsion thickens and is ready. The main emulsion crackles as it forms.

Purpose

The features of drug-loaded microspheres, such as encapsulation efficiency, release behaviour, and pharmacodynamics, are well known to be influenced by the primary emulsion (w1/o) preparation process (by ultrasonication or homogenization).

Evaluation of herbal shampoo

Quality control tests were done on the prepared formulations, including organoleptic and physicochemical characteristics such as pH, solid content, and viscosity. Specific tests for cleanser formulations, such as surface tension, foam volume and foam stability, detergency, eye irritation, skin sensitization tests, and a preliminary stability study, were also conducted to assure the quality of the goods. The results were compared to a commonly used herbal cleaner that was utilised as a reference.

Physical appearance/visual inspection

The physical appearance and ocular assessment of all samples were observed. The clarity, foam-producing capabilities, and fluidity of the prepared Formulations were assessed

Determination of pH

Using pH paper, the pH of a cleaner solution (10%w/v) in distilled water was tested at room temperature.

Foam, foam stability

200 mL surfactant solution is poured into a glass column containing 50 mL sane solution; the height of foam formed is measured immediately and again after a predetermined time period, and is proportional to the volume6.

Solid content

- Weighed a clean, dry china dish and added 4 grammes of cleaner.
- The cleanser dish was quite heavy. The exact weight of the cleanser was calculated.
- The cleanser-filled porcelain dish was placed on a hot plate to evaporate the liquid component. The weight was estimated after drying.

Test for wetting

Wetting time is the time it takes for the canvas paper to completely absorb water, as estimated by nothing. A disc of canvas paper weighing 0.44g was cut out with a diameter of 1 inch. The canvas paper disc was placed over the cleanser (1 percent v/v) surface and the time it took for the paper to sink was recorded using a timer.

Washability test

5gm sample of solid human hair is placed at 35%e in 200cc of water containing of Igm of shampoo. The flask is shaken 50 times in a minute for 4 minutes. Then washed once again with sufficient amount of water, then filter after the hair dried and weighed. The amount of soil removed under this condition is calculated by using the following equation.

Skin irritancy

Skin irritancy of shampoo can be checked by taking small amount of product on skin, after few minute to check whether local irritation or any inflammatory reaction are produce or not

Viscosity

The viscosity of the shampoo was determined by using Brookfield Viscometer LVDV Prime-I.The viscosity of shampoo was measured at room temperaturei.e. 30+2°C with varying rpm and torque.

Extrudability

The method adopted for evaluating ointment formulation for extrudability was based upon the quantity in percentage of ointment extruded from tube on application of certain load. More the quantity extruded better was its extrudability. The formulations were filled into a clean, lacquered aluminium collapsible one- ounce tube with a 5 mm opening. It was then placed in between two glass slides and was clamped. Extrudability was determined by weighing the amount of ointment extruded through the tip when a constant load of1kg was placed on the slides and ointment extruded was collected and weighed. The percentage of ointment extruded was calculated. The comparative extrudability of the formulations is noted.

Stability studies

Stability studies were performed in accordance with ICH guidelines for accelerated testing with required modifications. The sample taken formulation was taken and kept at room temperature (30± 2°C) as well as refrigerator (4+2°C) for duration of one month. The samples were tested for their physical appearance,pH,viscosity,% cleaning action.

RESULT AND DISCUSSIONS

Solubility

Solubility is defined as the ability of the substance to soluble in a solvent. One gram of the powder is weighed accurately and transferred into a beaker containing 100 ml of water. This was shaken well and warmed to increase the solubility. Then cooled and filter it, the residue obtained is weighed and noted.

ATR -FTIR Sprctra Analysis

The spectrum was captured between the wavelengths of 4000 and 400cm-1. An ATR- FTIR spectrum was obtained using an ATR-FTIR spectrophotometer after a sample was directly put into the cavity of the sample holder.

Compatability studies

Physical compatibility studies

The physical mixture of drag and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak Following a weak. the samples are examined for any physical changes such as discoloration, odour. etc..

Chemical compatibility studies

These compatibility studies are conducted by using an ATR-FTIR spectrophotometer and the spectrum was recorded in the wavenumber ragion of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect the sample from mortar and placed in the cavity of the sample holder and the spectrum was recorded.(Fig.No.2 ,3)

Evaluation result of avocado herbal shampoo for best formulation F-3

Determination of pH

Using pH paper, the pH of a cleaner solution (10%w/v) in distilled water was tested at room temperature. (Table.No.2)

Foam, foam stability

200 mL surfactant solution is poured into a glass column containing 50 mL same solution; the height of foam formed is measured immediately and again after a predetermined time period, and is proportional to the volume6.9(Table.No.3)

Solid content

Weighed a clean, dry china dish and added 4 grams of cleaner.

The cleanser dish was quite heavy. The exact weight of the cleanser was calculated.

The cleanser-filled porcelain dish was placed on a hot plate to evaporate the liquid component. The weight was estimated after drying.(Table.No.4)

Test for wetting

Wetting time is the time it takes for the canvas paper to completely absorb water, as estimated by nothing. A disc of canvas paper weighing 0.44g was cut out with a diameter of 1 inch. The canvas paper disc was placed over the cleanser (1 percent v/v) surface and the time it took for the paper to sink was recorded using a timer.Table.No.5)

Washability test

5gm sample of solid human hair is placed at 35%e in 200cc of water containing of Igm of shampoo. The flask is shaken 50 times in a minute for 4 minutes. Then washed once again with sufficient amount of water, then filter after the hair dried and weighed. The amount of soil removed under this condition is calculated by using the following equation.(Table.No.6)

Viscosity

The viscosity of the shampoo was determined by using Brookfield Viscometer LVDV Prime-I. The viscosity of shampoo was measured at room temperature i.e. 30+2°C with varying rpm and torque.(Table.No.7)

Skin irritancy

Skin irritancy of shampoo can be checked by taking small amount of product on skin, after few minute to check whether local irritation or any inflammatory reaction are produce or not.(Table.No.8)

Extrudability

The quantity in percentage sunscreen lotion extruded from tube on application of finger pressure was used as the basis for evaluating sunscreen lotion formulation for extrudability in the current study. Extrudability improved as the quantity extruded increased. The study formulation was placed in a clean, lacquered aluminium collapsible 5 gm tube with a 5 mm nasal tip opening, and pressure was applied to the tube using a finger. The amount of lotion extruded through the tip when a pressure was applied to a tube was then measured to assess tube extrudability.(Table.No.9)

Stability studies

Stability studies were performed in accordance with ICH guidelines for accelerated testing with required modifications. The sample taken formulation was taken and kept at room temperature (30± 2°C) as well as refrigerator (4+2°C) for duration of one month. The samples were tested for their physical appearance,pH,viscosity,% cleaning action.(Table.No.10)

SUMMARY AND CONCLUSION

The present study, we formulated an herbal shampoo containing avocado seed powder which is traditionally used for hair cleansing in India. The present study was carried out with aim of preparing herbal shampoo that reduces hair loss during combing, safer than the chemical conditioning agents to strengthen the hair growth.

ACKNOWLEDGEMENT

The authors are thankful to Dr. B.Jaykar, Professor and Registrar, Vinayaka Mission's Research Foundation (Deemed to be University) and Vinayaka Mission's College of Pharmacy, Salem, Tamil Nadu for extending their support and facilities for this research.

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Tabel.No:1.Composition Of Herbal Shampoo

S.NO	INGREDIENTS	F1	F2	F3	F4	F5
1	Avocado powder	30mg	30mg	30mg	30mg	30mg
2	Banana leaf powder	50mg	100mg	150mg	200mg	250mg
3	Aloe vera	2ml	2ml	2ml	2ml	2ml

4	Rice water	5ml	5ml	5ml	5ml	5ml
5	Xantham gum	5mg	7mg	10mg	13mg	20mg
6	Sodium benzoate	5mg	7mg	10mg	16mg	20mg
7	Rosemary oil	1.5ml	1.5ml	1.5ml	1.5ml	1.5ml
8	Lavender oil	2ml	2ml	2ml	2ml	2ml
9	Coconut oil	2ml	4ml	6ml	8ml	10ml
10	Fenugreek	50mg	50mg	50mg	50mg	50mg
11	Soapnut powder	25mg	50mg	75mg	100mg	125mg

Tabel.no:2. Determination of pH

Formulation.No:	pH Range
F1	6.1
F2	6.3
F3	6.6
F4	6.4
F5	6.5

Tabel.No:3.Determination Of Foam Height

Formulation No:	Foam Height
F1	14cm
F2	17cm
F3	30cm
F4	40cm
F5	55cm

Tabel.No:4.Determination Of Solid Content

Formulation No:	Solid Content
F1	13.14%
F2	19.21%
F3	23.25%
F4	25.27%
F5	28.29%

Tabel.No:5 Determination Of Wetting

Formulation No:	Wetting Time
F1	90s
F2	95s
F3	96s
F4	100s
F5	106s

Tabel.No:6 Washability Test

Formulation No:	Washability
F1	35.22%
F2	36.67%
F3	40.08%
F4	30.35%
F5	32.78%

Tabel.No:7 Determination Of Viscosity

Formulation No:	Viscosity
F1	1759
F2	1519
F3	2115
F4	4326
F5	4621

Tabel.No:8determination Of Skin Irritancy

Formulation No:	Skin irritancy
F1	No irritation on skin
F2	No irritation on skin
F3	No irritation on skin
F4	No irritation on skin
F5	No irritation on skin

Tabel.No:9 Determination Of Extrudability

Formulation No:	Extrudability
F1	2.354 gm
F2	0.621 gm
F3	1.579 gm
F4	1.894gm
F5	2.109gm

Tabel.No:10 Determination Of Stability Studies

Formulation No:	Stability studies
F1	Stable after 10 days
F2	Stable after 30 days
F3	Stable after 60 days
F4	Stable after 35 days
F5	Stable after 40 days

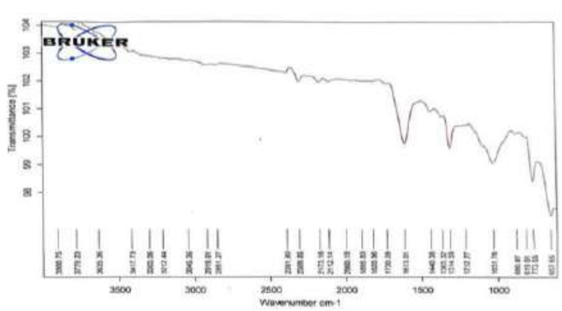

Fig.NO:1 ATR-FTIR Of Avocado seed powder

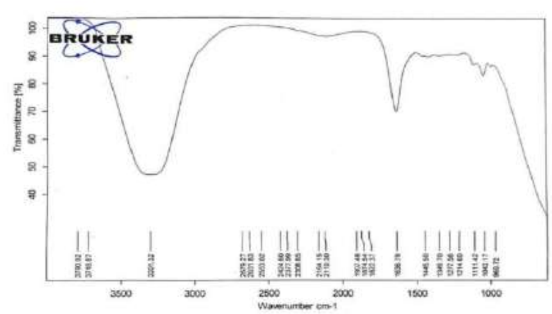

Fig.No:2 ATR-FTIR Of Avocado seed powder +Aloe vera+ Fenugreek +Rose mary oil+ Soapnut powder mixture

RESEARCH ARTICLE

Formulation and Evaluation of Triphala Gel for Bleeding Gums

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ABSTRACT

The objective of the present study was to design gel with the help of triphala powder. The purpose of this article is to promote research on gel in the presence of polyherbal ayurvedic medicine triphala powder. It consists of three fruits of plant species namely *Emblica officinalis* (Amalaki), *Terminalia bellerica* (Bibhitaki), *Terminalia chebula* (Haritaki).This article helps us to understand the role of triphala gel in dentistry which is particularly useful in the case of stopping bleeding gums caused by gum disorders like gingivitis and periodontitis. The formulation of triphala gel was prepared using HPMC, Carbopol, Triethanolamine, Ethanol, and Glycerol in four different batches. Formulated gel was evaluated for appearance, pH, viscosity, spread ability, in vitro studies and compatibility studies are done by ATR-FTIR Spectral analysis.

Keywords: Gingivitis, periodontitis, plaque inflammation, gel.

INTRODUCTION

Gels are homogeneous, semisolid preparations suitable hydrophilic or hydrophobic bases.Gels are typically formed by thickening a liquid phase with other components. They are typically made with appropriate gelling agents such as HPMC and Carbopol. As additives in the formulation of gels, substances such as antioxidants, stabilizers, and antimicrobial preservatives are used.[1]Gels are two-phase systems in which inorganic particles are not dissolved but are simply dispersed throughout the continuous phase and large organic particles are dispersed.[2]This results in gel classification into chemical and physical gel systems, respectively. Chemical gels are characterized by permanent covalent bonding, whereas physical gels are characterized by secondary intermolecular forces that are relatively weaker and reversible, such as hydrogen bonding, electrostatic interactions, dipole-dipoleinteractions, Vander Waals forces, and hydrophobic interactions. [3] Triphala is one of the most widely used drugs in the Indian medical system. Triphala (Sanskrit; tri=three, phala=fruits) is a well-known polyherbal medicine made up of three fruits from three different plant species.[4]They are *Emblica officinalis, Terminalia chebula, Terminalia bellerica.*[5]A reference to the Indian belief that triphala protects internal organs in the same way that a mother protects her children. Triphala helps in medical properties such as Antihyperlipidemic, Immunomodulatory, Anti-inflammatory, Anti-arthritic, Analgesic Antipyretic,Ulcerogenic-activities,Anticancer-activity,Antibacterial-activityAntidiabetic-activity,Wound healing activity[6].Bleeding gums may indicate that you have or are at risk of developing gum disease. Ongoing gum bleeding could be caused by plaque buildup on the teeth. It can also be a sign of serious medical condition [7]. Plaque buildup at the gum line is the primary cause of bleeding gums. This will result in gingivitis, or inflamed gums[8].Gum diseases can be divided into two types. They are Gingivitis and Periodontitis. [9-10].The aim of the present article was to formulate and evaluate triphala gel for bleeding gums.

MATERIALS AND METHODS

Materials

Triphala powder was collected from Health care pharmakon, Chennai. HPMC (K4M,K15M), glycerol, triethanolamine, ethanol, Tween 80 were purchased from VMCP, salem. All the chemicals and reagents used were of analytical grade only. ATR-FTIR, Digital Balance, Magnetic stirrers, pH meter (Digital), Bathsonicator, Brookfield viscometer.

Preparation of Triphala Gel

Accurately weight quantity of drug, HPMC (polymer) and tween 80 as stabilizer are dissolved in glycerol while stirring. Prepare aqueous phase containing Carbopol dissolved in water with continuous stirring and heat. This drug containing phase is sonicated on ultra-sonic bath sonicator. The drug phase is added drop by drop into the aqueous phase during homogenization to form o/w emulsion. The emulsion converted into droplets by homogenization. Homogenization was continued for one hour. Triethanolamine added to form the gel with continuous stirring to form a gel. The composition of various excipients used in formulation is listed in Table.No:1

Evaluation of Triphala Gel

Preformulation and evaluation studies were performed on the prepared gel.

(a)Organoleptic properties

Organoleptic properties aid in the primary identification of the drug ingredient as well as estimating the likelihood of patient acceptability of the raw materials odour, taste, and colour, as well as its likely inclusion in the final dose form. Changes in the colour and odour of the raw material in the formulation can sometimes indicate that the formulation's stability has changed (identical conditions).

(b)Solubility tests

In a variety of physiological environments, the organic solubility of triphala powder was determined as a function of pH. The drug's solubility in various solvents, including chloroform, water, and a diethyl ether, was investigated.

(c)ATIR - FTIR spectral analysis

The spectrum was captured at wavelengths ranging from 4000 to 400cm-1. After placing a homogeneous mixture of the drug in the sample holder's die cavity and recording the spectrum, an IR spectrum was obtained using an ATR-FTIR spectrophotometer.

(d)pH Determination

Using a digital pH meter, the gel pH was measured by completely immersing the glass electrode in the gel to cover the electrode. The measurement was performed in triplicate, with the average of the three readings used.

(e) Viscosity
The viscosity of the prepared gel was measured at 50 rpm and 25oC using a brook field viscometer and a spindle # 7. The corresponding deal reading on the viscometer was recorded, and the spindle was gradually lowered. The factor was applied to the deal reading.
(f) Spread ability
Two standard-sized glass slide sets were taken. The gel formulation was applied to one of the slides. After the other slide was placed on top of it, the gel was sandwiched between the two slides in an area occupied by a distance of 7.5 cm along the sides. On the upper slides, a 100g weight of gel was placed and uniformly pressed to form a thin layer between the two slides. The weight was secured to a stand with no movement and in such a way that only the upper slides could freely slip off due to the force of the weight tied to it. On the top side, a 20g weight was attached. The following formula was used to calculate spread ability:
S=m×1/ts
Where s is the spread ability, m is the weight tied to the upper slides, l is the length of the glass slide, and t is the time taken in seconds.
(g)Extrudability
In the current study, the amount of gel extruded from the tube when finger pressure was applied served as the basis for evaluating gel formulation for extrudability. As the quantity extruded increased, so did the extrudability. The study formulation was placed in a clean, lacquered aluminum collapsible 5 gm tube with a 5 mm nasal tip opening, and the tube was pressed with a finger. To assess tube extrudability, the amount of gel extruded through the tip when pressure was applied to a tube was measured.
(h) *In vitro* drug release
A Franz diffusion cell was used for in vitro drug release. The Triphala gel is in the recipient compartment, and the pH 7.4 buffer is in the donor compartment. Samples were taken at 12-hour intervals. Withdrawn samples were then analyzed in a UV Spectrophotometer at 278 nm for drug release.
(i)Stability studies
Stability testing predicts how the quality of a drug ingredient or drug product changes over time as a result of various environmental elements such as temperature, humidity, and light, allowing for recommended storage settings, re-test intervals, and shelf-lives. In most cases, observing the rate at which a product degrades at standard room temperature takes a long time. To avoid this unfavorable delay, the concepts of expedited stability investigations are used. The International Conference on Harmonization specifies the requirements for stability tests (ICH). "Guidelines for stability testing of novel drug compounds and products" (QIA). For one month, the optimised formulation was subjected to a stability study at 400°C and 75% RH.

RESULT AND DICUSSION

The prepared gel was visually inspected for the appearance, colour, and texture. All formulations were light brown in colour and odorless. Physical appearances of all formulation are opaque in nature. Colour: Light brownish colour, Odour: Unpleasant odour, Smoothness: Good, taste: salty and sour. The triphala powder is soluble in distilled water and the solubility was found to be 10mg/ml. ATR-FTIR spectroscopy was fixed at the range of 4000-400cm^{-2}.There is no interaction between drug and excipients and the Fig. No 1 and Fig. No 2 are listed below. Formulation of prepared gel which indicates the study result of pH ranging from 6.2 to 6.7. Among this studied formulation F1 to F4 formulation F1 show pH value of 6.2 which was optimal range compare to rest of these formulation. Viscosity of all the formulations range from (1657cps) to(1607cps).F1 Shows a better consistency with viscosity level of 0.893 cps. The spread ability of the gel was determined by its viscosity and was evaluated across all four formulations. The extrudability of the gel was based upon the viscosity, and it was evaluated from all the four formulations .The formulation (F1) having better consistency of the gel. When compared to other formulations, F1 has superior spread ability. Because the F1 had a better consistency, the gel could be easily spread with a small amount of shears The stability studies for triphala powder as gel were carried out for about 1month. The ph, viscosity, spreadability, extrudability, *In vitro* drug release of all the formulations was found. The results were tabulated below the Table.No:2, 3, 4,5,6,and 7.

CONCLUSION

In the present research work an attempt was made to develop triphala gel for bleeding gums. The preformulation studies are conducted and also the evaluation studies are conducted at four different formulations. The stability studies for the triphala gel formulation were conducted for a period of one month. The study results indicated negligible level of changes were observed. *In vitro* drug release was found to be 93.98% at 40°C/75 % RH for one month. As a result was revealed to be the formulation (F1) and all of the reports are within the specification ranges at refrigerated stability studies.

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Table.No 1: Formulation of Triphala Gel

Formulation code	**F1**	**F2**	**F3**	**F4**
Triphala powder(gm)	10	10	10	10
HPMC(gm)	0.15	0.3	0.25	0.8
Tween 80	0.1	0.4	0.6	0.9
Glycerol	5	11	16	20
Carbopal(gm)	0.5	0.2	0.4	0.3
Triethanolamine	2	4	5	7
Water(make upto)	100	100	100	100

Table.No:2 pH Measurement

Formulation code	**pH**
F1	6.2
F2	7.6
F3	6.4
F4	6.7

Table.No:3 Viscosity Measurement

Formulation code	**Viscosity(cps)**
F1	1657cps
F2	1627cps
F3	1617cps
F4	1607cps

Table.No:4 Spread ability Measurement

Formulation code	**Spreadability(g.cm/sec)**
F1	94.22(g.cm/sec)
F2	90.42(g.cm/sec)
F3	86.62(g.cm/sec)
F4	84.03(g.cm/sec)

Table.No:5 Extrudability Measurements

Formulation code	**Extrudability (gm)**
F1	31.23
F2	24.34
F3	15.54
F4	12.43

Table.No: 6 *In vitro* Drug Release

S.No	**Time(hr)**	**F1**	**F2**	**F3**	**F4**
		% of drug release			
1	0	0	0	0	0
2	1	16	15	12	10
3	2	27	26	25	21
4	3	39	38	37	33
5	4	42	41	38	36
6	5	56	55	52	50
7	6	64	63	60	58

8	7	73	72	70	69
9	8	79	78	76	74
10	9	85	84	80	79
11	10	89	88	86	84
12	11	90	89	87	85
13	12	93	91	88	87

Table. No: 7 stability parameter of selected formulation

Parameters	**Initial**	**After one month 40/75(°C/ RH)**
Appearance	Pale brown colour	Pale brown colour
Feel on Application	Smooth	Smooth
Ph	6.2	6.3
Viscosity	0.893cps	0.946cps
Spreadability	94.22(g.cm/sec)	92.22(g.cm/sec)

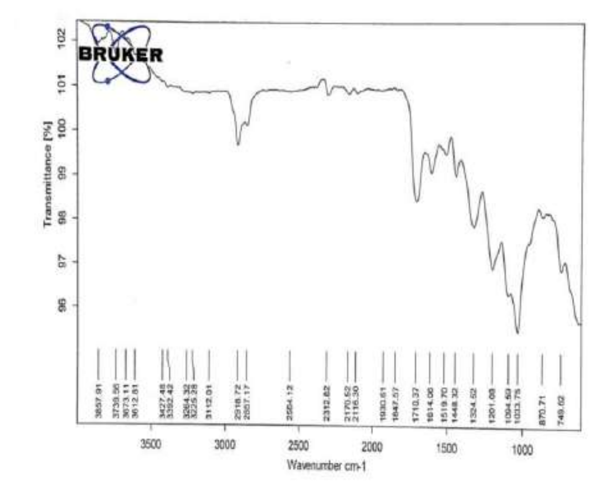

Fig.No1: ATR-FTIR spectra analysis of Triphala powder

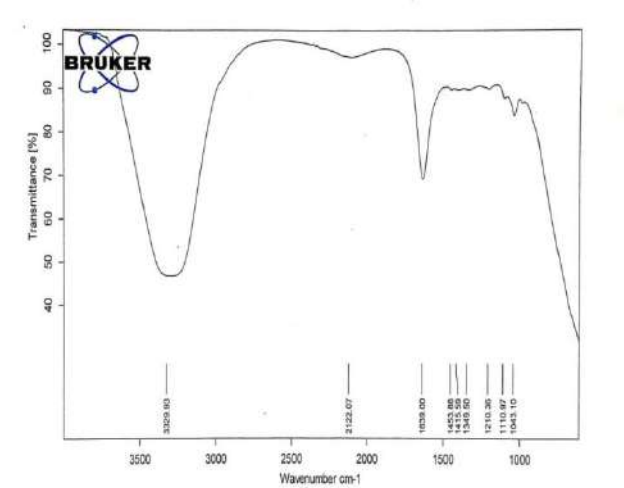

Fig No: 2 ATR-FTIR spectra analysis of formulation of triphala gel

RESEARCH ARTICLE

Development of Herbal Mosquito Repellent Formulations

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ABSTRACT

The present study was conducted to determine the mosquito repellent activities of some selected plant materials to obtain safe and efficient herbal mosquito repellent formulations to prevent humans from mosquito by combinations of the selected plant materials like lemongrass contains (Citronella Oil), turmeric contains (Curcumin), Neem, Eucalyptus oil.

Keywords: Mosquito repellent, Herbal Ingredient, Evaluation test, Stability studies

INTRODUCTION

Mosquitoes are among the most irritating blood-sucking insects that humans have to deal with [37]. Mosquitoes belonging to the Anopheles, Culex, and Aedes genera are vectors for diseases such as Dengue fever, Malaria, Yellow fever, Japanese Encephalitis, and various other ailments. Mosquitoes alone are responsible for transmitting diseases to approximately 700 million people worldwide, with over one million deaths reported each year.

Kingdom : Animalia
Phylum : Arthropoda
Class : Insecta
Order : Diptera
Family : Culicidae [38]

There are a variety of mosquito repellents available on the market nowadays.
Mosquito repellent sprays are widely available and can be applied to clothing or the skin.
According to a previous study, some of the best sprays have high amounts of DEET, but they also have more side effects.

As a result, mosquito repellents containing herbal components are thought to be safer than repellents containing DEET.

What is Mosquito repellent Spray?

A mosquito repellent is a substance that keeps mosquitos away from humans, preventing them from bitting and feeding on their blood. It usually contains an active ingredient that repels mosquitoes and secondary ingredients that, among other things, dilute the active ingredient to a desired concentration and aid in its release when needed. Mosquito repellents come in various forms, including creams, lotions, oils, and sticks that can be applied directly to the skin. They're also available in aerosol and pump-spray forms for use on the skin and clothing. On the other hand, insecticides are used to kill insects, whereas mosquito repellents are used to repel mosquitos.

Mosquito and Mosquito-Borne Diseases

Mosquitoes are one of the most blood-sucking insects that humans face. Several mosquito species from the genera Anopheles, Culex, and Aedes serve as vectors for pathogens that cause diseases such as Dengue fever, Malaria, Yellow fever, Japanese Encephalitis, and other infections. Mosquitoes alone are responsible for transmitting diseases to approximately 700 million people worldwide, with over one million deaths reported each year. Mosquito repellents are used to prevent the spread of these dangerous diseases. So that a herbal mosquito repellent is formulated

Plants Used for the Formulation of Herbal mosquito repellent Spray Formulation

Citronella	(*Cymbopogon nardus)*
Neem	(*Azadirachta indica)*
Turmeric	*(Curcuma Longa)*
Eucalyptus	*(Eucalyptus globulus)*

Cymbopogon nardus (Citronella)

Kingdom	: Plantae
Order	: Poales
Family	: Poaceae
Genus	: Cymbopogon
Species	: C. nardus [1]

Synonyms

Citronella grass, Nardus, Mana grass, Nard grass.

Biological Source

It is the oil obtained by the steam distillation of fresh leaves of *Cymbopogon nardus* (*L.*) Rendle, belongs to the family Poaceae.

Geographical Source

Citronella is native to Southeast Asia and grown commercially in Sri Lanka[2], [3]India, Burma, Indonesia, and Java. In South Florida and southern California, it is grown as ornamental.

Cultivation and Collection

Seeds are used to propagate it. It requires a lengthy, warm-season and may not be able to withstand cool, damp winters. They're planted in the summer at a height of 2,000–3,000 meters above sea level. It necessitates a minimum yearly rainfall of 750 mm. After eight months of growth, the crop is ready to harvest with sufficient irrigation.

Chemical Constituents

Citronella grass has a volatile oil content. Citronellic acid, nerol, citral, borneol, camphene, citronellol, citronellal, dipentene, and limonene

Uses

Citronella grass is the source of commercial citronella oil, which is used as an insect repellent in perfumery. Antiseptic, deodorant, tonic, insecticide, diaphoretic, parasitic, bactericidal, and stimulant are all properties of citronella oil. Citronella oil can be combined with other vegetable oils and used as an insect repellent when applied to the skin.

Eucalyptus globulus

Kingdom : Plantae
Order : Myrtales
Family : Myrtaceae
Genus : Eucalyptus
Species : E. globules [6]

Synonyms

Eucalyptus, Stringy Bark Tree, Bluegum, Blue Gum Tree.

Biological Source

Eucalyptus oil is the essential oil obtained by the distillation of fresh leaves of *Eucalyptus globulus* and other species like *E. polybractea, E. viminalis, and E. smithii*, belonging to the family *Myrtaceae.*

Geographical Source

It is mainly found in Australia, Tasmania, the United States, Spain, Portugal, Brazil, North and South Africa, India, France, and Southern Europe.

Chemical Constituents

The "Blue Gum," Eucalyptus globulus (S. Eucalyptus), is a medium to very tall forest tree that can reach 70 meters in optimum conditions. Eucalyptus globulus, on the other hand, is more usually 15-25 m tall and has a rough, greyish bark that is shed in long ribbons on the top trunk and branches. 1,8-cineole is the major chemical component of eucalyptus oil (60-70 %). In addition, eucalyptus oil contains -pinene (9 %), -pinene (0.4 %), limonene (0.04%), terpene-4-ol (0.3 %), aromadendrene (2.5 %), epiglobulol (0.4 %), and global (2.7 %) [6].

Uses

Stimulant, antiseptic, flavouring agent, fragrant, deodorant, expectorant, antibacterial, febrifuge, diuretic, and antispasmodic are all uses for the oil. It's also used to treat lung disorders, sore throats, colds, and as a vapour bath for asthma, bronchitis, and other respiratory ailments[6].

Curcuma longa (Turmeric)

Kingdom :Plantae
Order : Zingiberales
Family : Zingiberaceae
Genus : *Curcuma*
Species : *C. longa [7]*

Synonyms

Saffron Indian; Haldi (Hindi); Curcuma; Rhizome curcuma.

Biological Source

Turmeric is the dried rhizome of *Curcuma longa Linn*. (syn. *C.domestica Valeton*)., belonging to the family *Zingiberaceae.*

Geographical Source

The plant is native to southern Asia and is cultivated extensively in temperate regions. It is grown on a larger scale in India, China, East Indies, Pakistan, and Malaya.

Chemical Constituents

Turmeric includes curcuminoids (5%) and essential oil, which give it its yellow colour (6 %). Curcumin I (60%) is the main component of the coloring matter, with tiny amounts of curcumin III, curcumin II, and dihydro curcumin also present. Zingiberene

Uses

Turmeric is used as an anti-inflammatory, stomachic, uretic, anodyne for biliary calculus, stimulant, tonic, carminative, blood purifier, antiperiodic, alterative, spice, ointment colouring agent, and a common cold and cough cure. It is applied to the skin as a cream to improve the complexion[9].

***Azadirachta indica* (Neem)**

Kingdom	: Plantae
Order	: Sapindales
Family	: Meliaceae
Genus	: Azadirachta
Species	: A. indica [10]

Biological Source

Neem consists of almost all the parts of the plant which is used as a drug of *Azadirachta indica.* It belongs to the family *Meliaceae.*

Geographical source

India is a native of *Azadirachta.* It is also cultivated in Nepal Pakistan Bangladesh and Sri Lanka. Neem is a fast-growing tree that can reach a height of 15-20 meters, with a chance of reaching 35-40 meters. It is a perennial plant.

Chemical constituents

Quercetin, nimbosterol, and Nimbin are all found in the leaves. Flowers: nimbosterol, kaempferol Bark: Nimbin, nimbidin, nimbosterol Seeds: azadirachtin, azadiradione, Nimbin, vepinin

Uses

Nimbin has anti-inflammatory, anti-pyretic, anti-histamine, and anti-fungal properties. Nimbin has anti-bacterial, anti-ulcer, and anti-fungal qualities. Nimbidol has antitubercular, anti-protozoal, and anti-pyretic activities.

MATERIALS AND METHODS

Organoleptic properties

The organoleptic quality of a Natural substance refers to its appearance, odour, colour, and taste. The study's first stage is to characterise these features, which assists in the primary identification of the Natural substance as well as estimating the probability of patient acceptability of the raw materials odour, taste, and colour, as well as its probable inclusion in the final dose form. Changes in the colour and odour of the raw material in the formulation might sometimes indicate changes in the formulation's stability (under identical conditions).

Compatibility studies

Physical compatibility studies

The physical mixture of drug and excipient was retained in a Petri dish and exposed to storage at normal temperature and high temperature in a stability chamber at 45°C/75 % RH for a weak. Following a weak, the samples are examined for any physical changes such as discoloration, odour, etc.,

Chemical compatibility studies

These compatibility studies were conducted using an ATR-FTIR spectrophotometer, and the spectrum was recorded in the wave number region of 4000 to 400cm-1. Natural oils and excipients were mixed well by using the mortar until complete mixing. Then collect, the sample was from mortar and placed in the cavity of the sample holder, and the spectrum was recorded. Extraction of the Active Ingredients From the Plant Extraction of Citronella from Citronella leaf. The Extraction process was done using Clevenger Apparatus by (Hydro Distillation) process.

Procedure

1. 10 g of Coarsely powdered Citronella leaf were taken and added to the Round bottom with 250 ml of water In a distillation Flask. Add a Few pieces of Porcelain to it(To avoid bumping during distillation)
2. Set up the apparatus as represented in the (figure1)
3. Fill the tubes (Receiver and Return tube) With water by introducing it at side using a pipette.
4. Close the Side Tube
5. For Heating the flask Heating Mantle is Used.
6. Lift the flask at Intervals and Shake the contents, Until the Liquid is Boiling Steadily.
7. The vapor enters into the fractionallating column and enters into the condenser; the vapor gets cooled due to the presence of water in the condenser.
8. And finally, Volatile Oils Gets Separated via the outlet.

Preparation of *Eucalyptus globulus*

Eucalyptus was purchased from the nearby shop

Preparation of *Azadirachta indica* (Neem) Leaf Extract

Fresh neem leaves are collected from neem trees, cleaned, washed with water, and the extraction process is done by Using Soxhlet Extraction Process

Procedure

1. 40g, 50g, and 61.4g of Neem leaves and barks, respectively, were weighed and put into the thimble of the Soxhlet extractor.
2. 300ml of the solvent or ethanol was measured with a measuring cylinder and poured into the still pot of the Soxhlet extractor. The apparatus was then coupled. The condenser unit was connected to an overhead water tank to cool rising solvent vapor.
3. The heat source was a Bunsen burner operating at a temperature of 68°C. The solvent evaporated during the distillation path, thimble, and the expansion adapter, after which it condensed at the condenser unit of the Soxhlet extractor.
4. At this position, the condensed vapor returned to the thimble as liquid droplets and contacted the sample therein.
5. It then broke the sample membranes to release the Neem oil content, which accumulated with the solvent at the siphon (or reflux arm) of the Soxhlet extractor.
6. When the solvent in the thimble rose to the point of the siphon top, the entire content of the thimble and siphon was emptied back into the still pot of the soxhlet extractor.
7. The process was repeated severally for about nine refluxes in three hours, after which the extraction process was completed. The temperature was regulated using a thermometer.
8. After extraction, the resulting liquid was a mixture of the solvent used for extraction and the Neem oil extract.
9. The liquid was discharged into a Liebig condenser to divide the solvent from the oil extract. The mixture was distilled at a temperature of 68°C until the Neem oil extract was utterly free of the solvent.

Diethyl ether was then used to purify the Neem oil extract, after which it was exposed to the atmosphere for a while to ensure the elimination of the solvent odour.

Preparation of Turmeric Extract *Curcuma Longa*

To extract Curcumin from Rhizomes of Turmeric (Curcuma Longa) Soxhlet Extraction Process is Used

Procedure

1. Extract about 50g of Turmeric Powder with 95 % alcohol in a Soxhlet Assembly until all the Colouring matter is extracted.
2. Distill off alcoholic extract to a Semisolid brown colored mass (about 4.5%)
3. Dissolve the crude extract in 50 ml of benzene and extract twice with an equal volume of 0.1% NaOH Solution
4. Combine the alkaline extracts and acidify with dilute. Hcl. A Yellow Coloured Precipitate is Formed. Allow it to settle for about fifteen minutes
5. After Setting of Precipitate, concentrate the extract by boiling on a water bath and at the same time dissolving the residue in boiling, the resinous material would agglomerate and form a lumpy mass.Filter the solution in the hot condition, concentrate filtrate to a minimal volume, and cool to get Curcumin.

Herbal Mosquito Repellent Spray Formulation:

Ingredients

Constituents	(S1)	(S2)	(S3)	(S4)
Citronella essential oil (ml)	10.00	12.00	13.00	15.00
Eucalyptus essential oil (ml)	10.00	10.00	10.00	10.00
Turmeric essential oil (ml)	10.00	10.00	10.00	10.00
Neem extract (ml)	10.00	10.00	10.00	10.00
Ethanol (ml)	50.00	50.0	50.00	50.00
Purified Water (ml)	50.00	50.00	50.00	50.00

Procedure

Weigh the herbal extracts to the measured volume

- Add 10 ml of Citronella Oil in Mortar
- Add 10 ml of Eucalyptus Oil into the mortar, then mix it with Pestle
- Add 10 ml of Turmeric and Neem extract to it until it combines homogeneously
- Ethanol is added
- Makeup to the final volume with a sufficient quantity of purified water.
- Evaluation Test for Herbal Mosquito Repellent [38]

Bio-Efficacy Test

Bio-efficacy tests of the mosquito repellent spray were done outdoor, and indoor field trials were conducted in two days from 6 am to 11 am by separately Spraying the mosquito repellent spray on volunteers' legs. Untreated legs of another volunteer were used as a control for this experiment [28].

Cage Test:

The Cage test may be used to assess the viability of mosquito repellent substances for sprays and adsorbed materials quickly and effectively [37]. Its purpose is to observe mosquitos landing on untreated and treated fabric in the cage. The advantages of this method are that it provides the human with the actual situation of the mosquito probing and biting and direct observation of the mosquitoes' behavior toward the treated materials. Some studies reported cage dimension changes; used a cage 18 X18 X 18 cm dimension, cage 30 X30 X 30 cm dimension, cage 34X 32X 32 cm dimension; dimensions of the cage are 35 X 35 X 35 cm. Two other studies used larger cage dimensions, measuring 40 X 30 X 30 cm and 45 X 45 X 45 cm, respectively. Transparent mosquito nets are used to conceal the cage for easy observation and to keep mosquitoes out. It has holes for arm access, which are also covered with nets. The cage must be filled with 20-30 mosquitoes starved overnight and given only sucrose solution. Updated standards use fewer mosquitoes in the cage (as few as 30 mosquitoes), as a lower density provides more accuracy, better reflects the typical biting environment encountered during most indoor and outdoor activities, and provides a comfortable environment for volunteers. Volunteers should not smoke and should refrain from using fragrance or repellent products for the study duration. This factor may alter a person's attractiveness to mosquitoes, affecting the repellency test's outcome. To prepare the volunteer, Hands must be washed with unscented soap, rinsed, and placed separately from each other. By a distance of about 20 meters, they are separated. The volunteers' arms will be covered in gloves or treated materials [27].

The left arm was used as a control, while the right arm was used to test the treatments.
Both forearms with untreated and treated materials will be exposed to the mosquito population for 3 minutes simultaneously. The test will continue if at least two mosquitos land or bite within the first three minutes. If no mosquitos have been landed in 3 minutes, the hand will withdraw from the cage. The number of mosquitos landing will be counted independently using a digital camera for an accurate result. The exposition is repeated every 30 minutes for the next 8 hours, or until the repellency is lost[29].

Irritancy Test
An irritancy test is done to check whether there is any irritation caused by the prepared herbal mosquito repellent spray formulation. The spray is sprayed on different people and checked whether it causes any irritation.
Stability Test
A stability test for herbal mosquito repellent spray is done to check whether the formulsted product was stable for a longer duration.

RESULT AND DISCUSSION

Organoleptic properties
The present study was carried out to develop mosquito repellent spray using natural oils. Assessment of the drug's physical description / organoleptic property is the primary step for drug substance recognition. It helps to check the feasibility of the drug for formulating into the intended dosage form. This also helps assess the patient acceptability factors such as color, nature, odour, and taste which eventually leads to better patient compliance.

Lemongrass oil
Colour: yellow
Odour: lemony& grassy
Taste: lemon with hints of ginger

Neem oil
Colour: Pale green
Odour: garlic or Sulphur
Taste: bitter

Eucalyptus oil
Colour: Pale yellow
Odour: aromatic and camphoraceous
Taste: pungent, camphoraceous

Turmeric Extract
Colour: Yellow

Odour: damp cardboard
Taste: Bitter

The colour, odour, nature and taste of the API were evaluated, and it was observed as specified in the monograph. Based on the observation, it was found satisfactory to formulate the intended tablet dosage form, and no discomfort is likely to arise in patient compliance.

Compatibility studies
Physical compatibility studies
From the study of physical compatibility, it can be confirmed that there are no color changes in the physical mixture. It can be concluded that all the excipients were compatible with natural oil. The compatibility study was performed at 40^0C/75%RH and found that excipients don't have to interact with natural oil.

Chemical compatibility studies
ATR-FTIR spectrum of pure drug and prepared Spray was compared to study of drug with the excipients and the spectrum was recorded in the wave number region of 4000 to 400cm^{-1}. According to the functional category, these excipients were mixed with natural oils. This indicates that the drug is compatible with the formulation components, and the results shown

Bio-efficacy test results of the mosquito repellent spray

Day 1			Day 2					
Indoor			Outdoor		Indoor		Outdoor	
Time	Control	Spray	Control	Spray	Control	Spray	Control	Spray
6 - 7 am	12	0	11	0	10	0	09	0
7 - 8 am	17	0	13	0	16	0	18	0
8 -9 am	15	0	16	0	15	0	16	0
9 - 10 am	08	0	09	0	12	0	10	0
10 -11 am	06	0	05	0	07	0	06	0

Observation
According to the indoor and outdoor field trials, which were carried out for six hours each day for two days, both the Mosquito repellent spray have shown 100% Mosquito repellency[28].
Cage Test Result of Mosquito Repellent Spray
The percentage of mosquito repellency was calculated by using the formula;

$$\text{Percentage of mosquito repellency} = \frac{C-T}{C}$$

C = No of mosquitos Bites on Control
T= No of Mosquitos Bites on Test (When Prepared Formulation is applied)

Times of testing	No of Mosquitos Bites on Control (Left Arm)	No of Mosquito Bites on Test (Right Arm)	Percentage of Mosquito Repellency
1	6	0	100%
2	10	4	96%
3	8	0	100%
4	5	0	100%

Observation
This indicates that the mosquito bites on the left arm, and while inserting the spray-treated hand the mosquito gets repelled away; this shows the repellency of the prepared formulation.

Irritancy Test

Any allergic consequence/s after use of this product [30]?

Yes/No	No. of Volunteers	No of Volunteers Who Gets Allergy
Yes	0	0
No	10	10
Total	10	10

RESULT

All Volunteers noted the product is safe.

Stability test result

The prepared formulation is stored for one month and checked every week whether there are any changes in the formulation.

SUMMARY AND CONCLUSION

- In the present research work, an attempt was made to develop Herbal Mosquito Repellent Spray to provide safe and non-toxic to humans by using Herbal Plants.
- The Physiochemical characterization for a Pure drug, such as organoleptic properties ATR-FTIR spectroscopic studies, were investigated and confirmed.
- The Pre-formulation studies were carried out. Organoleptic studies and phytochemical analysis has been used to analyze herbal plants.
- Various Evaluation test has been done to check the Mosquito Repellency
- Bio-efficacy Test Shows 100 % of Mosquito repellency
- A cage test is also done to check the percentage of mosquito repellency, and it shows various repellency results for different persons.
- Irritancy test result shows that the prepared herbal mosquito repellent does not causes any irritation after spraying it.
- Stability studies are done to check the stability of the product, and the result shows that the prepared product is entirely stable.
- On storage for one month and checking that no changes occur in the formulation, hence prepared formulation is stable.

CONCLUSION

Mosquito repellents protect human beings from mosquitoes' stings, thereby promising safety from mosquito carried diseases. Many mosquito repellents are available in the market to protect people from mosquitoes and give the length of protection one needed. Most everyone uses different kinds of mosquito repellents for repelling mosquitoes. Repellents do not kill mosquitoes. They just make humans unattractive to mosquitoes. The type of mosquito repellent used and concentration of active ingredient decides the number of hours a person can be protected from mosquito bites. Mosquito repellent spray is widely used for anti-repellency for mosquito.

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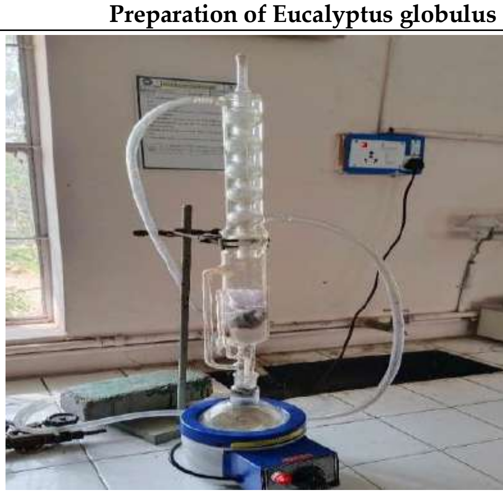
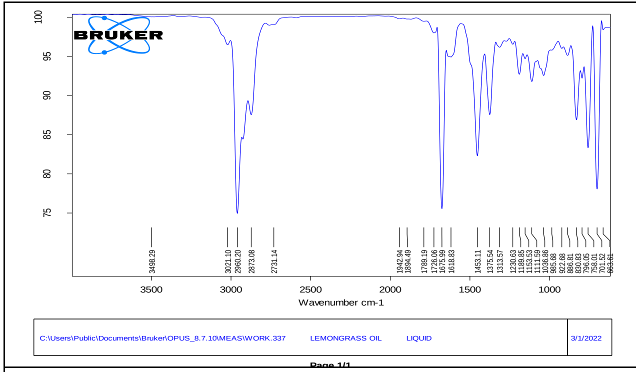
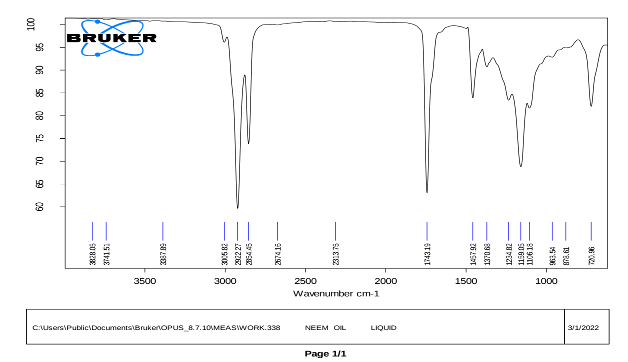
Cymbopogon nardus **(Citronella)**	***Eucalyptus globulus***

Palanisamy and Sriram

	
***Curcuma longa* (Turmeric)**	***Azadirachta indica* (Neem)**
	
Preparation of Eucalyptus globulus	**Soxhlet Extraction of Neem**
	
Soxhlet Extraction Of Turmeric	**The left arm was used as a control, while the right arm was used to test the treatments.**

	
ATR-FTIR spectrum of lemongrass oil	**ATR-FTIR spectrum of Neem oil**

RESEARCH ARTICLE

Characterization of Physicochemical Parameters to Design and Development of Rifaximin Loaded Nanoparticles

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ABSTRACT

The present study investigates systematically some of the important physicochemical properties of nanoparticles loaded with Rifaximin. Rifaximin is a semisynthetic, rifamycin-based non-systemic antibiotic, meaning that the drug will not pass the gastrointestinal wall into the circulation as is common for other types of orally administered antibiotics. It has multiple indications and is used in the treatment of traveler's diarrhoea caused by E. coli; reduction in risk of overt hepatic encephalopathy recurrence; as well as diarrhea-predominant irritable bowel syndrome (IBS-D) in adult women and men. Rifaximin is available in formulations, mostly as oral tablets. Before the development of novel dosage forms, it is essential that certain fundamental physical and chemical properties of the drug molecule and other additional properties of the drug powder are determined. This assessment decides many of the subsequent events and approaches in formulation development. A modified release nanoparticles of Rifaximin prepared by ultrasonication method using PLGA [poly (lactic-co-glycolic acid)] as drug entrapping polymeric material. Before selection of excipients, the Preformulation study of drug substance Rifaximin completed for developing desirable formulation of modified release nanoparticles. The physicochemical properties such as solubility, pH, pKa, dissolution, melting point, bulk density, flow properties, excipient compatibility and assay of Rifaximin were assessed.

Keywords: Nanoparticles, PLGA, entrapment efficiency, modified release, Rifaximin, Preformulation

INTRODUCTION

Rifaximin, 2S-Acetyloxy-5,6,21,23-tetrahydroxy-27-methoxy-2,4,11, 16,20,22,24,26-octamethyl-2,7 (epoxypentoeleca (1,11, 13) trienimino) benzofuro[4,5-e] pyride [1,2-a] benzimidazole-1,15(2H)-dione, is a structural analog of rifampin and a non-systemic, gastrointestinal site-specific antibiotic[1-2]. It has multiple indications and used in treatment of traveller's diarrhoea caused by E. coli; reduction in risk of overt hepatic encephalopathy recurrence; as well as diarrhoea-predominant irritable bowel syndrome (IBS-D) in adult women and men. Dosage for Travellers' diarrhoea: One 200 mg tablet taken orally three times a day[3-4]. Dosage for Hepatic encephalopathy: One 550 mg tablet taken orally two times a day. The adverse effects associated with Rifaximin for treatment in travellers'diarrhoea (≥ 5%): Flatulence, headache, abdominal pain, rectal tenesmus, defecation urgency and nausea. Most common adverse reactions in hepatic encephalopathy (≥ 10%): Peripheral edema, nausea, dizziness, fatigue, ascites, flatulence, and headache. Additionally, Rifaximin reported to have a mean elimination half-life of approximately 6 hours, demanding administered in multiple doses daily; thus, there is massive need to design and formulate new drug delivery systems that would effectively modify the release of Rifaximin, which would help to reduce the dosing frequency and adverse effects[5-6].

When a newly synthesized drug shows sufficient pharmacologic activity in animal models, Preformulation commences to warrants evaluating the drug in humans. These studies should focus on those physicochemical properties of the new compound that could affect drug performance and development of an efficacious dosage form. A thorough understanding of these properties may ultimately provide a rational for formulation design or support the need for molecular modification. Preformulation commences when a newly synthesized drug shows sufficient pharmacologic promise in animal models to warrants evaluation in man. These studies should focus on those physicochemical properties of the new compound that could affect drug performance and development of an efficacious dosage form. A thorough understanding of these properties may ultimately provide a rational for formulation design, or support the need for molecular modification[7-8]. The objective of this study was to determine some of the physicochemical properties such as solubility, pH, pKa, dissolution, melting point, bulk density, flow properties, excipient compatibility and assay of Rifaximin.

MATERIALS AND METHODS

Rifaximin procured from Optimus Drugs, India, PLGA (grades 50:50, 65:35, 75:25) procured from Corbion, Netherlands. Polyvinyl alcohol, Dichloromethane, Acetonewere supplied by Merck, Germany. The HPLC grade water was prepared by using Evoqua water technologies, UK. WATERS Alliance e2695 equipped with Photodiode Array Detector 996was used for the assay of Rifaximin. Acetonitrile (ACN) of HPLC grade and dipotassium hydrogen phosphate and phosphoric acid were supplied by Merck. All chemicals used in the study were of analytical grade and used without further purification.

Experimental Studies

Determination of Solubility

The Rifaximin was evaluated for solubility in water, acetone, methanol, diethyl ether chloroform and ethanol in accordance with the British pharmacopoeia specifications[9-10].

pH Determination

This was done by shaking a 1%w/v dispersion of the sample in water for 5 min and the pH was determined using a digital pH meter (Mettler Toledo, UK) [11]. The data presented here is for triplicate determinations and are reported in Table 1.

True Density

True density of Rifaximin was determined by liquid displacement method. It is calculated from the volume of intrusion fluid (toluene) displaced in the pycnometer by a given mass of powder [12].

$$D = \left(\frac{M}{\mathrm{Vp} - \mathrm{Vi}}\right)$$

Where, D is true density, Vp is the total volume of the pycnometer and Vi is the volume of intrusion fluid in the pycnometer containing the mass of powder (M). All the estimations were done in triplicate and average values are reported in Table 1.

Determination of Bulk Density, Bulkiness and Compressibility Index

The bulk density of Rifaximin was determined by the three-tap method (Marshall. K*et al., 1991*). 10g of Rifaximin powder was carefully introduced into a 100 ml graduated cylinder. The cylinder was dropped onto a hard wood surface 3 times from a height of 1inch at an interval of 2 seconds. The bulk density was obtained by dividing the weight of the sample by volume of the sample contained in the cylinder. Reciprocal of bulk density or the specific bulk volume gives the bulkiness. The percent compressibility index (I) of the Rifaximin was calculated using following formula [13]and the results are given in Table1.

$$I= \left(1-\frac{V}{Vo}\right)x100$$

Angle of Repose

Angle of repose measured using Granulate flow tester (Erweka, Germany) according to Pfrengle; the powder falls onto a plate with a specified surface and creates a cone [14]. An integrated laser measures the sidewall of the built-up cone and the actual angle is calculated. The mean diameters of the base of the powder cones were determined and the tangent of the angle of repose calculated using the equation:

$$\text{Tan } a = 2h/D$$

The data presented here were obtained from triplicate determinations and presented in Table 1.

Determination of Partition Coefficient

10 mg drug was added in 50 ml of n-Octanol (pre saturated with water) and it was shaken well and then 50 ml of distilled water (pre saturated with n- Octanol) was added and mixture was shaken by mechanical shaker for 24 hours. After 24 hours both phases were separated. Absorbance was taken for both the phases and concentration in each phases were calculated[15]. Results are presented in Table 1.

$$\text{Partition Coefficient} = \left(\frac{\text{Drug concentration in Octanol}}{\text{Drug concentration in water}}\right)$$

Percentage of Moisture Loss

Moisture loss determined with moisture analyser (Sartorius, Germany), about 4g of drug placed in the moisture analyser and loss on drying measured at a temperature 105±2°C [16-17]. Results are presented in Table 1.

$$\text{\% of moisture loss} = \left(\frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}}\right)\times 100$$

Determination of Particle Size Distribution

Particle size distribution of Rifaximin measured using Laser diffraction method (Mastersizer 2000, Malvern, UK). Weighed about 100mg of drug in a 50ml volumetric flask. add few drops of hexane and make a paste. Then add about 20ml of hexane and 2-3 drops of 0.1% lecithin in hexane, stir well and sonicate for 1 minute while mixing. Flush the sample dispersant with Toluene. Flush with hexane set to 2500RPM, again fill the sample dispersant with 100ml hexane and set to 2500RPM and measure the background. After background measurement, add the sample in the dispersion unit until the obscuration limit range reaches between 10-30%[18]. Wait about 2 minutes to stabilize the obscuration of the laser beam and start the measurement. Results are presented in Table 2 and Figure 1.

Drug Polymer Interaction Studies

Fourier Transform Infrared Spectroscopy (FTIR)

Drug-polymer interactions were studied by FT-IR Cary 630 Spectrometer (Agilent Technologies). The spectra were recorded for Rifaximin, PLGA, physical mixture of Rifaximin: PLGA (1:1) Samples were prepared in KBr disks (2 mg sample in 200 mg KBr) with a hydrostatic press at a force of 5.2 πcm2 for 3 minutes. The scanning range was 400 - 4000 cm2 and the resolution was 4 cm^{-1}[19].

Differential Scanning Calorimetry

The DSC thermogram of samples were recorded in a Q100 Differential Scanning Calorimeter (TA Instruments). Weigh exactly 2mg of Rifaximin and transfer it into standard aluminium pan cover with aluminium lid and crimp the pan using crimper with Rifaximin sample prepared by weigh exactly 2mg of mixture of PLGA and Rifaximin, transfer it into standard aluminium pan cover with aluminium lid and crimp the pan using crimper. Formulation excipients with Rifaximin sample prepared by excipients mixtures with Rifaximin, transfer it in to standard aluminium pan cover with aluminium lid and crimp the pan using crimper. Then subject to programmed temperature changes using differential scanning calorimetry [20-22].

RESULTS AND DISCUSSION

The results of solubility, true density, bulk density, compressibility index, angle of repose, moisture content, pH, Partition Coefficient are given in Table 1. Particle size distribution of drug has influence on many bulk properties of pharmaceutical interest such as flow properties, packing, packing densities, compressibility segregation characteristics etc. The particle size distribution of Rifaximin was shown in Figure 1. Drug–Excipients compatibility study based physical observation and assay confirms no colour change was observed. Based on the chemical evaluation it was found that there was no significant change observed indicating that the drug is compatible with the added ingredients. The results of this study were given in Table 3 to 5. DSC thermograms of samples showed characteristic endothermic peak which were comparable with the endothermic peak of an individual sample shown in Figure 2.Hence, there were no physico-chemical instabilities between the drug and excipients. FT-IR spectrum of samples showed characteristic absorption bands which were comparable with the absorption bands of an individual sample. Hence, there were no physico-chemical instabilities between the drug and excipients.

CONCLUSION

During product development any risk associated are assessed by evaluating the properties of drug at very early stage which is the Preformulation phase. Decisions made on the data generated during this phase can enable scientific thought process on the subsequent development phases. Therefore, it is important that Preformulation evaluation should be accomplished to enable rational decisions during development. The data generated can have impact on the quantity and quality of the drugs as well as the equipment available and the expertise of the personnel conducting the investigations. In this study we successfully completed the physicochemical characterization of Rifaximin properties like morphology, size, solubility, pH, partition coefficient, Surface area flow property, drug-excipient compatibility study. This knowledge obtained may be useful in developing modified release formulations mainly sustained release formulation of Rifaximin loaded nanoparticles.

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Table 1: Physicochemical properties of Rifaximin

Parameters	Results
Description	Rifaximin occurs as red-orange powder.
Solubility	Soluble in acetone and methanol. Practically insoluble in water.
pH	6.7+0.41
True density (gm/cc)	1.72+0.16
Bulk density (gm/cc)	0.253 ± 0.02
Tapped density (gm/cc)	0.358 ± 0.05
Compressibility Index (%)	29.41 ± 1.15
Angle of repose (o)	> 66
Partition Coefficient	1.36 ± 0.31
Moisture content (%)	1.84

Table 2: Particle size distribution of Rifaximin

Volume	Size range (µm)
d (0.1)	0.133
d (0.5)	3.065
d (0.9)	9.118

Table 3: Physical characteristics of individual drug and excipients

S. No	Sample ID	Initial description	Final description
1.	Rifaximin	Red-orange powder	No change
2.	PLGA	White to tan granules	No change

Table 4: Physical characteristics of drug-excipient mixture

S. No	Sample ID	Initial description	Final description
1.	Rifaximin	Red-orange powder	No change
2.	Rifaximin+ PLGA	Red-orange granular powder	No change

Table 5: Chemical characteristics of drug-excipient mixture

S. No	Sample ID	Initial assay (%)	Final assay (%)
1.	Rifaximin	99.87	99.85
2.	Rifaximin+ PLGA	99.83	99.82

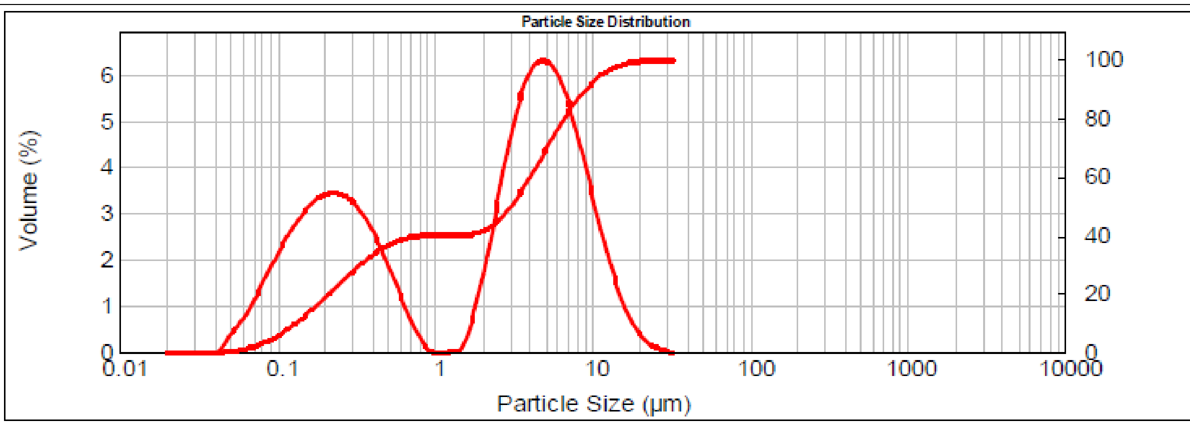
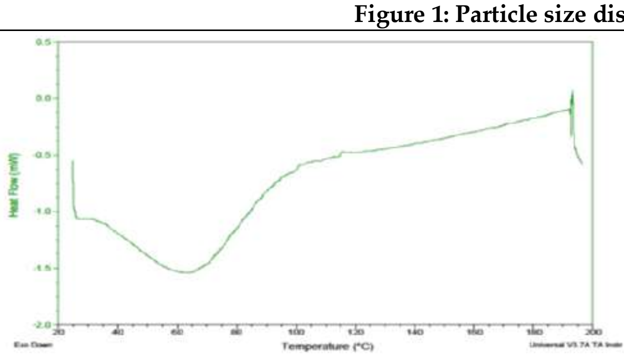
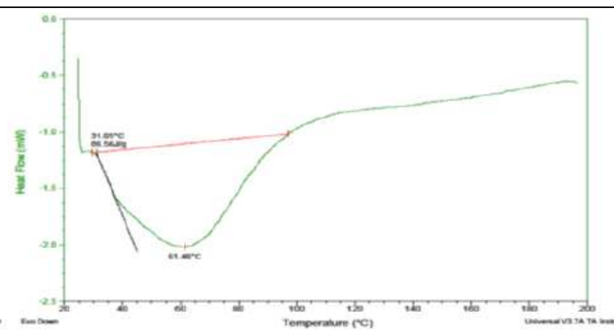


Figure 1: Particle size distribution of Rifaximin



DSC thermogram of Rifaximin



DSC thermogram of Rifaximin+PLGA

Figure 2: DSC thermograms of Pure Rifaximin and Rifaximin with PLGA

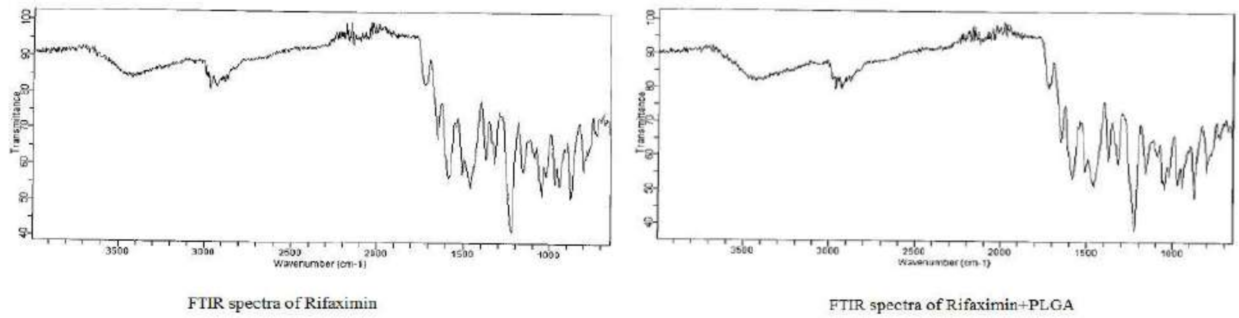


Figure 3: FTIR spectra of Pure Rifaximin and Rifaximin with PLGA

RESEARCH ARTICLE

Neural Network Analysis on Employee Relationship Management among Public Sector Bank Employees – with Reference to Chennai Metro Branches

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ABSTRACT

Psychological contract is an unwritten contract between employer and employee in order to fulfill their employment obligations. The organizational support one experiences from the work and from other components (Employee involvement, Working Hours, Job satisfaction) at the work place improves morale and thereby impacts performance. All these factors and many more combine to form a general perception of Psychological contract. This research paper focuses on the Psychological Contract among Employees in public sector banks. The aim of this study is to find out the employee's and managers' perception towards psychological contract (with Chennai metro branches). Here the Psychological contract is measured by taking into account Relational, Transactional, Balanced and Transitional relationship as its four dimensions. The influence of Psychological contract Dimensions on job satisfaction is considered as an important factor in this research and also influence of Involvement towards the support received by the employee perceived from their organization. Convenient sampling methods was adopted to collect data from Branch managers/and employees in public sector banks. Cronbach's alpha shows the reliability as .907 in case of employees and .846 in case of Manager psychological Contract. ANOVA, Regression and Neural Network were performed to analysis the data. The result revealed that a cordial relationship between employee and manager results in full support from the management. This leads to better employee satisfaction in public sector banks.

Keywords: Psychological contract, Employee Involvement, Organizational Support, Employee Relationship Management.

INTRODUCTION

Psychological contract is an unwritten contract between employer and employee in order to fulfill their employment obligations. Returning to the nature of the psychological contract as reciprocal obligations between the two parties to the employment relationship, it follows that there are two perspectives to the psychological contract: the employer and employee. In turn, this raises the issue of who represents the employer. Given that managers, as agents of the organizations, are in a position to convey promises or future commitments to employees, they themselves can hold psychological contracts regarding the mutual obligations between themselves and employees. This is consistent with Rousseau's interpretation that 'organizations become party to psychological contracts as principals who directly express their own terms or through agents who represent them' (1995, p. 60). As employees view the actions by agents of the organization as actions of the organization itself, it follows that the agents of the organization can hold psychological contracts.

REVIEW OF LITERATURE

The Theory of Equilibrium Barnard's (1938) is one of the basic foundations for the psychological contract which assumed that employees' continued participation depends upon adequate rewards from the organization. Therefore this theory gives the idea of a reciprocal exchange underlying the employee-organization relationship. Similarly Social Exchange theory Blau (1964) differentiated social from economic exchange along a number of dimensions: specificity of obligations, time frame and the norm of reciprocity. In short, economic exchange is one in which the obligations of each party are specified, the mechanism in place to ensure fulfillment of those obligations is the formal contract and the exchange has a limited time frame. The concept of psychological contract has been derived from the "Understanding of organizational behavior" Argyris (1960). This theory explains psychological contract as an implicit understanding between the group of employees and their foreman. This theory assumes that employees would perform at higher level if the organization did not interfere too much with the employee groups norm and in return employees would respect the right of the organization to evolve and also this theory defines psychological contract as an exchange of tangible specific and preliminary economic resources agreed by the two parties that permitted the fulfillment of each party's needs.

Coyle – Shapiro, J (2002) has conducted the study among public sector employees to examine the contribution of Psychological Contract framework to understand Organizational Citizenship Behavior by separating perceived contract breach into its two component i.e., Perceived employer obligation explained unique variance in three dimensions of citizenship behavior (Helping, Advocacy and Functional participation) beyond that accounted for by perceived employer inducement. Employees' acceptance of the norm of reciprocity moderated the relationship between employer inducement and the dimensions of advocacy and functional participation. Employees trust in their employer moderated the relationship between perceived employer obligation and the dimensions of advocacy and functional participation. Contrary to the hypotheses procedural or interactional justice were not found to moderate the relationship between Psychological contract and Organizational Citizenship Behavior.

Guillermo E. Dabos and Denise M. Rousseau (2004) in their study assessed the joint perceptions of the employee and his or her employer to examine mutuality and reciprocity in the employment relationship. Paired psychological contract reports were obtained from 80 employee–employer dyads in 16 university-based research centers. On the basis of in-depth study of the research setting, research directors were identified as primary agents for the university (employer) in shaping the terms of employment of staff scientists (employees). By assessing the extent of consistency between employee and employer beliefs regarding their exchange agreement, the study mapped the variation and consequences of mutuality and reciprocity in psychological contracts. Results indicate that both mutuality and reciprocity are positively related to archival indicators of research productivity and career advancement, in addition to self-reported measures of Met Expectations and intention to continue working with the employer.

David E. Guest andNeil Conway in theirresearch have predominantly focused on employee views and have largely neglected the organizational perspective and the management of the psychological contract. This article begins to redress the balance by reporting a study, based on a survey of 1,306 senior HR managers that explores the management of the psychological contract and in particular the role of organizational communication. Three distinct and relevant aspects of organizational communication are identified, concerned with initial entry, day-to-day work and more future-oriented, top-down communication. Effective use of these forms of communication is associated with what manager's judge to be a clearer and less frequently breached set of organizational promises and commitments, as well as with a fairer exchange and a more positive impact of policies and practices on employee attitudes and behavior. The study confirms that the psychological contract offers managers a useful framework within which to consider and manage the employment relationship.

Akyay UYGUR & Gonca KILIC The investigation studied the level of organizational commitment and the job involvement of the personnel at Central Organization of Ministry of Health in Turkey. 210 subjects, selected randomly, were distributed the questionnaire forms. Of the questionnaires, 180 of them (86%) returned and 168 of them were regarded valid and acceptable and analyzed. A moderate positive correlation was found out between organizational commitment and job involvement (r=0,44). In the light of this, there is a significant correlation between organizational commitment and job involvement, though not very strong.

The social exchange view of commitment (R. Eisenberger, R. Huntington, S. Hutchison, & D. Sowa, 1986) suggests that employees' perceptions of the organization's commitment to them (perceived organizational support, or POS) creates feelings of obligation to the employer, which enhances employees' work behavior. The authors addressed the question of whether POS or the more traditional commitment concepts of affective commitment (AC) and continuance commitment (CC) were better predictors of employee behavior (organizational citizenship and impression management). Participants were 383 employees and their managers. Although results showed that both AC and POS were positively related to organizational citizenship and that CC was negatively related to organizational citizenship, POS was the best predictor. These findings support the social exchange view that POS creates feelings of obligation that contribute to citizenship behaviors. In addition, CC was unrelated, whereas AC and POS were positively correlated, with some impression management behaviors.

Need for the Study

This study is an attempt to provide the individual-level perception towards the psychological contract (Relational, Balanced, Transitional and Transactional)from both Employee side as well as from Manager side and its influences over the Job satisfaction. Employee involvement (Information, Rewards, Knowledge and Power) towards organizational Support.This study further helps both parties to understand that having a healthy relationship (Contract) between employee and Managers which in turn contributes towards the improved performance and job satisfaction.

Objectives of the study

To analyze the relationship between psychological contract and job satisfaction

To know the significant relationship between Working hours and Job satisfaction

To find out the relationship between Organizational support and Employee involvement

METHODOLOGY

Sample Size

Data for this study were collected from 140 (Employees) and 35(Manager's) working in Public sector banks

Questionnaire

Questionnaire was developed by adopting various authors' scale Rousseau's (2008) psychological contract was used to measure psychological contract between managers and employees. Eisternberg's (1986) Perceived organization support scale was used to measure the organization support received by the employees from their managers. Edward Lawler (1988) Employee involvement scale was used to measure the employees and manager involvement towards their work.

Findings
Demographic Variables
Employees

1. 47.1% of respondents were male and 52.9 % of respondents were female employees.
2. 80% of respondents were married only 20% of respondents were unmarried.
3. 1.4% of respondents have minimum qualification of SSLC, 56.4%of respondents have graduation as their minimum qualification, 37.9% of respondents were Post graduate, 4.3% of respondents have other degree such as ITI, C.A.(IIB) B.Tech and Diploma.
4. It shows that 13.6% of belongs to 25yrs of age,18.6% of respondents belongs to 25-30yrs of age, 7.9% of respondents belongs to 31-35yrs of age, 7.1% of respondent belongs to 36-40yrs of age,6.4% of respondent belongs to 41-45yrs of age, 12.9% of respondent belongs to 46-50yrs of age and 33.6% of respondents belongs to above 50yrs of age.

Managers

1. 85.7% of respondents were male and 14.3 % of respondents were female.
2. 91.4% of respondents were married only 8.6% of respondents were unmarried.
3. 48.6%of respondents have graduation as their minimum qualification, 40% of respondents were Post graduate, 11.4% of respondents have other degree such as ITI, C.A.(IIB) B.Tech and Diploma.
4. It shows that 5.7 % of respondents belongs to 31-35yrs ,36-40yrs and 41-45yrs of age, 17.1% of respondent belongs to 46-50yrs of age and 65.7% of respondents belongs to above 50yrs of age. It shows that maximum number of respondents were above 50yrs of age.

Network information explains the factors,Input layer techniques, covariates and output layer. Education qualification is the only factor, Relational, Balanced, Transactional and Transitional as the co variates, Output layer ie., dependent variable is Satisfaction. Sigmoid techniques has been used in order to get more accurate result. Incase of radial bais function it is only 84.6% of accuracy and in Hyperbolic tangent it is 84% and in case of Sigmoid it is 92% of accuracy therefore Sigmoid techniques has been used.

Diagram-1 Network Structure

The above diagram explains the network of the neural analysis. It consists of neurons, Layers and output. In this bias used as the measurement between the prediction versus actual probability. It shows that the educational qualification as the factor classified into 4 level Qualification-1 is SSLC, Qualification -2 Graduate, Qualification-3 Post graduate, Qualification- 4 Others, Relational, Balanced, Transitional and Transactional considered as the dimensions of Psychological Contract these variables goes into the seires of iteration two hidden layer and 7 nodes gives the accuracy and predict the position of satisfaction 1&2 i.e., Satisfaction 1 = 1 (Yes) Satisfaction 1 = 2(No).
Model summary shows 8% of incorrect prediction has been observed.

Diagram-2 Cluster Box Plot

Diagram-2 explains the misclassification error. In case of Yes Category there are some No's also predicted Likewise in No Category some yes were predicted. Independent variable importance shows that Balanced contract (Performance support, External Marketability and Employee Development) 0.464 was considered as the most influencing factor for employees satisfaction, Relational contract (Loyalty and Stability) 0.313, Qualification and Transactional with .085, Last but not least transitional contract also plays a role in employee satisfaction.

Diagram-3 Horizontal Bar Chart

Based on the scores and percentage of importance diagram explains the most influencing factors of Employees satisfaction

Manager Perspective

The table –3shows sample used for training is 27 and for testing is 8.Valid cases shown here is 35 which means all the original observation are valid. Network information explains the factors,Input layer techniques, covariates and output layer. Education qualification is the only factor, Relational, Balanced, Transactional and Transitional as the co variates, Output layer ie., dependent variable is Satisfaction. Sigmoid techniques has been used in order to get more accurate result. Incase of radial bais function it is only 75% of accuracy and in Hyperbolic tangent it is 77.5% and in case of Sigmoid it is 87.5% of accuracy therefore Sigmoid techniques has been used.

Diagram-4 Network Structure

The above diagram explains the network of the neural analysis. It consists of neurons, Layers and output. In this bias used as the measurement between the prediction versus actual probability. It shows that the educational qualification as the factor classified into 4 level Qualification-1 is SSLC, Qualification -2 Graduate, Qualification-3 Post graduate, Qualification- 4 Others, Relational, Balanced, Transitional and Transactional considered as the dimensions of Psychological Contract these variables goes into the seires of iteration two hidden layer and 2 node gives the accuracy and predict the position of satisfaction 1&2 i.e., Satisfaction 1 = 1 (Yes) Satisfaction 1 = 2(No).
Model summary shows 12.5% of incorrect prediction has been observed in the training time of 0:00:00.02
Parameter estimates shows the satisfaction of managers in public sector banks

Diagram-5 Cluster Box Plot

Diagram-5 explains the misclassification error. In case of Yes Category there are some No's also predicted Likewise in No Category some yes were predicted. Independent variable importance shows that Transitional contract (Trust, Uncertainty and Erosion) 0.599 was considered as the most influencing factor for manager's satisfaction, Relational contract (Loyalty and Stability) 0.313, Balanced contract (Performance support, External Marketability and Employee Development) 0.080, Transactional with .087, Last but not least Qualification also plays a role in manager's satisfaction. Based on the scores and percentage of importance diagram explains the most influencing factors of Managers satisfaction

Regression Analysis:

Multiple regression analysis was conducted to examine the relationship between the Work attitude, psychological well-being and Job satisfaction. By considering the occupational and psychological well being dimensions as predictor and job satisfaction as criterion variable.

From employee perspective

The model summary of Employee Involvement (Predictor) and it explains the 64.1% of organizational support (R^2 = 0.411, F = 23.539, p <0.01).

The coefficient and correlation of independent variables (Dimensions of Employee Involvement) with Organizational support as the dependent variable Employee Involvement as predictor variable in which organizational support was explained by Reward (β = 0.400, t = 4.078, p < 0.01) and also by power (β = 0.233, t = 2.488, p < 0.05)
Employee Involvement (x) is predictor then dependent variable Organizational Support (y)

$Y= 1.559+0.059x_1+0.306x_2 + 0.046x_3+0.146x_4$

x_1= Information, x_2 = Reward x_3= Knowledge x_4= Power.
The minimum value in this case 2.4296 and maximum value is 4.2884. It shows employees who ever attain the minimum value feel that they were moderately receiving bonus and moderately take part in the decision making process and those who ever attain maximum value feel that they were receiving high bonus and also actively involved in decision making process of working in turns makes employee to feel them satisfied with their work. Hence, there is a strong positive relationship between the Employee Involvement and Organizational Support.

From Manager Perspective
The model summary of Employee Involvement (Predictor) and it explains the 82.2% of organizational support (R^2 = 0.675, F = 15.571, p <0.01).The coefficient and correlation of independent variables (Dimensions of Employee Involvement) with Organizational support as the dependent variable Employee Involvement as predictor variable in which organizational support was explained by Knowledge (β = 0.263, t = 2.125, p < 0.05)
Employee Involvement (x) is predictor then dependent variable Organizational Support (y)

$$Y = 1.485+0.120x_1+0.196x_2 + 0.332x_3+0.185x_4$$

x_1= Information, x_2 = Reward x_3= Knowledge x_4= Power.
The minimum value in this case 2.6153 and maximum value is 4.4485. It shows employees who ever attain the minimum value feel that they were moderately aware of the techniques used at the work place with less capabilities of professional knowledge and those who ever attain maximum value feel that they were aware of the new techniques used at the work place and also feel that they are having the capabilities, professional knowledge in turns makes employee to contributes towards organizational performance. Hence, there is a strong positive relationship between the Employee Involvement and Organizational Support.

CONCLUSION

This study statistically proves that psychological contract is one of the prospective mechanisms for Employee Satisfaction. To receive the high level of employment support from their superior an employee needs to involve them dynamically in their work. In conclusion it is noted that a cordial relationship between employee and manager results in full support from the management. This leads to better employee satisfaction. Well satisfied and self motivated employee performs much better than his counter parts who have not received adequate support.

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Table – 1 Case Processing Summary

		N	Percent
Sample	Training	90	64.3%
	Testing	50	35.7%
Valid		140	100.0%
Excluded		0	
Total		140	

Table-2 Classification

Sample	Observed	Predicted		
		Yes	No	Percent Correct
Training	Yes	76	0	100.0%
	No	14	0	0.0%
	Overall Percent	100.0%	0.0%	84.4%
Testing	Yes	46	0	100.0%
	No	4	0	0.0%
	Overall Percent	100.0%	0.0%	92.0%

Dependent Variable: Are you happy with your current employment? (Satisfaction)

Table - 3 Case Processing Summary

		N	Percent
Sample	Training	27	77.1%
	Testing	8	22.9%
Valid		35	100.0%
Excluded		0	
Total		35	

Table - 4 Classification

Sample	Observed	Predicted		
		Yes	No	Percent Correct
Training	Yes	23	0	100.0%
	No	4	0	0.0%
	Overall Percent	100.0%	0.0%	85.2%
Testing	Yes	7	0	100.0%
	No	1	0	0.0%
	Overall Percent	100.0%	0.0%	87.5%

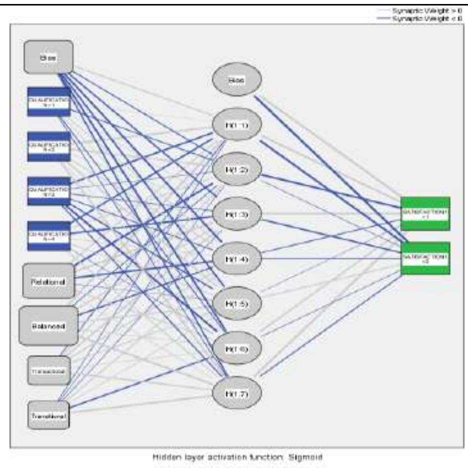

Fig.1.Network Structure

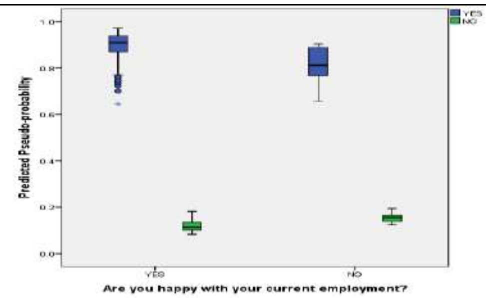

Fig.2.Cluster Box Plot

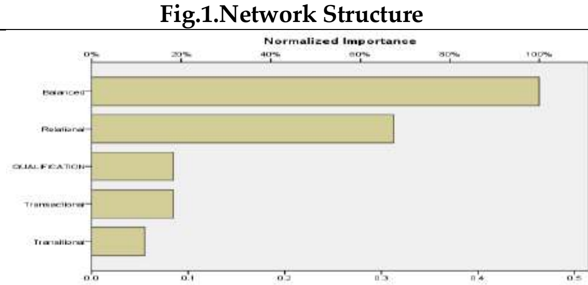

Fig.3. Horizontal Bar Chart

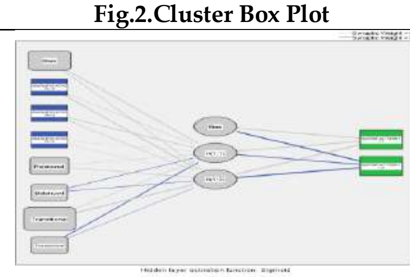

Fig. 4. Network Structure

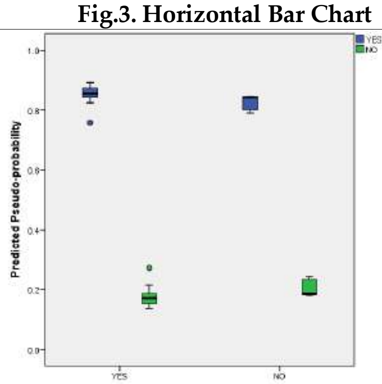

Fig.5. Cluster Box Plot

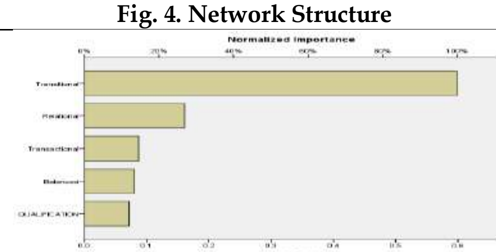

Fig. 6.Performance

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RESEARCH ARTICLE

Formulation and Evaluation of Ointment Containing *Phyllanthus niruri* L. for Wound Healing Therapy

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ABSTRACT

Drug delivery systems ensure that pharmaceuticals are absorbed and delivered to the precise location where they are needed in the body. Ointment has long been regarded as a vital component of cosmetic goods as topical therapies due to its ease of application and removal. Human skin is often harmed, yet it also has the ability to heal. However, the natural healing process can take a long time in the early stages of an injury. In such cases, a medical ointment can be applied to the injured area to aid in its recovery. *Phyllanthus niruri Linn*, is a small herb that belongs to the *phyllanthaceae* family and has a wide range of medicinal properties. It is widely used around the world. It is utilized in wound healing and other skin diseases in the ancient systems of medicines in India. The extract contained alkaloids, saponins, tannins, flavonoids, reducing sugar, carbohydrates, and glycosides, according to phytochemical analyses. The ointment was made using the fusion method and contains powder from *Phyllanthus niruri L.* This ointment, which contains crude powder, has wound healing activity because it contains gallic acid, beta-sitosterol, ellagic acid, and alkaloids-4-methoxysecurinine, which is involved in wound healing. For the formulation, an in-vitro test was carried out. RESULT: The developed formulation of ointment containing *Phyllanthus niruri L.* was proved to be safe and effective in the wound healing therapy.

Keywords: *Phyllanthus niruri L.*, topical delivery, water soluble base, wound healing.

INTRODUCTION

Drug delivery systems are methods for ensuring that medications are absorbed into the body and delivered to the precise location where they are needed. These systems must consider a variety of factors, including drug effectiveness and ease of distribution [1]. Topical drug administration is a localized drug delivery system that can be used to administer drugs to any part of the body via ophthalmic, rectal, vaginal, and cutaneous channels [2]. The principal route of topical medication delivery is through the skin, which is one of the most easily accessible organs on the human body for topical administration [3], [4] Ointments are homogeneous, semi-solid formulations that are applied to the skin or mucous membrane externally. They're employed as emollients or to apply active chemicals to the skin for protective, medicinal, or preventive purposes, and when a degree of occlusion is needed [5]. The choice of an ointment base is influenced by a number of factors. The desired action, the nature of the medication to be included, as well as its bioavailability and stability, as well as the required shelf life of the finished product are all factors to consider. The qualities of an ointment base class are matched by the choice of a specific base [6]. The USP recognizes four general groups of ointment bases that can be employed therapeutically or as carriers for active components. They are: Hydrocarbon or oleaginous base, absorption base, removable base and water soluble base [7].

MATERIALS AND METHODS

Formulation of ointment

Procedure

The plant was collected and well dried in the sunshade for about 2-3 weeks. Then stem was removed from the dried plant and leaves, fruits were collected. Then it is placed in the Mixture ,and the fine powder is collected. Then powder were passed through the sieve no.150 and the fine powder was kept for further experiment. According to fusion method, each ingredient is added to the porcelain dish in water bath based on their heat liability for melting. polyethylene glycol 4000(PEG-4000) was weighted and melted in the porcelain dish by water bath. When the PEG is melted slightly , add white petrolatum and CetaStearyl alcohol and stir well in the water bath. Then add citric acid, liquid petrolatum and stir well. To the mixed content in the porcelain dish , *Phyllanthus niruri* L. powder was added and stir well. Then add propylene glycol, vitamin-E and stirred well. According to the fusion method, allow the mixture content for the coagulation process for a while. Thus, Ointment containing *Phyllanthus niruri* L. was prepared.

Fusion Method

By the fusion method, all or some of the components of an ointment are combined by being melted together and cooled with constant stirring until congealed. Components not melted are added to the congealing mixture as it is being cooled and stirred. Naturally, heat-labile substances and any volatile components are added last when the temperature of the mixture is low enough not to cause decomposition or volatilization of the components. Substances may be added to the congealing mixture as solutions or as insoluble powders levigated with a portion of the base. On a small scale, the fusion process may be conducted in a porcelain dish or glass container.(The result shown in the table no:1)

Evaluation of Ointment

All the prepared ointments were characterized for the parameters such as appearance, odour, colour, homogeneity, pH, viscosity, spread ability, extrude ability studies, irritancy, removal, *in vitro* diffusion studies and stability studies etc.

Appearance

The formulated ointment was visually evaluated for colour, appearance, and transparency. The smoothness of the ointment was stimulated by rubbing the formulation between the fingers to observe the smoothness, clumps, roughness, and homogeneity

pH

About 2.5 g of all formulations were taken in dry beaker and 50 ml of water was added. Beaker containing ointments was heated on water bath at 60–70°C. The pH of ointments determined using a pH meter. The determinations were carried out in triplicate and the averages of three readings were noted.

Viscocity

Brookfield Synchro-Lectric Viscometer (Model RVT) with Heli path Stand was used for rheological studies. The sample (50 g) was placed in a beaker and was allowed to equilibrate for 5 min before measuring the dial reading using a T-D spindle at 10, 20, 30, 50, 60, and 100 rpm. At each speed, the corresponding dial reading on the viscometer was noted. The spindle speed was successively lowered and the corresponding dial reading was noted. The measurements were carried in triplicate at ambient temperature. Direct multiplication of the dial readings with factors given in the Brookfield Viscometer catalog gave the viscosity in centipoises (CPS)

Spread ability

Spread ability of the formulation was determined by an apparatus suggested by Multimer with some modifications58. It consists of a wooden block having a pulley at one end with fixed glass slide on block. An excess of ointment (3 g) placed on ground plate. The ointment was sandwiched between this plate and another glass plate having the dimension of fixed ground plate and provided with the hook. A 1 kg weight was placed on the top of the two plates for 5 min to expel air and to provide a uniform film of the ointment between the plates. Excess of ointment was scrapped off from the edges. The top plate was then subjected to pull of 240 g. With the help of spring attached to the hook and time required by the top plate to cover a distance of 10 cm was noted. A shorter interval indicates better spreadability. Spreadability was calculated using the following formula:

$S = M \times L/T$

Where, S = Spreadability

M = Weight in the pan (tied to the upper slide)

L = Length moved by the glass slide and

T = Time (in seconds) taken to separate the slide completely each other.

Extrud ability

The method adopted for evaluating ointment formulation for extrudability was based upon the quantity in percentage of ointment extruded from tube on application of certain load. More the quantity extruded better was its extrudability. The formulations were filled into a clean, lacquered aluminium collapsible one- ounce tube with a 5 mm opening. It was then placed in between two glass slides and was clamped. Extrudability was determined by weighing the amount of ointment extruded through the tip when a constant load of1kg was placed on the slides and ointment extruded was collected and weighed. The percentage of ointment extruded was calculated. The comparative extrudability of the formulations is noted.

Irritancy Test

Mark an area (1sq.cm) on the left hand dorsal surface. The cream was applied to the specified area and time was noted. Irritancy, erythema, edema, was checked if any for regular intervals up to 24hrs and reported.

Removal Test

The ease of removal of the ointment applied was examined by washing the applied part with tap

***In-vitro* Diffusion Studies**

Kiescary chain instrument was used.2gms of ointment kept in donor compartment. After the entire cellophane membrane is contact with the receptor compartment containing 22ml of Phosphate buffer pH 6.6.The receptor compartment is stirred continuously at (100rpm) using magnetic stirrer. The temperature maintained at 37± 1 degree centigrade. The surface area is calculated for Diffusion studies 3.14cm sq. for hours. The sample was withdrawn at 30min interval. Same volume was replaced with free Phosphate buffer. Ointment containing herbal powder is measured after dilution. Repeat the test for 3 times. Average values are noted. Ointment applies on body surface applied topically surface tissue of the skin after application of substance. The skin is potentially appendages than through the matrix of stratum, corneum. Diffusion has been established. Dominant Diffusion mode properly into appendages. But occurs of the matrix of stratum, corneum. Penetration of remaining epidermal layer and corneum circulation via capillaries. This is carried by Agar Nutrient medium. Any concentration poured into petridish a hole was made at the centre Ointment was placed on it. Time taken for ointment to diffuse was noted.

Stability Testing

Introduction

The time from the date of manufacture and packaging of the formulation until its chemical or biological activity is not less than a set level of labelled potency and its physical properties have not altered considerably or negatively can be characterised as the stability of a medicine. The stability of the active component must be a major consideration in selecting whether or not to accept or reject dosage forms for medications in any design or evaluation.

Objective of the study

Stability testing enables recommended storage settings, re-test intervals, and shelf-lives by predicting how the quality of a drug ingredient or drug product changes over time under the effect of various environmental elements such as temperature, humidity, and light. Observing the rate at which a product degrades under typical room temperature takes a lengthy period in most cases. The ideas of expedited stability investigations are used to avoid this unfavourable delay. The stability test requirements are described in the International Conference on Harmonization (ICH) Guidelines under "stability testing of New Drug Substances and Products" (QIA).

RESULT AND DISCUSSION

Organoleptic Characteristics

The colour of the dried plant powder is greenish-brown ,indistinct odour and bitter taste. The organoleptic properties, including texture, phase separation, homogeneity, and immediate skin feel of the ointment formulations, are shown in Table no: 4. Results showed that the ointments had a good appealing appearance and smooth texture, and they were all homogenous with no signs of phase separation.

IR- Spectra Analysis

ATR-FTIR spectrum of crude drug and prepared ointment was compared to study of drug with the excipients and the spectrum was recorder in the wave number region of 4000 to 400cm-1. The IR graph was found to be. (The result shown in the fig no:1)

Compatability Studies

Physical compatibility studies:

From the study of physical compatible, it can be confirmed, there is no colour changes occurs in the physical mixture and it can be concluded that all the excipients were compatible with natural powder. The compatibility study was performed at 400C/75%RH and found that excipients don't have interaction with herbal powder.

Chemical compatibility studies:

ATR-FTIR spectrum of crude drug and prepared ointment was compared to study crude drug with the excipients and the spectrum was recorder in the wave number region of 4000 to 400cm-1. According to functional category, the dried plant powder was mixed, and shows no destruction or deterioration with the excipients used. This indicates that the drug is compatible with the formulation components. ATR-FTIR spectroscopy was fixed at the range of 4000-400cm-1.There is no interaction between the drugs and excipients. (The results shown in the fig no:2)

Physiochemical Parameters Evaluation Of Ointment Formulation

Appearance

The prepared ointment was visually inspected for the appearance, colour, and texture. All formulations were white in colour and aromatic odor. Physical appearance of all formulation are opaque in nature. (The result shown in the table no: 2)

Determination of pH

Using a digital pH meter, pH measurements of the prepared ointment were taken by immersing the glass electrode entirely into the ointment system and covering it. pH of all formulations was found to be between 6.80 and 7.02 that is within the range which are presented in Table no:5.The pH of all formulations is basic in nature. so, it is skin friendly that does not cause any irritation. (The result shown in the table no: 3)

Determination of Viscosity

The viscosity of the ointment was determined by using Brookfield Viscometer LVDV Prime-I. The viscosity of ointment was measured at room temperature i.e., 30+2°C with varying rpm and torque. Viscosity of all the formulations was noted and found in the range of 2412 and 2851 CPS at 10 rpm . All the formulations were showed pseudoplastic flow which shows advantages in higher drilling rate and improved cutting lifting. (The result shown in the table no:4)

Determination of Spreadability

Ointment spread ability can be categorized into three groups: Low, moderate, and high. After screening, it was found to be inversely proportional to the concentration. The spreadability of all formulations was determined and it was observed that formulation F3 has greater spreadability as compared to other formulations as well as prototype formulations USP (T1) and IP (T2) as shown in (The result shown in the table no: 5).

Determination of Extrudability

The extrudability of the ointment was based upon the viscosity and it was evaluated from all the formulations. The formulation (F3) having better consistency of the ointment formulation. (The result shown in the table no :6)

Determination of irritancy

From the it was concluded that no irritation was observed from all formulation. (The result shown in table no:7)

Removal test

All formulation was easily removed with normal water.

In-*vitro* Diffusion Studies

The diffusion studies of the formulation results are shown in the. Drug release of the formulation (F3) after 4th hour is 91.2%. (The result shown in the table no:8).

Stability Studies

A stability study was carried out for the optimized formulation according to ICH guidelines at 40°C/75 % RH for one month. The results showed no significant change in the physical and chemical parameters of the ointment . Hence the formulation (F3) was found to be stable.(The result shown in the table no:9)

CONCLUSION

In the present research work an attempt was made to develop ointment containing dried powder of *Phyllanthus niruri* L. in the base polyethylene glycol 4000 (PEG4000). *Phyllanthus niruri* Involves in the wound healing therapy as discussed and PEG4000 is a water soluble base which can be easily remove by washing with water. The method of preparation is fusion method. In this ointment preparation white petrolatum, propylene glycol, liquid paraffin, citric acid, CetaStearyl alcohol, vitamin-E are used. White petrolatum is used as a moisturizer and emollient. Propylene glycol is used as amoisturizer and humectant. Liquid paraffin is used as emollient. Citric acid is used as preservative, anti-oxidant, buffer, anti-coagulant. CetaStearyl alcohol is used as an emulsion stabiliser, opacifying agent, viscosity increasing agent. Vitamin-E is used as a promote healthy skin. The comparison of the ATR-FTIR spectra of *Phyllanthus niruri L.* Powder and mixture of power with polymer which confirms that there is non interaction between compounds and there is no disappearance of the existing peak. This result in no degradation or destruction of the phytoconstituents of *Phyllanthus niruriL.*Specificallygallic acid, beta-sitosterol, ellagic acid and alkaloids-4 methoxy-securinineon observation of fingerprint region which involves in wound healing process. From the above criteria of base and other excipients the formulation forms the effective, safe and stable preparation for topical administration. From these, it is concluded that ointment containing *Phyllanthus niruri L.* in the form of powder achieves a stable, safe andharmless preparation which is useful in the wound healing therapy.

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Table no: 1 Formulation table.

S.No	INGREDIENT	F1	F2	F3
01.	*Phyllanthus niruri L.*	2g	2g	2g
02.	Polyethylene glycol 4000	7.0g	6.5g	5.5g
03.	White petrolatum	5.0g	5.0	5.5g
04.	Propylene glycol	3ml	3ml	3ml
05.	Liquid paraffin	3ml	3ml	3ml
06.	Citric acid	3g	3g	3g
07.	CetaStearyl alcohol	1	1.5g	2.0g
08.	Vitamin-E	1ml	1ml	1ml
	Total	25gm	25gm	25gm

Table no: 2 Organoleptic characteristics of ointment preparation

Formulation code	Texture	Phase separation	Homogeneity	Immediate skin feels
USP(T1)	Smooth	No	Homogeneous	No grittiness or greasiness
IP(T2)	Smooth	No	Homogeneous	No grittiness or greasiness

F1	Smooth	No	Homogeneous	Little grittiness and no greasiness
F2	Smooth	No	Homogeneous	No grittiness or greasiness
F3	Smooth	No	Homogeneous	No grittiness or greasiness

Table no: 3 pH measurement

Formulation code	pH(mean +_SD)
F1	6.80
F2	7.01
F3	6.59

Table no: 4 Viscosity Measurement

Formulation code	Viscosity at 10rpm(mean±SD)
F1	2851
F2	2612
F3	2472

Table No : 5 Spreadability Measurement

Formulation code	Spreadabilityg.cm/s (mean+_SD)
F1	80
F2	105
F3	107

Table No: 6extrudability measurement

Formulation code	Extrudability
F1	2.354 gm
F2	0.621 gm
F3	1.579 gm

Table No: 7 irritancy test measurement

Formulation code	Irritancy test
F1	No irritancy
F2	No irritancy
F3	No irritancy

Table No: 8 Diffusion study of ointment preparation.

S. No	Time (mins)	F1	F2	F3
		% OF DRUG RELEASE		
1	0	0	0	0
2	15	41.21	40.23	31.24
3	30	56.11	57.20	44.55
4	45	66.08	67.36	66.15
5	60	77.57	76.13	78
6	120	81.30	79.15	87.13
7	240	85.78	87.12	91.2

Table no: 9 stability parameter of selected formulation

Parameters	Initial	After one month40/75 (°C/RH)
Appearance	White in colour	White in colour
Feel on application	Smooth	Smooth
pH	6.59	6.7
Viscosity	2472 cps	2499 cps
Spread ability	107g.cm/sec	104g g.cm/sec
Extrude ability	1.579	1.497

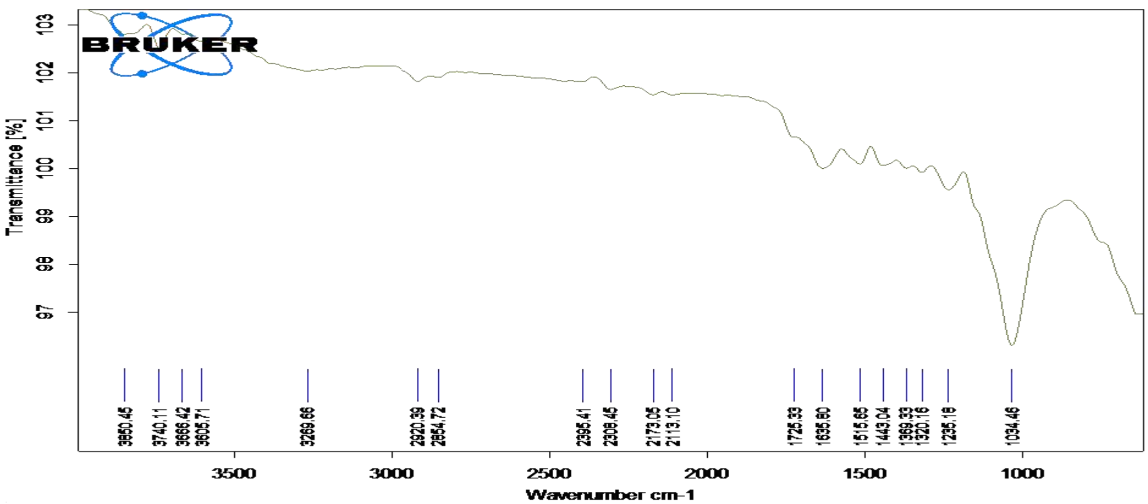

Fig. no. 1 ATR FTIR of *Phyllanthus niruri L.*

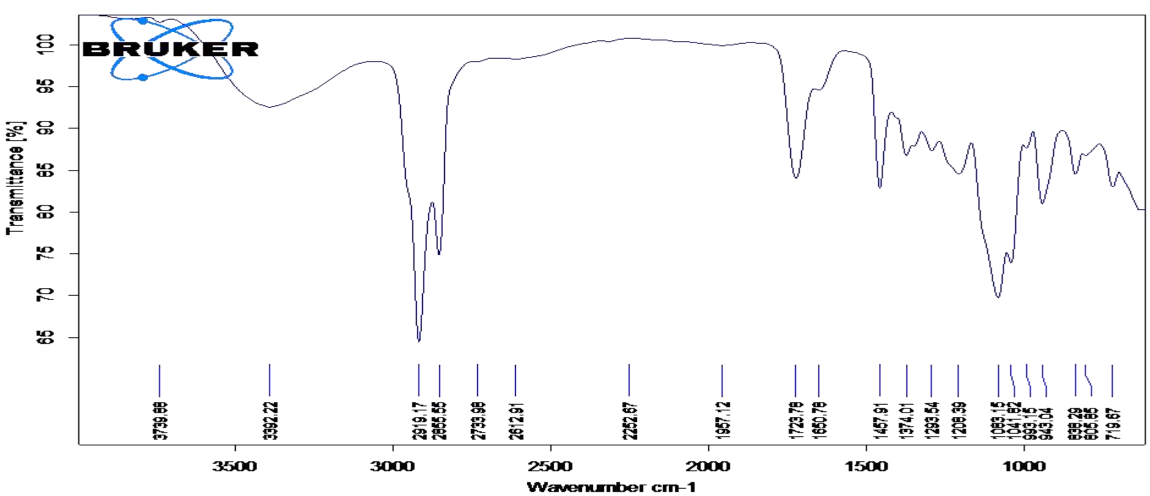

Fig no. 2 ATR FTIR ointment preparation contains *Phyllanthus niruri L.*

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RESEARCH ARTICLE

Application of Nanotechnology in Agriculture in India

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ABSTRACT

Conventional farming methods and technologies prevalent in India are no longer able to increase productivity. Instead, they are continuously increasing the hazard caused to the environment. Thus, the hazard caused to the environment needs to be overcome for the betterment of the rare planet earth. The traditional methods of sowing, irrigation, fertilizer application and plant protection have been in question since long. Nanotechnology is a novel way of solving the problem in the current scenario of agriculture because of the low dose concept of nanomaterials. The nanomaterials differ in their physical structures from the conventional materials which attributes the unique properties of these nanoparticles. The wide applications of nano technology in the field of agriculture have been discussed in this review along with their future aspects. The nano fertilisers have the ability to break the yield barriers without harming the environment. Similarly, the nanomaterials use in plant protection disrupts the development of resistance in the pests. India can achieve record breaking yield at a sustainable rate if nanotechnology is applied in the fields of precision water management, soil and water reclamation, biotechnology, pest surveillance, pest control, new-generation pesticides and food processing.

Keywords: nanocomposites, controlled release, targeted delivery, nano inputs, nano-sensors, precision agriculture

INTRODUCTION

Nanotechnology is the innovative technology where the size of the particles ranges between 1 to 10^2 n min diameter (Jeevanandam *et al*., 2018). It is the field where life sciences, material science and information technology converge together. It is an evolving field of science, which is able to resolve the issues which are difficult to solve in other fields of science (Bayda *et al*., 2019). The science and technology involving the study of matter on an ultra-micro scale is known as nanoscience or nanotechnology. It offers us to work, change and make tools, things and structures at the molecular level (Hossain *et al*., 2021). The enhanced surface area and reactivity including higher penetration into the cell facilitate the activation of plants and microbes that increase in input use efficiency (Ravishankar *et al*., 2020; Durgude *et al*., 2022). Nanoparticle has the potential to activate enzyme and release of polysaccharides which in turn performs as catalyst in metabolic processes of various flora and microbes (Tarafdar *et al*., 2015). The mode of actions of nanomaterials are considered as the basics thatare safe and cost effective with better longevity which have wide range of uses as farm inputs. Nanotechnology provides various agro-inputs such as nutrients, pesticides, carriers, sensors, chips, cellulose, barcode, quantum dots etc. consisting of nanomaterials. Fertilisers play an important role in improving the food production in developing countries like India. The Green Revolution brought into use of HYVs and hybrids which responded well to added fertilizer inputs (Mani and Mondal, 2016). However, the recent trend in Indian agriculture showed a yield stagnation, plateauing and decline in major crops that appear as major threats to food and nutritional security.

Nano fertilizers are the nanoparticles-oriented fertilizers, where nutrients are provided for better plant growth by increasing the ability and use efficiency of applied nutrients with a higher absorption and real time delivery of nutrients into the rhizosphere or through foliar spray (Durgude *et al*., 2022). There was considerable enhancement in productivity of various crops by providing the foliar spray of nano-nutrients. The present review article focuses on use of nanomaterials in farming considering the future prospects of application of nanotechnology in agriculture. Further, the article addresses some of the sustainable development goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and wellbeing) and SDG 15 (life on land) (UN, 2021).

PROPERTIES OF NANOPARTICLES

Nano-bio interfaces are with full of complexity and their activities depend on the characteristics of the nanoparticles, the biological phase (protein, cell membranes, endocytic vesicles or organelles), the medium in which it is acting and most essentially it depends upon any changes within them due to mutual effect (Tarafdar *et al*., 2015). The characteristics that administer the surface behaviour are the chemical constituent and the resultant solubility, surface charge, semi-conductivity, size, shape, surface curvature, crystallinity, porosity, surface heterogeneity, roughness, surface functionalization with charged groups, peptides or polymers (Mani and Mondal, 2016). The other aspects are consisting of the ratio/size, hydrophobicity, surface area, solubility, surface species contaminations, capacity to produce ROS, competitive binding sites with receptor, dispersion/aggregation (Nel *et al*., 2009).The increased activity of the nanoparticles is basically due to two principal properties.

Increased surface area

The angle at which the liquid-vapor interface meets the solid –surface interface is called contact angle and wetting is inversely proportional to contact angle. The liquid which contains nanoparticles behave differently in their spreading habit on solids. The small sized nanoparticles have less contact angle as compared to large sized particles because of the high surface to volume ratio. The decrease in contact angles leads to increased wetting (Guo *et al*., 2013).

Quantum effect

Quantum effect is generally due to quantum confinement effect. Due to this effect the band gap increases with decreasing size of the particles. With increasing surface energy various properties of nanoparticles can be modified like the melting point, reactivity, magnetic properties, etc. (Somasundaran *et al*., 2010).

Behavioural Pattern of Nano Fertilizers

In nano fertilisers the nutrients are encapsulated by nano materials and coated with thin protective film. The binding and coating in the nano fertilisers help in regulation of release of nutrients from the fertiliser capsule. Nano materials like nano tubes or nano pore are used to encapsulate the fertilisers (Twardowski, 2007).

Flow of nanoparticles and nanomaterials in ecosystem

The flow of nanoparticles and nanomaterial in ecosystems is dynamic in nature. The nanomaterial from industries, agriculture and nature flows towards the water-bodies, soil-particles and air; from where these materials are unified in the living system including the plants, microorganisms which are present in the soil and water. The materials are then taken forward in the higher trophic levels through the food chain (Monticone *et al*., 2000).

NEED OF NANOTECHNOLOGY IN INDIAN AGRICULTURE

- There are multifaceted problems in the concurrent Indian agriculture such as productivity stagnation of various crops, dwindling of soil fertility, various nutrient deficiencies, climatic aberrations, decline of arable land and shortage of water (Maitra and Pine, 2019; Zaman *et al*., 2018).
- Indian agriculture has become fatigued after the Green Revolution. The nutrient use efficiency has been declined and crops are not responding to the added nutrients against the routine or application of the recommended fertilizers (Maitra and Zaman, 2017; Maitra *et al*., 2018).
- The unbalanced and non-judicious application of fertilizers is a common phenomenon in Indian agriculture and that further has caused a huge damage to crop lands as well as natural water bodies (Maitra *et al*., 2001; Mohanta *et al*., 2021). Nitrogenous fertilizers, mainly urea, is greatly subsidized by the government and thus its use is more than other nutrients. Disproportionate use of N fertilizers disturbs groundwater and leads to eutrophication in aquatic systems. Such non-judicious fertilization leads to a severe alarm for rapid deterioration of soil health (Qureshi *et al*., 2018; Shankar *et al*., 2020; Sairam *et al*., 2020).
- There is a trend of gradual decrease in nutrient use efficiency by different crops and cropping systems in various agroclimatic zones of India (Morales-Diaz *et al*., 2017; Mangaraj *et al*., 2022; Pattanayak *et al*., 2022).
- Achieving the food and nutritional security for the growing population in India and other developing countries is a huge task in the present context of climate change. However, the multi-nutrient deficiencies are appeared as a new problem in Indian soils (Praharaj *et al*., 2021). The situation warrants an efficient input delivery and management system.

Considering the above issues, there is a need for intervention of novel technologies which have the potential. In this regard, nanotechnology can be considered with various kinds and forms of nanomaterials.

APPLICATIONS OF NANOFERTILIZERS

For balanced crop nutrition

Fertilizers perform a vital role in crop yield. It has been explicitly found that proper nutrient management increases about 35-40% of the productivity of any crops (Biswas and Sharma, 2008; Shankar *et al.,* 2021; Mohanta *et al.,* 2021). Because of this, the Government of India has subsidized the fertilizer costs and such subsidy is provided mainly in urea. that has led to excessive urea application to crop fields causing nitrate pollution in the ground water. The nutrient use efficiency (NUE) of some of the chemical nutrients such as nitrogen, phosphorus and potassium remained 30–35%, 18– 20% and 35–40%, respectively over a period of few decades. As a result, the most of the added fertilisers are getting into the aquatic and soil ecosystem (Adhikari, 2011). Nitrogen use efficiency (%) of conventional fertilizer was found to be 27% and the nitrogen use efficiency of nano-fertiliser was found to be 75% on pearl millet (Ombodi and Saigusa, 2000). The NUE of the Nano fertilizers is about 3 times greater than the conventional fertilizers. Besides this, nanofertilizer increases the stress tolerating ability because the nano fertilizers have growth promoters encapsulated with the nutrients inside the nano scale polymers. Therefore, the release of nutrients becomes slow and target specific (Iqbal and Umar, 2019). The N, P and K fertilisers when loaded inside the nano-clay they exhibit slow release of nutrients because of intercalation of clay around the polymer composite (Subramanian and Sharmil, 2009). Slow release phosphatic fertilisers was developed by Bansiwal *et al.* (2006) with the help of a carrier which is a surface modified zeolite. Cementing material made up of organic polymer intercalated in the layers of kaolinite checks the proclamation of nutrient from the commercially available fertilizers (Sen, 2015). Subramanian and Sharmil (2009) reported that nano nitrogenous fertilisers release NO_3-N for more than 30 days more than the conventional nitrogenous fertilisers (Ombodi and Saigusa, 2000). Greater surface areas of nano fertilisers increase the reactive points of the fertilisers which changes the physiochemical properties thus leading to better absorption of nutrients by the plants. The stimulating effect of nanoparticles in plants on seedling vigour was recorded by Zhu *et al.* (2010). All these processes help in increasing the nutrient-use efficiencies and thus, risks to the environmental is minimized.

Nano technology to solve the micronutrient deficiencies

Indian soils are lacking in micronutrients and of them, Zn, Fe, Cu and Mn are of prime importance as 48.1%, 11.2%, 7% and 5.1% of Indian soils lacking these, respectively. In some areas there are reports of deficiency of boron and molybdenum in some areas (Liu *et al*., 2006). Nutrient Use Efficiency of conventional Zn- 2-5% whereas the Nutrient Use Efficiency of Nano Zinc is 3 to 4 times more than Conventional Zn. Moreover, the zinc nanoparticles are low cost, eco-friendly both in terms of biosynthesis and application (Zhu *et al*., 2010). Similar data were also found in the case of iron where the nutrient use efficiency of Nano Fe is found to be 3 to 4 times more than Conventional Fe. Nano Fe has been reported to increase the dry weight of leaf, pod yield and the final yield in soybean (Gupta *et al*., 2005). Liu *et al*., (2005) recorded that nano-iron oxide facilitates photosynthesis as well as iron transfer in groundnut leaves whereas other treatments like organic materials and iron citrate didn't show any of these effects.

Effective weed control

In the present-day agriculture, herbicides are applied to control the weed population dynamics, however, they are supposed to be less effective under rainfed conditions. In this regard, nano-encapsulation of herbicides can be an effective tool to regulate the weeds population. Nanotechnology provides exciting ways for preventing the overuse of herbicide and facilitates safe and effective delivery (Scrinis and Lyons, 2007).The nano herbicides help in reducing substantial amounts of chemical use with increased crop productivity. Reduction in the amount of chemicals will in turn slow down the process of developing herbicide resistance which is an alarming problem. Moreover, the greater penetration effect of the chemicals will prevent the weed from developing resistance by eliminating it before the proposed time (Kalam, 2007). Manjunatha *et al*. (2016) reported that early killing or eliminating of weeds reduces the chemical herbicides resistance and sustains the activity of the active ingredients by extending the release over an extended time. Biodegradable polymeric substances with low or no toxic metabolites are used for the delivery of herbicides. Some of the examples are nanoemulsions, nanoencapsules, nanocontainers and nanocages (Khatem *et al*., 2016). But the nano formulations should also possess the capacity of faster degradation in the soil and lower release capacity inside the plants. Sodium dodecyl sulphate (SDS) encapsulated with the nano herbicides is used to improve the photo degradation of nanoparticles in the soil (Abigail and Chidambaram, 2017). The herbicides available in the market mainly aim at killing the above ground weeds portion but they are unable to inhibit the growth of underground vegetative portions, which actually regenerate in the next season (Dashora and Kanika, 2018). In the Tamil Nadu Agricultural University, encapsulated herbicide in a MnO_2 core shell shielded with bilayer polymers that open up and show the active ingredient on receipt of rainfall (Subramanian and Tarafdar, 2011).

NANOBIOTECHNOLOGY

Nanobiotechnology provides possible ways to enhance the efficiency and quality of farm output and food storage. It also helps in enhancing the safety of the food items in order to protect the consumers and the producers too. Nanobiotechnology is also used to produce new value-added products of cereals, fruits, oilseeds etc. (Hossain *et al*., 2021). New researchable areas and applications of Nanobiotechnology includes the study of DNA molecules, identification of protein and their manipulation to apply it in the nutraceuticals and pharmaceutical industry. The applications can be extended in the agricultural and food processing fields by use of controllable nano structures and novel nucleic acid engineered films.

ENHANCING SEED EMERGENCE

Seeds are the most important input in agricultural production. The registered seeds hardly show germination percentage of 80-90% due to the non-availability of moisture. So, seed coating and seed hardening studies are being done to improve the germination percentage in the field condition of India where almost 60% of land is rainfed. Carbon nanotubes are a type of material which has extensive surface area and helps in smart delivery of water and nutrients to the seeds. Different data shows that there is a positive correlation between the amounts of carbon nanotubes used with the germination percentage (Khodakovskaya *et al*. 2009).

PRECISION FARMING

Precision farming is defined as a system in which the goal is to maximise the production with minimum inputs like fertilisers, pesticides, herbicides etc (Bhattacharyay *et al*., 2020). Computers, global satellite positioning systems, and remote sensing devices are used to measure the different parameters in the localised niche and accordingly localised applications with variable rate are done. Thus, precision farming helps to reduce the agricultural wastes and lowers the environmental pollution. This leads to sustainability in the production system. Nano sensors linked into a GPS system for real-time monitoring can be used to carry out precision farming; the nano sensors can be spread throughout the field where they can measure and monitor the soil parameters. Nano sensors containing carbon nano-tubes are very small and these tubes can trap small molecules and measure their amount. This type of nano materials can be engineered, so that they create an electrical or chemo signal when they come in contact with such proteins or bacteria or water. The dendrimers are the actual molecules which are branched and bind with the target proteins or any chemical (Dashora and Sharma, 2018). Thus, precision farming will lead to enhanced and sustainable productivity due the accurate information provided through nano sensors.

FUTURE RESEARCH

Future of farming can be the nano bio-farming. The future, if foreseen, would certainly permit the progression of nanotechnology in the farm sector to endorse precision and smart agriculture guiding the precise use of the natural resources with latest and proven scientific technologies. The crop yield can be increased through involvement of nano porous zeolites that release nutrients and water slowly and efficiently. Further, plant protection can be made easy by using nano-capsules for weedicide application and pest management along with detection of harmful insect-pest by using nano-sensors (Scrinis and Lyons, 2007) Nanotechnology is potentially useful in the farm sector because of its quality to improve the life forms on the earth ensuring agricultural sustainability. The former President of India Dr. A. P. J. Abdul Kalam addressed scientists and technologists during April 2007 at Delhi: "We have to launch vertical missions under an umbrella organization with the public-private investment in at least 10 nanotechnology products in water, energy, agriculture, healthcare, space, defence sectors. Encourage the youth to take up the challenge in these missions with international collaborations."

CONCLUSIONS

The present agricultural context clearly demonstrated that the excess use of agro-chemicals used as inputs in agriculture has degraded soil, natural water body and food. The enhancement of crop production is mandatory for feeding the human and livestock population, but the same should not be in the cost of the ecosystem. Hence, the nanotechnology, as a new horizon of hope appeared before us to revolutionize the use of essential inputs in agriculture. Nano-materials perform better under lower concentration and no adverse effect has so far been noticed with recommended doses. Overall, Nano fertilizers are potentially efficient to improve the NUE, soil quality, ecosystem services and environmental soundness.

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REVIEW ARTICLE

Potential Role of Foliar Nutrition on Productivity of Field Crops – A Review

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ABSTRACT

To feed the rapidly growing population sustainably with shrinking land holdings under the framework of climate change enhancement of crop productivity adapting to the changing climate is imperative. As the all the high yielding varieties used in cultivation were highly responsive to added fertilizers. Increase in fertilizer use efficiency in catering nutrient needs of the crop would be directly proportional crop growth and yields achieved, respectively. On the other hand soil applied fertilizers were less efficient since they were influenced by various physio-chemical and biological properties of soil. In this scenario, supplementing nutrients through foliar spray was gaining a huge response. Keeping in this view, the literature on potential role of foliar nutrition on productivity of field crops was reviewed in this paper.

Keywords: DAP, urea, iron, boron, zinc, foliar application

INTRODUCTION

Availability of nutrients in the soil has a significant influence on growth and productivity of food grains. Soil has been acting as a store house for most of the plant essential nutrients. Intensive agricultural practices exhausts the innate nutrient concentration in the soil which was usually replaced though synthetic nutrient sources. Application of nutrient rich fertilizers to stabilize crop yield in nutrient deficient soils was a common practice prevailed and popularized from the era of green revolution (Zahed *et al.,* 2021).

However, soil applied fertilizers were influenced by physical, chemical and biological properties of the soil in turn limiting their availability to plant. The soil applied fertilizers were rendered less efficient to cater nutrient demand due to their chemical transformation into insoluble form, increased fixation in the soil colloidal lattice, subjected to leaching or runoff, respectively (Patil and Chetan,2018). The ability of leaves to absorb nutrients in the form of solution provided a breakthrough to confront this issue. Foliar application of fertilizers improves their application efficiency and in turn minimizes their quantitative requirement by the plant (Fageria *et al*., 2009; Praharaj *et al*., 2021). Further, in resolving acute nutrient deficiencies during any part of the crop life cycle. However, foliar application alone was not effective in meeting the entire crop nutrient demand but this could be handy in supplementing the additional nutrient requirement in association with soil application, respectively. Considering its future scope this present introspect was instigated to provide a deep understanding on the influence of nutrients applied through foliar spray on productivity of field crops.

EFFECT OF FOLIAR APPLICATION OF DAP ON FIELD CROPS

Diammonium phosphate (DAP)is the most popular fertilizer comprised of both nitrogen and phosphorus. These nutrients are helpful in plant growth and development attributing to higher crop yield. Foliar application of DAP was reported to supply appropriate amount of nutrients during stress conditions (Sruthi *et al*., 2020). Further, application of foliar spray with this fertilizer when required to the crop increased the yield of the crop. Tahir *et al.* (2014) found that application of DAP through foliar spray method increased the plant height,dry matter accumulation and yield of black gram. Similarly, Behera and Elamathi (2007) reported that application of 2% DAP through foliar spray at 25 and 35 DAS increased the plant height and yield of green gram. Dixit and Elamathi (2007) reported that application of DAP in association with NAA, boron, molybdenum increased the growth and yield attributing characters in green gram. Suhathiya and Ravichandran (2018) reported that foliar application of DAP in combinations with $ZnSO_4$, $FeSO_4$,boric acid , cobalt chloride resulted in higher yield and net returns in black gram.

EFFECT OF FOLIAR APPLICATION OF UREA ON FIELD CROPS

Among all the plant nutrients nitrogen is one of the important nutrient which is very essential for growth of the plant. Especially for rice crop application of nitrogen containing fertilizer is very useful. But in the present days more amount of nitrogenous fertilizers were causing environmental pollution. Therefore, foliar application method is used to decrease the usage of nitrogenous fertilizer and applied in an optimum amount without causing adverse effect on evironment. Application of nutrients through foliar method gave more yield with lower nitrogen application (Bhuyan *et al*., 2012). Manik *et al.* (2016) reported that application of urea through foliar spray combined with prilled urea gave maximum yield in rice. Rabin *et al.* (2016) realized that yield in Aman rice cultivars was enhanced with the application of foliar spray of urea @ 2% associated with basal dose. Venkatesh and Basu (2011) found that application of urea as basal dose before sowing in association with foliar spray of urea positively influenced the growth and yield of chickpea.Sajad*et al.* (2013) reported enhancement in protein content of the grain in addition to grain yield in maize.

EFFECT OF FOLIAR APPLICATION OF ZINC ON FIELD CROPS

Zinc deficiency results major problems *viz.*, reduced protein synthesis, enzyme inactivation, poor reproduction development etc. in plants. So, to avoid these problems we have to use best and appropriate method to reduce zinc deficiency and optimum usage of zinc in plants by foliar application method. Foliar application is a very effective method as compared to soil application because soil applied zinc was affected by soil parameters and undergone change in its chemical structure and rendered inactive (Wasaya *et al*., 2017). Phuphong *et al*. (2018) observed that application zinc with the help of foliar spray method was comparatively effective than soil applicationin rice crop. Ghasemi *et al.* (2017) reported that application of zinc through foliar spray with recommended amount produced maximum grain yield .Boonchuay *et al.* (2012) observed significant influence of zinc application during early stages of application in rice.

EFFECT OF FOLIAR APPLICATION OF BORON ON FIELD CROPS

Among all the nutrients boron is also one of the most important micronutrients. The boron deficiency plants causes many problems like improper grain filling, poor development of nodules , no proper germination of seeds . Application of boron through foliar spray was fond to be the most appropriate method as compared to soil application (Wasaya *et al.,* 2017). Ali *et al.* (2016) reported that among all foliar applications, boron supplementation produced significantly higher yield in rice. Menaka *et al.* (2018) reported that application of boron to chickpea through foliar spray resulted in higher yield and increase in pod filling in chickpea.

EFFECT OF FOLIAR APPLICATION OF IRON ON FIELD CROPS

Application of iron to plants at appropriate time is necessary but delay or reduction in the quantity of iron applied leads to severe deficiency and impacts the crop productivity significantly. In our country iron deficiency causes decrease in yield especially in rice crop. The foliar spray method was the effective method to reduce the deficiency of iron in the plants and it is one of the fastest method to decrease the deficiency of iron in the plants through this productivity increases and stress decreases in all the field crops (Habib, 2009).Singh and Singh (2018) reported significantly that application of iron micronutrient with the help of foliar spray method in interaction with zinc produced more yield in rice.Soni and Kushwaha (2020) reported that application of iron and PI in combination with zinc sulphate with recommended dose in method of foliar spray resulted in highest yield and highest net and gross returns in mungbean. Erbil *et al.* (2020) reported that foliar method of application was the best method in that application of iron in combination with molybdenum gave more yield and increased root nodulation in soyabean. Akhtar *et al.* (2019) reported that the effective method or way to reduce deficiency of iron was foliar application method and application of iron in foliar method increases the productivity in groundnut.

CONCLUSION

From this review it can be concluded that foliar application of fertilizers wee more efficient in supplementing the nutrient demand of field crops compared to sole soil application .However, complete elimination of soil application shall not be able to cater the nutrient requirement of the crop. Henceforth soil application of fertilizers with supplemental demand based foliar nutrition would be an efficient strategy to achieve sustainable crop production.

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RESEARCH ARTICLE

Adverse Impacts of Abiotic Stresses on Major Cereals and Climate Resilient Adaptation Options

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ABSTRACT

Cereals are considered as the major staple food and main source of dietary energy, but the gradual increase in climate change impacts on growth and productivity of cereals leading to huge yield loss and thereby, threatening the food and nutritional security. In a large sense, change in climatic conditions affects the adaptability of the crop to a particular region. Different practices like exploiting the natural resources, huge production and application of exogenous chemical inputs, deforestation and many more methods are adopted to increase the horizontal land area and production which indirectly increases the pace of climate change. Aberration in climatic factors ultimately causes the abiotic and biotic stresses to crops. Abiotic stresses include the non-living factors like temperature (low and high), drought, salinity, heavy metal contamination etc. which affect the living organisms in a defined environment. Among various abiotic stresses, drought, temperature and salinity are the prime concerns. To combat problems and to maintain the sustainable cereal production, different approaches like adaptation of agronomic techniques and climate resilient approaches are to be followed. The article focused on various adaptation options to sustain cereal production and agricultural sustainability.

Keywords: Climate change, abiotic stress, rice, wheat, maize, adaptation options, climate resilient technologies

INTRODUCTION

India is an agriculture-based country which depicts that the major part of economy and the livelihood depends on agriculture. However, the gradual climate change hampers the production and adaptability of the crops (Brahmachari *et al*., 2018; Maitra *et al*., 2020; Das *et al*., 2021).Climate change is slow and continuous but man-made activities increases its pace which intensify natural calamities like flood, drought, temperature rise and change in rainfall pattern, etc. The frequency and the intensity of climate change decides the impact on food production(IPCC,

2019) and nutritional security (Maitra, 2019).Climate is a major component which determine pattern and type of agriculture (Aryal *et al*., 2020) of a specified region whereas any environmental change will give stress to the biological system of crops. Stress categorised into biotic and abiotic stress in which biotic stress is due to interactions between organisms starting from predation to allelopathy whereas abiotic stress appears due to the adverse effects of non-living environmental factors such as soil moisture stress(drought and flood), temperature(high and low), salinity, heavy metal, mineral nutrients, etc (Bhadra *et al*., 2021). Out of which soil moisture shortage, salinity, thermos-stress and imbalance in soil and nutrient are the prime issues which affects the flourish of the crops due to the variations within the plants at their physiological, morphological and molecular levels (Hossain *et al*., 2021a). Heat stress reduces yield about 50%, 31% and 42% in rice, wheat and maize respectively (Hossain *et al*., 2021b). Around the world,100 Mha (37%) of irrigated land has water logging and salinity problems and 20% of it to a great extent(Ali *et al*., 2001).Worldwide the crop production decreased by 2-6% due to variation in climate on an average for wheat it decreased by 6%, rice by 3.2% and maize by 7.4% (Zhao *et al*., 2017). Climate change and abiotic stresses are somehow interlinked to each other as change in agro-climatic conditions may cause stress on crops and hamper its adaptability (Singh *et al*., 2021).

Rice is a major cereal which feeds close to half of the world's population (Carriger and Vallee, 2007). To provide the foods to the vast and ever-growing population the production should also need to rise, but land and water scarcity (Khush,2005; Laik *et al*., 2021) and increase in demand caused forced cultivation of rice beyond normal monsoon periods(Prasad *et al*., 2006)to season where heat-stress a vital limitation for growth. By 2100,decadal climate projections showed an increase of 1.8 to 4.0°C in mean surface air temperature with an increase in variability around the mean temperature (IPCC, 2007).After rice, wheat attains second position as a food crop in the world which contributed over 30% of cereal production, i.e., 734 Mt from 214 Mha area (FAOSTAT, 2018).Among the cereals, wheat gets cultivated over a large area than any other cereals (Lakshmi *et al*., 2021), but the production is more for maize than wheat and rice. It is widely recognised that drought, salinity and low temperature are the main abiotic stresses for agriculture production which reduce the real genetic potentiality of the crop(Zhu, 2002).

The article focuses on various impacts of abiotic stresses on cereal crops and suitable adaptation options to combat them for sustainable crop yield. The article also addresses some Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), SDG 13 (climate action), and SDG 15 (life on land) (UN, 2021).

Impacts of Abiotic Stresses on Major Cereals

Major cereal crops, namely, rice, wheat and maize are adversely affected by abiotic stresses and during recent times, climate change and global warming are causing fata influences on the performance of various crops. In the following subheadings, the effect of environmental stress on the attributes of major cereal crops have been discussed. Also, the adoption options against the burdens have been narrated.

Impacts of Drought Stress on Cereals

Drought is considered as a major stress among all stresses which affects the crops and its severity increases in different parts of world (Passioura, 2007). Among various abiotic stresses, drought is more prominently reflected in wheat productivity (Fathi and Tari, 2016; Hossain *et al*., 2021c) and it may cause damage during all the crop growth stages. In the initial growth stage, it reduces crop stand with the reduction in the number of tillers, but, at the mid stage it reasons for reduction in dry matter accumulation, effective tillers and number of grains. The drought incidence at the reproductive growth stage is also fatal in wheat because it results in reduced drtmatter, fertility and grain weight (Tiwari *et al*., 2015). The growth and yield of maize are hampered due to water scarcity as it needs water during the critical growth stages and is sensitive to moisture stress. Maize grown under rained conditions commonly faces drought problems. Among all stages, reproductive stage is considered as more susceptible to drought because of translocation of photo synthates to reproductive part because of moisture scarcity (Taiz and Zeiger, 2006). Normally, drought affects different stages of maize, but the sensitive stages are seedling, knee height, flowering and grain filling. Drought during seedling stage affects initial establishment of crop, root growth, plant vigour, length of cob and kernel per row etc. However, at knee high stage it reduces height of plant, rate of photosynthesis and biomass production. Flowering stage is considered as another sensitive stage of maize to stress due to moisture shortage as it reduces the production and viability of pollen and causes tassel blasting; whereas the grain filling stage is another sensitive stage as it causes reduction in size of seed, test weight and grain yield. Rice is also sensitive to drought as it causes aberration in transpiration, leaf rolling and leaf damage reducing photosynthates production (Bhadra *et al*., 2021).

Management of Drought Stress on cereals

Forecast of drought and communication of advisory to the farmers are important to combat against drought. There are few options of agronomic manipulation such as choice of drought tolerant and short duration varieties, change in seeding or transplanting time, adoption of water efficient irrigation systems, ridge and furrow sowing in maize, zero-tillage seeding in wheat, fertilizer management, application of anti-transpirant are commonly adopted irrespective of crops (Ward and Makhija, 2018; Avinash *et al*., 2019; Peng *et al*., 2019; Mphande *et al*., 2020).

Impacts of Temperature Stress on Cereals

Wheat needs 14 to 15°C temperature at ripening stage and beyond 25°C reduces grain weight, but the critical temperature for grain filling is 35.4°C (Porter and Gawith, 1998). The temperature fluctuation causes yield loss by hampering grain formation and filling processes (Rane *et al*., 2007). However, cold and frost injury can also reduce wheat yield in North India (Tiwari *et al*., 2017).In maize, heat stress is considered as the second major constraint after drought which reduces the grain yield by15% or more. High temperature at reproductive stage cause abortion of pollen, desiccation of silk and reduced grain set, ultimately lead-ing to reduction in economic yield. Temperature > 32^{0}C affects the crop growth and if it goes beyond 38^{0}C then it causes inactivation of enzyme which inhabits the net photosynthesis in leaves. Rubisco enzyme functioning decreases if temperature exceeds 32.5^{0}C whereas at 45^{0}C it nearly reaches to completely inactivation state. High temperature along with low humidity cause the desiccation of exposed silk and pollen grains when release from anther because of thin outer membrane layer. Damage level to crop depends on the exposure time and intensity of high temperature. High temperature stress in seedling or primordial growth stage cause poor germination of seed and affects root growth and plant vigour. However, in knee height stage it causes stunting of crop, rolling of leaves, leaf firing and also reduction in rate of photosynthesis, total biomass and increase in the rate of transpiration. Stress during flowering stage cause reduction in production and viability of pollen, pollen shedding duration and inducing tassel blasting and abortion of pollen and even delays silkingand reduction of test weight and even 25-50% reduction in grain yield (Chen *et al*., 2018).

Growth stages of rice are divided into three, i.e., vegetative, reproductive and ripening stage. Reproductive growth phase is compative sensitive to heat as than to other stages. High temperature stress cause reduction in plant height, number of tillers and total dry matter accumulation (Yoshida *et al*., 1981) along with substantial increase in spikelet sterility(Krishnan *et al*., 2012).Among reproductive stage, flowering or an thesis stage is considered as more sensitive (Krishnan *et al*., 2012) as it affects dehiscence of anther which in turn increases the spikelet sterility. During grain filling, exposure to high temperature causes decrease in grain weight, grain filling, more of chalky and milky white rice grains (Yoshida *et al*., 1981).

Management of Temperature Stress on cereals

Agronomic practices and changing varieties are two suitable options against thermos-stress (Mamun *et al*., 2015). Japan and other Asian countries already started adopting heat tolerant rice cultivars (Iizumi, 2019). Additionally, agronomic practices such as changing the manipulation timing (for upland rice) and efficient water management are some more options to combat heat stress in rice (Morita *et al*., 2016).

Similarly, wheat varieties tolerant to heat are to be chosen (Chen *et al*., 2018). Besides, sowing at appropriate time, zero tilling are important to manage the thermos-stress. Increase in plant stand was also considered as a suitable adaptation measure against heat stress in Iran along with additional increment of nitrogenous fertilizer application (Hochman *et al*., 2009). Moreover, planting of maize in furrows, mulching and staggered planting are some more practices to manage heat stress (Santosh and Maitra, 2021, 2022).

Impacts of Salinity Stress on Cereals

Salinity in soil is a problem of the world in agriculture domain as it reduces the productivity of the most of the crops inclusive of major cereals. The salinity declines the crop yield in various ways (Hasanuzzaman *et al*., 2013). The impacts of salinity stress on crops are ion toxicity and osmotic stress. When the salinity stress is increased, plants show the reduction of water in the roots and reduces nutrients absorption takes place (Ahanger et al., 2017). Soil salinity forms reactive oxygen species (ROS) and superoxide which are responsible in damaging nucleic acids, membrane lipids, and proteins. There are some antioxidant enzymes that cause resistance against the damages of salinity. In saline soils, crop production can be drastically reduced by up to 40% in major cereals (Zhu, 2016).Soil salinity decreases production potential of crops by up to 40%. Salinity stress adversely affects the yield and quality of wheat (Loutfy *et al*., 2020).Salinity stress reduces grain weight, length of spike, number of spikelets which ultimately reduces wheat yield (Tiwari *et al*., 2017).Salinity stress in maize causes poor sprouting, germination and stand establishment at the initial stage. During the vegetative stage soil salinity causes yellowing of leaves, leaf tip burning, leaves rottening and plant mortality. Rice is more resistant to salinity stress at reproductive and grain filling stages than at germination and vegetative periods (Heenan *et al*., 1988). Effect of salinity on rice cause inhibition of germination, difficulties in crop area establishment, leaf area development, decrease in dry matter production, reduction in spikelet number per panicle ,1000 grain weight, delay in seed set and also even sterility can occur (Khatun and Flowers,, 1995).

Management of Temperature Stress on cereals

Soil salinity tolerant varieties of rice (CSR 10, CSR, 13, CSR43, SR 26 B, Bidhan 2 and CSR36) and wheat (KRL210, HD 2967) have been developed (Sarangi et al., 2021; Sheoran et al., 2021). There are some more rice landraces which are to be evaluated and used for th purpose (Mukrram *et al*., 2011; Qin et al., 2020). Moreover, some cultural practices such as leaching of salts, application of gypsum, seed priming, mulching and cultivation of summer crops in furrows are to be adopted in the saline tracts.

CONCLUSION

There is great progress done in understanding the responses of crops to different abiotic stresses. Crops experienced under the consequences of climate change a number of abiotic stresses which created the yield losses. To minimize the loss, various crop management practices are to be adopted such as adoption of appropriate and stress tolerant cultivars and hybrids and the suitable varieties that can escape the stress period. Development of resistant or tolerant cultivars is one of the best options to reduce the losses. The anthropogenic activities such as excessive fertilizer application, inappropriate irrigation, unnecessary tillage operations should be avoided. The suitable management options described in the article are to be followed as adaptation strategies to minimize the ill effects of abiotic stress targeting sustainable cereals production.

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RESEARCH ARTICLE

Influence of Preservative Solutions in Improving Floral Quality and Longevity of Gerbera

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ABSTRACT

Prolonged vase life is a key to meet the growing market demand of cut-flowers. To find out the most potential chemical preservative to enhance shelf life of gerbera, an experiment was laid outin randomized block design with ninetreatments, *viz.*, tap water, 2% of sucrose solution,4% sucrose solution,50ppm citric acid,100ppm citric acid, 2% of sucrose solution+50ppm citric acid, 2% of sucrose solution+100ppm citric acid, 4% sucrose solution+50ppm citric acid, 4% sucrose solution+100ppm citric acid with three replications. The results indicated that 4%sucrose+100ppm citric acid was superior in enhancing the capitulum diameter, delaying the stem bending, petal shrivelling and increase the weight of the flower. Henceforth, it was concluded that post harvest treatment with 4%sucrose+100ppm citric acid could be an appropriate vase life enhancer that has the potential to prolong vase life of gerbera.

Keywords: Sucrose, Citric acid, Vase life, Gerbera, Tap water

INTRODUCTION

Gerbera (*Gerbera jamesonii*) is a high value cut flower widely used in decorations and thereby conferring highest demand in export market (Maitra et al., 2020a,b). Gerbera is a diploid plant widely distributed in South Africa, Africa, Madagascar, and tropical Asia (Reddy et al., 2016). It is a stemless perennial herb with pitiolated, coarse or leathery leaves (Khalaj et al., 2015).Gerbera constitutes variety of attractive, colourful inflorescences, that are available in different sizes to meet the user's requirement(Li et al., 2015). However, vase life of many gerbera cultivars were moderate in nature which is discouraging its potential at a commercial scale.

The major factors affecting the vase life of cut flowers are nutrient deficiency, bacterial and fungal clogging of vascular tissues which might minimize the uptake of water from the vase solution, attributing to floret wilting, respectively (Shabanian et al., 2018). In this context, preferable use of chemicals that improve water uptake and retention were gaining wider recognisation in improving the vase life of gerbera.

Among the various vaselife enhancers sucrose is commonly used and easily available form that is known to prolong the shelf life of cut flowers. The cut flowers treated with sucrose solution after harvest provide an additional supply of respiratory substrates in turn influences the opening and closing of stomata (Malakar et al., 2019). Similarly, citric acid is another vase life enhancer which attributes in regulating the pH of vase solution and consequently disfavours bacterial growth that might clog vascular tissues *viz.* xylem, respectively (Mehdikhah et al., 2016). However, the information available on appropriate concentration when used solely or in combination on gerbera was meagre. In the light of above facts, the present investigation was undertaken to evaluate the alone and combined application of sucrose and citric acid in extending the shelf life of gerbera. Further, the article addresses some of the Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and wellbeing) and SDG 15 (life on land) (UN, 2021).

MATERIALS AND METHODS

In the present study, flowers were collected from three and half years old Gerbera (*Gerbera jamesonii*) plants of Ankur variety raised under controlled environment. To examine the effect of the vase solution components on the keeping quality of gerbera cut flowers, an experiment was laid out in randomized block design with nine different preservative solutions (treatments) viz tap water(T_1), 50 ppm citric acid(T_2), 100 ppm citric acid(T_3), 2% sucrose(T_4), 4% sucrose(T_5) ,50 ppm citric acid +2% sucrose(T_6), 50 ppm citric acid + 4% sucrose(T_7), 100 ppm citric acid +2% sucrose(T_8), 100 ppm citric acid + 4% sucrose(T_9), replicated thrice. This experiment was carried out in biochemistry laboratory, Centurion university of technology and management, R.Sitapur, Odisha . Data recorded during the experiment were namely capitulum diameter (cm), longevity of flowers (days), days taken for stem bending, days taken for first petal shrivelling and fresh weight of flowers (g) of gerbera cut flowers, respectively.

Capitulum diameter (cm)
Capitulum diameter was measured using a scale and a fully opened flower was used for this purpose. The scale was laid out horizontally on the capitulum and readings were recorded at 1st, 3rd and on final day in centimetres.

Longevity of flowers (days)
Longevity of flower was determined as the number of days from starting the experiment to the fully fading stage. Vase life of gerbera varied among the vase solutions. The fading stage was observed daily and recorded till the flower completely abscised.

Days taken for stem bending
The data related to days taken for stem bending was recorded through visual observation from the starting of experiment till bending of bending of stems was observed.

Days taken for first petal shriveling
The data related to days taken for first petal shriveling was recorded through visual observation from the starting of experiment till first petals of gerbera flower were observed to shrivel.

Fresh weight of flower (g)
The fresh weight of the flower was measured by weighing balance on the final day of its shelf life period and was recorded in grams.

Statistical analysis

Observations recorded were analysed using single factor randomized block design through OPSTAT online (http://14.139.232.166/opstat/onefactor.htm?flavor=One+Factor+Analysis) and treatments were compared at 5% level of significance.

RESULTS AND DISCUSSION

Capitulum diameter (cm)

The data presented in the Table 1 revealed that capitulum diameter was significantly influenced at 3rd and final day of observation by vaselife enhancers. Among the treatments, 100 ppm citric acid + 4% sucrose recorded maximum increase capitulum diameter on third day of observation over tap water (control). Similarly, this data indicated maximum retention of capitulum diameter by 100 ppm citric acid + 4% sucrose over other treatments in comparison. This might be attributed due to promotion of water uptake and increased hydraulic conductivity by appropriate combination of sucrose and citric acid, respectively. Similar findings were observed by Bahran et al. (2018) and Khan et al. (2015).

Longevity of flowers (days)

The data presented in Table 2 reported that longevity of gerbera was significantly influenced by application chemical vase life enhancers over tap water (control). Among different vase life enhancers under comparison 4% sucrose solution+100ppm citric acid was found significantly superior in boosting the longevity of gerbera flowers. Further, the treatments consisting100 ppm citric acid + 4% sucrose, 50 ppm citric acid + 4% sucrose,50 ppm citric acid +2% sucrose, 4% sucrose,2% sucrose and 100 ppm citric acid were significantly at par with respect to observed longevity of flowers. However, significantly lower longevity was recorded by the flowers treated with only tap water (control)., respectively. This might attributed to role of sucrose as a respiratory substrate, resulting in delayed protein degradation and added up by reduced vascular blockage attributed by the combination of citric acid in appropriate concentration. Similar, findings were obtained by Lakmali et al. (2016) and Muraleedharan et al. (2019).

Days taken for stem bending

The perusal of data presented in Table 2 revealed that, days taken for stem bending was significantly influenced by application chemical vase life enhancers over control (tap water).Among different vase life enhancers under comparison 4% sucrose solution+100ppm citric acid was found significantly superior and recorded higher number of days for stem bending. While, treatments comprising of 100 ppm citric acid + 4% sucrose, 50 ppm citric acid + 4% sucrose,50 ppm citric acid +2% sucrose, 4% sucrose,2% sucrose and 100 ppm citric acid were significantly at par in terms of days taken for stem bending, respectively. However, significantly less number of days for stem bending was recorded by the flowers treated with only tap water (control). This might be due the role of sucrose in increasing the osmotic concentration of gerbera, associated with reduced micro-organism growth attributed due to addition of citric acid in appropriate concentration. Similar findings were observed by Khan et al. (2015) and Lakmali et al. (2016).

Days taken for first petal shrivelling

The perusal of data on days taken for first petal shrivelling presented in Table 2 revealed that, it was significantly influenced by application chemical vase life enhancers over control (tap water). Among different vase life enhancers under comparison 4% sucrose solution+100ppm citric acid was found significantly superior and recorded more number of days for first petal shrivelling. While, treatments comprising of 100 ppm citric acid + 4% sucrose, 50 ppm citric acid + 4% sucrose, 50 ppm citric acid +2% sucrose, 4% sucrose, 2% sucrose and 100 ppm citric acid were significantly at par in terms of days taken for first petal shrivelling, respectively. However, significantly less number of days for first petal shrivelling was recorded by the flowers treated with only tap water (control). This might be attributed due to increased concentration of dissolved sugars (osmotically active) in the petalsassociated with reduced blockage of xylem vessels. Similar findings were obtained by Mehraj et al. (2016) and Khan et al. (2015).

Fresh weight of the flower

The perusal of data on fresh weight of the gerbera flower on the final day of its vase life was presented in Table 2 revealed that, days taken for stem bending was significantly influenced by application chemical vase life enhancers over control (tap water).Among different vase life enhancers under comparison 4% sucrose solution+100ppm citric acid was found significantly superior and recorded higher number of days for stem bending. While, treatments comprising of 100 ppm citric acid + 4% sucrose, 50 ppm citric acid + 4% sucrose,50 ppm citric acid +2% sucrose, 4% sucrose,2% sucrose and 100 ppm citric acid were significantly at par in terms of days taken for stem bending, respectively. However, significantly less number of days for stem bending was recorded by the flowers treated with only tap water (control).This might be due to the increased water uptake and hydraulic conductivity through appropriate combination of sucrose and citric acid. Similar findings were observed byMuraleedharan et al. (2019)

CONCLUSION

The present study revealed that all the chemical preservatives improved the quality of gerbera flower. Among the treatments under comparison, 4%sucrose+100ppm citric acid showed a superior response in enhancing the capitulum diameter, delaying the stem bending, petal shrivelling and increase the weight of the flower. Therefore, it can be concluded that post harvest treatment with a holding solution comprising 4%sucrose+100ppm citric acid has the potential to prolong the keeping quality and vase life of gerbera flowers.

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Table 1: Effect of preservative solutions on capitulum diameter of gerbera

Treatments	Day 1	Day 3	Final
T_1: Tap water	9.03	12.09	6.85
T_2: 50 ppm citric acid	9.11	12.37	7.48
T_3: 100 ppm citric acid	9.53	12.87	8.03
T_4: 2% sucrose	9.15	12.55	7.65
T_5: 4% sucrose	9.23	12.96	8.12
T_6: 50 ppm citric acid +2% sucrose	9.35	13.15	8.27
T_7: 50 ppm citric acid + 4% sucrose	9.43	13.29	8.44
T_8: 100 ppm citric acid +2% sucrose	9.49	13.43	8.86
T_9: 100 ppm citric acid + 4% sucrose	9.63	13.89	9.70
SE (m)	0.21	0.19	0.18
CD (5%)	NS	0.56	0.55

Table 2: Effect preservative solutions on quality parameters of gerbera

Treatments	Longevity of flowers (days)	Days taken for stem bending	Days taken for first petal shrivelling	Fresh Weight of the flower
T_1: Tap water	5.6	3.6	1.9	7.33
T_2: 50 ppm citric acid	6.7	4.2	2.3	8.73
T_3: 100 ppm citric acid	7.7	4.8	2.6	10.00
T_4: 2% sucrose	7.7	4.9	2.6	10.07
T_5: 4% sucrose	7.7	4.9	2.6	10.13
T_6: 50 ppm citric acid +2% sucrose	7.8	4.9	2.6	10.20
T_7: 50 ppm citric acid + 4% sucrose	7.9	5.0	2.7	10.27
T_8: 100 ppm citric acid +2% sucrose	8.0	5.0	2.7	10.33
T_9: 100 ppm citric acid + 4% sucrose	9.0	5.7	3.0	11.73
SE (m)	0.15	0.09	0.05	1.42
CD (5%)	0.45	0.28	0.15	0.29

RESEARCH ARTICLE

Lodging: A Devastating Problem of Cereals

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ABSTRACT

Permanent bending as well as displacement of plants from their standing position is referred to as lodging. It is a devastating problem in cereals especially wheat, oat and barley. This generally occurs during the harvesting season of these crops. This can be categorized into stem and root lodging. It is a complicated phenomenon influenced by many factors including wind, rain, topography, soil type, previous crop management and disease. Cereals cultivated with heavy inputs especially high irrigation andfertilizers are more susceptible to lodging. This is responsible for drastic reduction of yield of cereals. It also enhances cost of harvesting along with reduced quality. Therefore, adoption of proper strategies of planting and time, population, nutrition, rotation as well as disease management helps in reduction of lodging.

Keywords: cereals, lodging, stem strength, wheat

INTRODUCTION

Lodging is an important problem especially among cereals resulting in permanent displacement of crops, stems or roots from their vertical orientation under unfavorable weather or soil conditions (Dahiya *et al.*, 2018; Laik *et al.*, 2021).It has been reported that the process of lodging among cereals is basically due to the cumulative effect of inadequate stem strength of the crop as well as different abiotic conditions including soil, heavy rainfall, strong wind, hail, topography of the region etc.(Berry, 2012; Das *et al.*, 2021; Dey *et al.*, 2021). Lodging in cereals can be classified into stem lodging and root lodging (Sterling *et al.*, 2003; Hu *et al.*, 2013). Plant height is in association with stem lodging (Verma *et al.*, 2005; Mohanta *et al.*, 2021). The ultimate plant height is determined by elongation of internode, which is regulated by genes responsible for biosynthesis as well as signaling of gibberellin (GA) and brassinosteroid (BR). As these two major plant hormones are responsible for various biological processes throughout plant growth and development, lack of optimum concentration of GAs and BRs biosyntheses are responsible for dwarf or semi-dwarf stature, resulting in enhanced lodging tolerance (Maitra *et al*., 1998; Weiss *et al*., 2007; Pramanick *et al*., 2018; Hossain *et al*., 2021).

Factors affecting lodging

There are different factors responsible for lodging. Different types of root and crown diseases may be responsible for weakening of stem thereby causing lodging of the plant. Insects attack causes stem breakage. Excessive or high tiller densities can also cause lodging due to decrease in light transmittance, main root length, number of first lateral roots, root volume, number of internodes and diameter of internodes**.** Therefore, seed sowing under specific spacing gradient is essential**.** Excessive application of nitrogenous fertilizers, high seeding rates, excessive soil moisture and use of tall varieties (are several other factors responsible for lodging.

Lodging can occur due to buckling of stem. The force of wind exerts leverage on plants. Stem lodging occurs only when stem has insufficient stem strength to support its shoots against the leverage. Excessive rainfall decreases anchorage of roots in soil. Improper anchorage of roots in soil causes root lodging. It has been reported that wind speed of 5 km/hr has significant effect in lodging of cereals. Reports show that a rainfall of 6 to 11 mm in a day can reduce soil surface strength drastically and hence significantly increase the risk of lodging. Soils with crumby structure, lower clay content or higher organic matter reduce anchorage; thereby making plants more susceptible to lodging.

Effect of nitrogen on lodging of wheat

Excessive amount of nitrogen application often increases the tendency of lodging in wheat crop. Scientists proved that the lodging in wheat was due to excessive nitrogen supply primarily affecting the basal culm internodes. It was also reported that on increasing of nitrogen dose, the length of basal internodes increases by 10-25%. They observed that rate of nitrogen was not significantly affecting plant height but it was proved that increased rate of nitrogen increases the chances of lodging.

Effects of lodging

Scientists proved that yield for spring wheat reduced by 4 to 33 percent due to lodging. The most critical stages for lodging are heading and early grain development. They showed that grain yield reduced by 7-35 per cent due to culm lodging. It had maximum effect within the first 20 days after anthesis. Reports show that lodging results in plants with reduced photosynthetic capabilities and hence there is reduced assimilation of carbohydrates. Lodging affects nutrient and moisture uptake from soil resulting in incomplete filling of kernels, lowered carbohydrate content and reduced test weight.

Lodging causes uneven maturity, higher moisture content and decreased grain quality in crops. Under severe cases, lodging may also cause deformed and shriveled kernels. Reports show that kernel number remains unaffected but grain weight is severely reduced due to lodging. If the crop encountered lodging 10 days after heading, it may result in loss of up to 40 % of the yield.

Control of lodging

The problem of lodging in cereals is a matter of great attention today because of its severe damage to the crops. As a result of lodging there is reduction in yield as well as quality of the wheat grain. Therefore a thorough research of all the factors responsible for lodging is essential for the scientists with an aim to obtain superior varieties which are stiff and agronomically improved. Availability of lodging tolerant varieties is therefore an essential pre-requisite for increasing production. Unfortunately due to its complex nature there have been no clear cut solutions to this problem. A thorough study of different factors governing lodging tolerance, therefore, essential for the breeders for developing superior varieties combining stiffness of straw with other agronomically desirable characters. Varietal differences in lodging tolerance have been reported in different reports. The introgression of dwarfing genes in wheat resulted in plants which had shorter and stronger straw and hence were tolerant to lodging. The plants showed higher yield under optimum level of nitrogen application. Scientists reported that lodging score depends upon variety, sowing time and plant density. However, it was inferred that varieties having a single dwarfing gene, are much taller than those varieties having two dwarfing genes, yet the former show less lodging. Scientists proved significant differences in varieties for lodging tolerance among which a variety named Bacanora lodged upto 25 per cent as compared to no lodging by Baviacora 92. The application of growth inhibitor like Cerone (2 -chloroethyl phosphoric acid) and CCC (chlormequat chloride) were reported to be responsible for controlling lodging by reducing plant height (Jankowicz-Cieslak *et al*., 2016).

Inheritance of lodging resistance

Scientists reported that lodging in wheat is basically due to failure in structure rather than due loss in anchorage. They proved that most of varieties having Rht 1 gene were highly lodging resistant as compared to the varieties having Rht2 gene. They studied the effect of root and shoot characteristics on the lodging resistance and concluded that lodging mostly occurs during grain filling stage due to heavy spikes and wet soil. They revealed that stems which were thicker and heavier were proved to be lodging resistant.

Characters associated with lodging

Under artificial lodging conditions (the plants were bound to get lodged after anthesis by flooding irrigation and pushing the culms at specified angle) proved that total dry weight of the plants were found to be drastically reduced in lodged plants as compared to non-lodged plants. Lodging causes reduction in grain quality and promotes time consuming harvest. It has been proved that lodging of wheat at an angle of 45° from vertical would cause reduction in grain yield by 18%.On the other hand, lodging at an angle of 80° from the vertical at the time of anthesis would result in loss in grain yield by 7–35%, 43–61%, and 54% (Berry and Spink, 2012; Kumar *et al*., 2021; Singh *et al*., 2017). The insertion of dwarfing genes at the Green Revolution reduced the chances of lodging by reducing the leverage towards the base of stem and anchorage system by decreasing the plant height which promotes greater rates of fertilization. The leverage was further decreased by the use of plant growth regulators.

Assessment of lodging

Different properties of the biophysical support structures have been quantified for winter wheat and spring wheat through a validated model of lodging of wheat which demonstrates the interaction of plant, soil (moisture) and wind properties (Pinera-Chavez *et al.,* 2016; Dey *et al*., 2021). Scientists estimated plant height and diameter of each tillers in but stem strength was not evaluated.

Root anchorage strength is one of the essential parameters studied and researched for assessing lodging in plants. In fact, it was reported that lodging of plants is not only genotypic character(Mondal *et al*., 1997; Ookawa *et al*., 2014)but is also dependent upon different agronomic practices followed during cultivation for the production of thicker, stronger and stiffer stems along with stronger root systems. Scientists compared stem strengths and root structures of plants and compared them with weight or force to be beard by them. Assessment of stem strength is an excellent measure of susceptibility of plants to anchorage failures. This is also essential for assessment of stability of plants.

Now-a-days, special attention has been focused on different mechanics of root anchorage, because it has been reported that cereals undergo more of root lodging than stem lodging. Root anchorage in the soil medium is basically dependent upon the rooting system of plants and is definitely an essential parameter of determining lodging resistance.

CONCLUSION

One of the most important problems in wheat is lodging which is responsible for drastic reduction in the yield and quality of the grains. Therefore, in order to overcome this problem, several measures have been taken e.g. reduction of plant height through introduction of *Rht* genes during green revolution. However, the *Rht*-genes are associated with reduced yield. Therefore, under the above circumstance, development of lodging tolerant plant with considerable higher yield is required.

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RESEARCH ARTICLE

Nutrition of Wheat Crop through Micronutrient Management

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ABSTRACT

Wheat (*Triticum aestivum* L.) is the predominant cereal crop of the globe and is staple food crop of millions of people. Grains of the wheat contain 8 to 12 per cent protein *viz.*, gluten which is mainly responsible for bread stuff and essential for bakeries. Wheat stands second next to rice in terms of food grain production. Plants require micronutrients for its normal growth. Deficiencies of micronutrient drastically affects the growth, metabolism and reproductive phase of plants. The essential micronutrients are zinc (Zn), manganese (Mn), copper (Cu), iron (Fe), boron (B), molybdenum (Mo), chlorine (Cl) and Nickle (Ni). Nutrient deficiencies are not restricted only to N, P, K but have also extended to Zn, B, Fe, and S. Deficiencies of Zn and Fe are widespread followed by Mn and B under Indian conditions. Micronutrient deficiencies in crop plants are widespread due to intensive cropping practices and adoption of high yielding cultivars, enhanced production of crops on marginal soils, increased use of high analysis fertilizers, decreased use of animal manures, composts and crop residues, cultivation on soils which are low reservoirs for native micronutrients. Some of the factors affecting micronutrient availability are total content in soil, soil texture, organic matter content, soil pH, soil aeration, nutrient interaction in plant system.

Key words: Wheat, Micronutrients, Growth and yield, Uptake of micronutrients

INTRODUCTION

Wheat (*Triticum* spp.) is the principle source of energy and food for wide area of India's population, especially in northern states. A total of 30 million hectares have been planted with wheat crop (14% of global area) to produce the all-time highest output of 99.70 million tonnes of wheat (13.64% of world production) with a record average productivity of 3371 kg/ha. With a 36 percent share of total food grains produced in India, India has a substantial role in food basket consumption, assuring not just food security but also nutrition security. China, India, the United States, Russia, Canada, and Mexico are among the major producers of this crop (Zahan *et al*., 2021).Due to adoption of new and latest agricultural technologies, i.e., cultivation of high yielding crop varieties, expansion of irrigation facilities, increased use of high analysis fertilizers and higher intensity of cropping, which was possible owing to mechanized farming, resulted in the faster depletion of the finite micronutrient reserves of soils. As a result of these developments in India deficiency of micronutrient started emerging. Further, the adoption of rice-wheat system particularly on coarse textured and non-traditional rice growing areas has resulted in the over mining of the micronutrients from soils. The increase use of poor quality irrigation water to meet the water requirement of this cropping system is further increased deficiency problem of micronutrients.

For the first time deficiency of zinc was noticed in rice on soils of tarai region of India, In Uttar Pradesh, in 1965 and in wheat on sandy soils of Punjab in1970. Later on, it engulfed the whole of India where intensive cultivation, particularly of rice and wheat was practiced areas (Lakshmi *et al*., 2021; Praharaj *et al*., 2021). Deficiency of zinc was major cause of low crop yields till eighties but subsequently the deficits of multiple elements such as manganese, iron, molybdenum and boron were discovered in certain conditions based on soil type and crop planted. With the introduction varieties which are of high yield potential and responsive to fertilizer, many crops, including wheat, have experienced micronutrient losses as a result of the practise of using large amounts of high analysis macronutrient fertilisers combined with less use of organic manure and little recycling of crop residues. It is well documented that the deficiency of micronutrients in soils of arid and semiarid region.

The major yielding limiting factors and can generally disturb plant yield and quality(Yassen *et al*., 2010).The extent of micronutrient deficiency in some districts of Karnataka Revealed that, the highest zinc deficiency was found in Bidar district 91.72%Deficient samples out of 7761 samples analyzed followed by 90 34% in HaveriAnd 87.47% in Davanagere district out of 1648 and 7493 samples analysed Respectively. Copper deficiency was more pronounced (1.33%) in Bidar districtOut of 3151 samples analyzed followed by 0.90% in Gadag district MATE Deficiency was more in Gadag district (24,69%) followed by Bidar district(10.83%). Dharwad district has more deficiencies in Boron (34.06%) followed by Haveri district (20.49%). Fe deficiency was more in Gadag district (67 23%)Followed by Gulbarga district (62.05%) Singh (2004) reported that, the critical limits of micronutrients in soil.

The critical limits of micronutrients in both soil as well as plants are copper(0.2 ppm in soil and < 6 ppm in plants), Molybdenum (0.2 ppm in soil and < 1.0Ppm in plants).While, the values for critical limits are iron (4.5 ppm in soil and < 50 ppm in Plants) and Mn (2.0 ppm in soil and <20 ppm in plants).

Effect of micronutrients on growth, yield and yield components

Some of the adverse effects of micronutrient deficiencies induced stress in plants include low crop yield, imperfect plant morphological structure, widespread infestation of various diseases and pests, low activation phytosiderophores and lower fertilizer use efficiency. Plant products that are both quantitative and qualitative can only be obtained when they are paired with optimal plant nutrition. Soil application of $ZnSO_4$ @ 10 kg ha^{-1} noticed significantly higher leaf area (71.27 dm^2 / m row length), leaf area index (3.14), leaf are duration (92.90days) and CGR (0.207 g/dm/day) (Natarajan *et al*., 2006). Amjad *et al*. (2011) reported that, leaf area index (3.49) was significantly higher with 2 kg /ha of boron application which was also found at par (3.46 and 3.37) for micronutrient combined application. He also claimed that applying boron at a rate of 2 kg/ha sped up crop growth (to 33.40 $g/m^2/day$) followed by combination application of micronutrients (Zn + Cu + Fe + Mn + B) and soil application of zinc and copper @ 10 kg/ha and 6 kg/ha, respectively. Furthermore, different micronutrients have a substantial impact on wheat's relative growth rate. The application of boron at a rate of 5 kg/ha resulted in the highest RGR (89.60).Later, different micronutrients had a substantial impact on net assimilation rate (3.19), which was comparable to zinc treatment at 10 kg/ha (2.92 Mg/m2/day).In general, boron stimulated tissue development and plant growth, resulting in higher boron concentrations in leaves and, as a result, a larger leaf area index. Micronutrients, both individually and in combination, have a considerable impact on crop growth rate. Plant development was aided by the addition of micronutrients, which promoted photosynthesis and other physiological functions.

According to Ghamry *et al*. (2009), a combination of boron (50 mg/l) + molybdenum (25 mg/l) + zinc (250 mg/l) yielded the greatest values for all yield characteristics examined. When B, Mo, and Zn were applied together, the seed yield was higher (5.69 Mg/ha) than when B, Mo, or Zn were applied separately. According to Amjad *et al*. (2011), the largest number of tillers were produced when copper was applied at a rate of 8 kg/ha (249). Following that, soil applications of Mn (8 kg/ha), Cu (6 kg/ha), Zn (10 kg/ha), and Mn (16 kg/ha) were made, with statistically equivalent numbers of tillers (229.8, 226.5, 220.8, and 218.5/m2 respectively).Furthermore, boron application at 2 kg/ha yielded the highest number of grains/spikelet (46.50). Because boron is involved in the transport of food resources in plants. As a result, it was critical in grain setting and increasing the quantity of grains in wheat. Similarly, the combined application of Zn + Cu + Fe + Mn + B resulted in the highest grain weight (44.64 g). This could be attributed to increased assimilate buildup in the grain, resulting in heavier wheat grains.Boron at a rate of 2 kg/ha resulted in the highest grain yield (3.67 t/ha). The use of boron resulted in the highest grain yield due to the highest number of grains/spike, whereas the use of Cu and Mn resulted in greater grain yield due to the increased number of tillers. Boron improved plant development by increasing LAI, CGR, NAR, and other yield-related metrics. Among the many micronutrient application strategies, such as side dressing, foliar application, and soil application, soil application (at sowing) was determined to be the most cost-effective (Nadim *et al*., 2013). The number of tillers, grains per spike, and grain production of wheat were all increased when the soil application method was combined with boron treatment.

Farhan *et al*. (2021) reported that boron application at the rate of 0.3 kg ha^{-1}, and foliar application at 60 days after sowing resulted in higher plant height (5.24%), leaf area (9.18%), no. of grains $spike^{-1}$ (30.9 %), no. of spike m^{-2} (18.8%), spike length (65.6%), Grains yield (34.6%). Higher grain yield, an increase of 36.4% in Boron. Harvest index and higher Physiological Efficiency of wheat was obtained when 2 kg ha^{-1} of Bwas applied (Galido *et al*., 2018). Yaseen *et al*. (2010) reported that, foliar spray of Fe @ 1.6 kg $FeSO_4$ / 250Litre of water + Mn @ 2.4 kg $MnSO_4$ / 250 litre of water + Zn @ 0.72 kg $ZnSO_4$/250 litre of water in combination exhibited highest grain yield (2.75 t/fed), straw yield (5.81 t/fed) and 1000-grain weight (47.97 g) of wheat. Combined application of Zn (2%) + Fe (1%) + Mn (2%) + Cu (1%) + B(1%) at tillers + Boot + Joint + Ear was produced higher no. of grains per spike(42.7), maximum 1000-grain weight (37.6 g) and higher grain yield (3670 kg/ha)Of wheat (Muhammad *et al*., 2010).Grain yield, straw yield, 1000-grain weight, and the number of seeds per spikelet all increased significantly after Fe fertilisation. Their concentration and total uptake in grain and flag leaves, as well as the grain protein content, increased dramatically after Fe was applied. At lower rates, Fe application demonstrated a substantial response to wheat. Increases in Fe dose up to 12 kg ha^{-1} enhanced grain yield, whereas greater doses had little effect (Abbas et al., 2009). According to Yadav *et al*. (2011), using Fe-Zn enriched organics with RDNP boosted wheat grain and biomass yield by 2.3 to 6.6 percent when compared to direct application and by 5.6 to 10.3 percent when compared to no treatment of the micronutrients. In contrast, treatment of Fe-Zn enriched organic improved the availability of Fe (5.9 to 18.4%) and Zn (24.3 to 48.5%) as well as their uptake (12.9 to 24.1 percent for Fe and 13.4 to 28.8 percent for Zn) by wheat when compared to direct and no application of these elements.

According to Yadav *et al*. (2011), light soils with low accessible iron and zinc should be fertilised with Fe @ 4 kg and Zn @ 2 kg in the form of enriched FYM (500 kg), along with the recommended fertiliser dose (120-60-40kg NPK ha^{-1}) and 2.5t FYM ha^{-1} to increase production and economic return. Four kilogramme Fe ha^{-1} as $FeSO_4$ (19 per cent Fe) and 2.0 kg Zn ha^{-1} as $ZnSO_4$ (21 per cent Zn) in 500kg FYM ha^{-1} could be done before 45 days of sowing for compost enrichment.

Zeidan *et al*. (2010) indicated that foliar spray of $ZnSO_4$ H_2O @ 0.5%along with NPK (80:50:75 kg/ha) resulted in maximum grain number / spike, highest grain yield (3416 kg/fed) and straw yield (4173 kg/fed) of wheat. The importance of foliar application of micronutrients in generating greater yields may be owing to their vital involvement in crop growth, involving in photosynthetic processes, respiration, and other biochemical and physiological activities. Application of Nano fertilizer in zinc complexed chitosan nanoparticle form (zn-CNP) for ferti-fortification increased zinc content in grain without affecting yield of gain, protein content, spikelet's per spike, 1000-kernel weight *etc.*In four-year field studies on plots with varied soil zinc content, grain zinc enrichment was consistent, demonstrating the applicability of Zn-CNP as a novel Nano fertilizer that improved fertiliser usage efficiency (Dapkekar *et al*., 2018).

According to Abbas *et al*. (2011), the highest grain production of wheat (4.59 $Mgha^{-1}$) was achieved with a Mn treatment of 16 kg kg ha^{-1}. In soil treatment of Mn @ 16 kg ha^{-1}, the maximum straw yield (6.12 $Mgha^{-1}$) was recorded. The percentage increase in straw production attributable to 16 kg $Mnha^{-1}$ over NPK alone was 7.8%. The maximum number of tillers that can be used (314.87 m2). With 16 kg of Mn ha^{-1} the highest 1000-grain weight (37.70 g) was achieved. Except for P, the administration of Mn considerably boosted the absorption of N, K, and Mn. Mn^{2+} applied externally boosts photosynthesis, net assimilation, relative growth, and yield (Sultana *et al*., 2001). Manganese supplementation considerably increased Mn absorption in wheat. Similarly, using electron spin resonance spectroscopy, Singh & Bharti (2006) discovered that the Mna+ content of seeds has a direct linear connection with the height of wheat cultivars, suggesting that the Mn2+ content of seeds might be used as a criterion to identify the mature plant's height. Highest grain yield was recorded in cultivar Lasani-2008when Mn was supplied through seed priming at 0.1 and 0.01MMn solution whereas, in cultivar Faisalabad-2008 Mn foliar application reduced the grain yield (Amanullah *et al*., 2017).Addition of Mn to soil registered a higher Mn concentrations in plant tissues (Shankar *et al.*2014) and organic manures application in conjunction with phosphate fertilizer significantly improved the availability ofMn in soil vis-à-vis plant Mn content (Narender *et al*., 2018; Karimian *et al*. 2012).

Jahir *et al*. (2009) reported that application of boron at booting stage recorded significantly increased number of grains/spike (54.75). This may be due to the reason that boron plays a vital role in grain setting of wheat. Perhaps, the supply of boron at this stage helps in grain filling and ultimately sterility is reduced. The maximum 1000-grain weight (47.83 g) was observed where boron Was applied at jointing. The maximum grain yield (4592.83 kg/ha) of wheat was observed in treatment where boron was sprayed at booting might be due to that the application of boron enhanced pollen tube germination and grain setting at booting stage. Nataraj *et al*. (2005) indicated that soil application of ZnSO4 @ 10 kg/haexhibited maximum dry matter (239 g/m row length), highest number ofgrains/spike (41.82), maximum 1000-grain weight (34.0 g) and highest grain(31.23 q/ha) and straw yield (49.36 g) of wheat.

Sajid *et al*. (2009) indicated that highest number of grains / spike was produced by combined application of both zinc (2 g/litre) and boron (30 g/litre)Following that, boron is applied to the leaves as foliar spray. The combined treatment of zinc and boron resulted in enhanced grain weight (52.2 g), followed by foliar application of zinc (50.1 g). Foliar spray of crop nutrients at later stages ensures better crop nutrition during an thesis and at grain filling stage, which intern may result in greater grain weight. The foliar application of zinc and boron combindly yielded the highest grain yield. Kumar *et al*. (2019) suggested that Cu fluxes and it's interactions with other micronutrients (Fe, Mn and Zn) affect the wheat growth and yield. Cu application in excess amount may induce the deficiency of other micronutrients and adversely affect the yield. Hence, judicious and adequate amendment of Cucan contribute to a great deal in enhancing wheat crop yield.

According to Nadim *et al.* (2011), the application of boron @ 2 kg ha-1 and copper @ 8 kg ha-1 among the micronutrients (Zn, Fe, B) had a substantial favourable influence on majority of the yield contributing factors of wheat cv. Gomal-8.More grains $spike^{-1}$, higher grain weight, and higher grain production were seen when boron was applied at a rate of 2 kg ha^{-1}. With the application of various quantities of Hal-Ton and mineral fertilisers, the content of Cu, Fe, Mn, and Zn in wheat leaf, straw, and grain rose (Khan *et al*., 2006).Total uptake of Zn, Cu, Fe, and Mn in grain and flag leaves was greatly increased, according to Ziaeian and Malakouti (2001). These micronutrients aid in the creation of chlorophyll, nucleic acid, and protein, as well as participating in various photosynthesis and respiration enzymatic functions (Reddy, 2004).

Effect of micronutrients on uptake and quality

World health organization reported deficiencies of iron, zinc and vitamin A in human population of developing countries. Zn deficiencies cause a number of health problems like impairment in linear growth, sexual maturation learning ability, immune functions and the central system. Wheat is the mostcritical nutrient sources for human and animals play an vital role inproduction of food combinations worldwide. Zn also plays tremendous role for increasing Fe concentration which in turn is an integral part of many proteins and enzymes that maintain good health.

According to Anand and Patil (2005), simultaneous micronutrient administration resulted in significantly higher grain production (42.23 q/ha) and straw yield (68.79 g/ha).This increase in grain and straw yields might be ascribed to the combined effectof significant improvement in growth and yield attributes of plant height (97.7 cm),effective tillers / m^2 area (253), 1000-grain weight (42.23 g).Yassen *et al.* (2010) reported that combined application of Fe @ 1.6 kgFeSO4/250 litres of water + Mn @ 2.4 kg $MnSO_4$ / 250 litre of water + Zn @ 0.72Kg $ZnSO_4$/250 litre of water resulted the highest uptake of nitrogen (60.32 kg/fed)and gave maximum protein yield of 377.1 kg/fed. However, the highest protein concentration (13.95%) was found with a combined application of Mn @ 2.4 kgMnSO4 + Zn @ 0.72 kg ZnSO4 in 250 litre of water. Mn (0.2 percent MnSO4 solution) at 25, 37, and 49 DAS, with medium fertiliser levels, demonstrated that Mn content was increased in the grains, according to Shukla and Warsi (2000).Modaihsh (1997) revealed that foliar application of micronutrients (Fe, Cu, Zn, and Mn) in the form of sulphate rather than chelate (either EDTA or EDDHA) resulted in higher concentrations of these elements in wheat grain (*Triticum aestivum* L.), with both Zn and Mn concentrations being higher than others. Mn seed priming at 0.01 M Mn solution yielded the highest grain Mn content in cultivar Lasani-2008, whereas Mn seed coating (250 mg kg-1 seed) yielded the best results in cultivar Faisalabad-2008 (Amanllah *et al*., 2017).

Yassen *et al*. (2010) his result indicated that spraying with micronutrients showed increases in grain micronutrients concentrations (Fe, Zn and Mn). The increment of grain Fe concentrations ranged between 8-37% where the lowest value recorded as a result of spraying. The plants with Zn + Mn, while highest value recorded when plants was sprayed with Fe. On the contrary, the increment in grain Zn concentrations rangedbetween 23-50% by Fe + Mn and Zn foliar spray respectively. The increment ingrain Mn concentration ranged between 18-43%.Spraying plants with micronutrients treatments resulted in great increment in the uptake of Fe, Zn and Mn uptake. The highest increment in the uptake ofFe was obtained as a result of spraying wheat plants with Fe + Mn treatment. On the contary, spraying plants with Zn treatment showed highest grain Zn and Mn uptake (Yassen *et al*., 2010).Habib (2009) reported that combined application of Zn @ 150g/ha + Fe @ 150 g/ha. While, concentration of Zn in wheat grain was highest (50.9mg/kg) with Zn application @ 150 g/ha. Whereas, application of Fe @ 150 g/haresulted in highest concentration of Fe in wheat grain (146.70 mg/kg). Ranjbar and Bahmaniar (2007) opined that soil application of zinc @ 15 kg/ha + foliar spray of Zn @ 900 g/ha exhibited the highest grain Zn content(67.27 g/g), Grain Fe content (39.63 g/g) and highest protein content(18.97%) of wheat in comparision to no zinc fertilizers. Zeidan *et al.* (2010) indicated that foliar application of Mn @ 0.5$MnSO_4$ H_2O + Fe @ 1.0% $FeSO_4H_2O$ and Zn @ 0.5% $ZnSO_4$ H_2O in combination with recommended NPK (80:50:75) were improved the grain protein Content (10.6 to 11.10%), Mn (42 to 54.6 mg/kg), Zn (25 to 47.10 mg/kg), Fe (40To 54.90 mg/kg) and Ca (6.80 to 9.5 mg/kg).

Foliar spray of ferric citrate, $FeSO_4$-7H_2O, ferric citrate + $ZnSO_4$-7H_2O and Foliar spray of complex micronutrients @ 0.62% at each heading stage at 10 DAS and at milky stage showed significant improvement in Fe, Zn concentration in grains as well as in bran and flour (Yuegiang *et al*. 2010).Nataraja *et al*. (2005) reported the highest dry matter production, number of grainsspike^{-1}, 1000 grain weight, grain yield and straw yield with the application of 100 per centP_2O_5 and 10 kg $ZnSO_4$ ha^{-1}. Uptake of P, Zn and Fe was significantly influenced due to P, Zn and iron application. However, further increase in phosphorus level (upto 150% P2O5) resulted in lower uptake of nutrients.

Ghamry *et al.* (2009) reported that combined spraying of boron (50 mg/l) +Molybdenum (25 mg/l) + zinc (250 mg/l) recorded the maximum Fe (106.2Mg/kg) and Mn (47.5 mg/kg) content in wheat grain and was significantly superior over control (80.90 mg/kg). However, zinc spray @ 250 mg/l) gave high Zn concentration in grains (47.03 mg/kg) Soil application of $FeSO_4$ @ 5 kg/ha recorded maximum uptake of Fe(1448.58 g/ha) by wheat. While $ZnSO_4$application @ 10 kg/ha to soil exhibited the highest Zn uptake (267.89 g/ha) by wheat (Nataraja, 2005). Brunes et al. (2015) verified that boron fertilization, applied at sowing or tillering in doses between 2.5 and 3.0 kg ha-1 caused an increase in the number of seeds and spikes per plant, but with a reduction of seed yield per plant, mass of 1000 seeds and the hectoliter mass, unlike the one verified in the present work. However, a drastic reduction of grain yield was observed above the dose of 2.8 kg ha^{-1} of B.

Ananda and Patil (2005) opined that soil application of Fe (25 kg/ha) + Zn(25 kg/ha) in combination with RDF recorded significant protein content(13.25%)and beta-carotene content (8.26 ppm). Manganese uptake was dramatically boosted with increasing quantities of Mn above NPK alone, according to Abbas et al. (2011).Niyigaba *et al*. (2019)showed that foliar application of Zn and Fe is a practical approach to increase Zn and Fe concentration, and to improve the quality of wheat grains.

Economics

Muhammed *et al*. (2010) indicated that maximum net income (Rs.58.354)and B.C ratio (2.97) was recorded where shelter was exogenously applied at four growth stages (tillering, booting, jointing and earing) of combined application of (Zn + Mn + Fe + Cu + B) wheat compared withcontrol (no application) which resulted in lower net income (Rs.27996), and BC ratio (2.28). The increase in BC ratio due to foliar application of shelter four growth stages in supposedly due to the enhanced grain yield. Application of 5 kg Zn/ha recorded the highest returns (Rs. 15647) and proved superior to the control (Rs. 13484) and 10 kg Zn/ha (Dewal and Pareek, 2004).According to Tahir *et al*. (2009), at the booting stage, boron application at 617 ml/ 247 litre of water produced the highest grain income (Rs. 56015/ha), maximum net revenue (Rs. 34132/ha), and highest B:C ratio (2.07).Galindo et al. (2018), boron management in wheat crops in Brazilian conditions is very important to provide economical return, ensuring profitability from production of irrigated wheat

Application of Mn @ 16 kg/ha gave significantly the highest income of Wheat (983 US $ /ha) while, highest net return (Rs. 564.37 US $ /ha) was obtained with application of Mn @ 12 kg/ha. However, BC ratio was highest(245) with 4 kg Mn/ha. (Abbas *et al*. 2011). In a field experiment, Hussain *et al*., (2005) investigated the effect of micronutrient mixtures at different physiological growth stages of wheat and discovered that foliar spray of micronutrients at tillering+booting+milking growth stages of wheat yielded the highest net profit. With Mn seed priming (0.01 M Mn) for cultivar Lasani-2008 and Mn seed coating (500 mg kg-1 seed) for cultivar Faisalabad-2008, the maximum net benefit and benefit cost ratio were reached (Amanullah *et al*., 2017).

CONCLUSION

From the above, reviews it could be concluded that, soil and foliar sprays of micronutrients are suggested to be applied along with recommended dose of NPK for better crop nutrition and increase crop growth which will ensure higher yields and quality. Further, foliar applications of micronutrients led to an increase in concentrations of micronutrients in wheat grains and this effect may be attributed mainly to the vital physiological roles in plant cells which promote the uptake of micronutrients. The article also addresses some Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), and SDG 15 (life on land) (UN, 2021).

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RESEARCH ARTICLE

Growth, Yield and Economics of Summer Maize (*Zea mays*) as Influenced by Nitrogen Management Options

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ABSTRACT

Maize an important cereal is highly influenced by nitrogen application. Moreover, non-judicious use of nitrogenous fertilizer is not only costly but also harmful to agro ecosystem. Considering the above facts, a field experiment was designed at the Agriculture Farm of Centurion University of Technology and Management, Odisha, India during summer of 2020-21 to find out the impact of nitrogen management on growth and productivity of maize. The experiment was consisted of eight treatments, namely, 150% recommended dose of nitrogen (RDN), 125% RDN, 100% RDN, 75% RDN, 50% RDN, leaf colour chart (LCC) based application and Control. The treatments were laid out in completely randomized block design (CRBD) with three replications. The maize hybrid considered was Bioseed 9544.The treatment with 150 % RDN recorded superior results in terms of yield attributes, *viz.*,plant height (184.3 cm),dry matter accumulation (1841.4 g/m) at harvest and leaf area index (5.68) at 90 DAS. Also, the treatment showed better results in terms of grain yield (7.95 t/ha), Cost of cultivation (42847 Rs. ha^{-1}) Gross return (106240 Rs. ha^{-1}), Net return (63393 Rs. ha^{-1}) and B:C Ratio (1.4).The treatment comprised of LCC based nitrogen application also resulted in better performance in expression of all the parameters, but it was statistically at par with150% RDN,100% RDN and 125% RDN. The results clearly indicate that nitrogen optimization in maize can be done by using precision tool(LCC) to obtain optimum growth, yield and economics by the crop.

Keywords: Maize,Leaf colour chart (LCC), Growth, Yields, Economics**.**

INTRODUCTION

Maize (*Zea mays* L.) belongs to the family *Poaceae* and originated in Mexico. Maize is one of the most important cereal crops of the world and contributes to foodsecurity in several developing countries. In India, maize is considered as the third most vital cereals after rice and wheat. Importance of maize lies within the proven fact that it's not only used for human food as well as animal feed and also used in food processing industries that makes it popularin the world (Maitra *et al*., 2019, 2020). Hence, it is called as 'Queen of Cereals' (Rana *et al*.,2017). Maize grain contains11.1% protein, 66.3% carbohydrate, 3.6% fat, 2.7% fiber and 1.5% minerals such as calcium, phosphorous, iron and vitamins(A, B, E)(Joshi *et al*., 2017).In the world, maize production is 1162.3 million t that comes from more than 169 countries with a harvest area of 201.9 million ha and yield of 5.75 t/ha (FAOSTAT, 2020). In India, the total area cultivated under maize was 9.72 mha with a production and average productivity of 28.64million t and 2945 kg/ha, respectively during 2019-20 (Government of India, 2020). The study area is located in the southern part of the state of Odisha where maize cultivation is catching up. In Odisha, the area under maize was 2.54 lakh ha in 2019-20 with a production and average productivity of 7.33 lakh t 2886 kg/ha respectively (Government of Odisha, 2020).

Various agronomic options, especially, nutrient management is a prime strategy to achieve the demand for food and sustainable production for the rapidly increasing population in the world and improving food and nutritional quality (Manasa *et al*., 2018; Praharaj *et al*., 2021). All plants need sufficient amount of essential nutrients for their proper growth and development and the efficient nutrient management can prove to be much beneficial and healthy for various environmental resources (Mohapatro *et al*., 2020; Ghosh *et al*., 2021).The awareness among farmers about the future consequences of increased use of chemical fertilizers will enhance the adoption of developed strategies of nutrient application (Nduwimana *et al*., 2020; Cheptoek *et al*., 2021). Nitrogen is regarded as the most essential nutrient required by maize for its timely and proper growth and development (Jat*et al*., 2013; Maitra *et al*., 2019).

The precision nutrient management tools grew up against the excessive consumption of chemical fertilizers including its limited productions, increasing cost of production and the after effects on soil and ultimately pollution to agroecosystem (Bhuiya *et al*.,2020). The quantity of nutrient loss can be easily controlled with the adoption of precision nutrient management strategies (Hedley, 2015).Precision inputs management practices have showed much efficient results in agricultural production(Fountas *et al*., 2015). The phenotypical appearance of any crop plant is dependent on the availability and the applied quantity of nitrogen at its different growth stages and nitrogen use efficiency too(Kumar *et al*., 2014). Earlier studies revealed that use of various precision nitrogen as well as nutrient management tools such as Greenseeker (Ali *et al*., 2017; Mohanta *et al*., 2021), Nutrient Expert (Jat *et al*., 2021; Sharma *et al*., 2021), SPAD meter (Singh and Ali, 2020), Chlorophyll content meter (Dong *et al*., 2019;) and Leaf Color Chart (LCC) (Singh *et al*., 2016; Kumar *et al*., 2018) resulted in judicious nutrient management by expressing higher productivity and nutrient use efficiency. In this regard, the LCCcan be considered as the handiest and cost-effective precision nutrient management tool containing different shades of green color for optimizing nitrogen needs of maize (Banerjee *et al*., 2014). Use of the LCC can guide the small and marginal maize farmers for optimization of nutrient. Research work on use of the LCC in south Odisha conditions is meagre and hence, an investigation was undertaken to optimize nitrogen use in maize cultivation for increasing yield and obtaining higher nitrogen use efficiency.

MATERIALS AND METHODS

A field experiment was carried out during the *rabi* season of 2020-21 at the Agricultural Research farm (located at 23°39'N latitude and 87°42'E longitude and at an altitude of 145 meters above mean sea level) of M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Gajapati, Odisha under the agro-climatic conditions of North Eastern Ghats. The soil data reported on the experimental site shows that the soil is sandy clay loam in texture, slightly acidic in reaction with a pH of 6.1 and low in organic carbon(0.35%), available nitrogen(230.3 kg ha^{-1}) and potassium (125 kg ha^{-1}) but medium in phosphorus(11.2 kg ha^{-1}).The maximum temperature varied from 30.7° C in January to 36.8°C in April and minimum temperature ranged between 15.1° C in January and 22.2°C in April. The temperature condition of the area remained more or less normal during the cropping period (Fig. 1).The weekly sunshine hours ranged from 3.0 hr./day to 10.3 hr./day from January to April during the cropping season. During the crop growing period, the relative humidity in morning varied from 75.7 to 95.9% and relative humidity in the afternoon ranged from 33.86 to 64.9%.

The experiment was carried out during *rabi*season (January to May, 2020) and laid out by Completely Randomized Block Design (CRBD), with three replications. Seven treatments were tested in the trial, namely, 150% RDN (T_1), 125% RDN (T_2), 100% RDN (T_3), 75% RDN (T_4), 50% RDN (T_5), LCC based application 25 kg/ha N @basal, 45 kg/ha N at 21 DAS, 45 kg/ha N @ LCC<5 at 45 DAS (T_6) and control (T_7) with plot size of 6 × 3.6 m. The maize hybrid considered was 'Bio seed 9544. The sources of fertilizers were urea for N, single super phosphate for P_2O_5 and muriate of potash for K_2O. The basal dose (one-fourth) of N fertilizer was applied in the net plots and remaining N was applied in two equal splits at knee height stage and before tasseling. Full doses of phosphorous and potassium were applied as basal according to the experimental plan. The recommended dose of fertilizer (NPK) considered for application was 120:60:60 kg/ha. The recommended dose of nitrogen (RDN) applied was 120 kg/ha and the quantity of N fertilizer was applied through LCC was 115 kg/ha.

Seeds were sown at a spacing of 60cm (row to row) and 25 cm (plant to plant).As the experiment is carried out in *rabi*, the crop has received a minimal rainfall. The irrigation was given as and when required for maintaining the favorable crop growth. The field was ploughed crosswise for two times with a tractor to bring the soil to a good tilth and then leveled after cleaning of weeds. The field was laid out into plots with the provision of irrigation channels. The crop was sown on 04 January and harvested on 02 May of 2020. Atrazine was sprayed two days after sowing (DAS) as a pre-emergence herbicide and hand weeded twice at 20 and 45 DAS. To raise the crops successfully five irrigations were provided. The crop faced mild attack of Lepidopteran pest and Emamectin Benzoate was sprayed at 2 g per liter of water at 32DAS.The data on yield attributes such as number of cobs/plant, number of grains/cob, 100 seed weight (g), and grain yield (kg/ha) ands over yield (kg/ha) were recorded. Further the harvest index was computed.

The data were analyzed as per the standard procedure for analysis of variance as described by Gomez and Gomez (1984). The significance of treatments was tested by F test. The standard error of mean was computed in all cases. The difference in the treatment means were tested by using critical difference (CD) at 5% level of probability. The Excel software (Microsoft Office Home and Student version 2019-en-us, Microsoft Inc., Redmond, Washington, (USA) was used for statistical analysis and drawing figure.

RESULTS AND DISCUSSION

Growth attributes

The obtained results showed that the growth attribute of maize increased steadily upto 90 DAS and little change is noticed at the time of harvest. The growth attributes of maize were significantly influenced by different nitrogen management practices (figure 1,2 and 3). The data on growth attribute showed a similar trend where the treatment with 150% of RDN (T_1) expressed the highest values, but it remained statistically at par with 125% RDN (T_2),100% RDN (T_3) and LCC (T_6). At time of harvest, among different treatments, the maximum plant height(184.3 cm) was obtained with application of 150% of RDN (T_1) and the lowest was recorded in control (139.7 cm); while other treatments like 125% RDN (T_2), 100% RDN (T_3) and LCC (T_6) were statistically at par with 150% RDN (T_1). The highest leaf area index(5.68) at 90 DAS and Dry matter accumulation (1841.4 g/m)was obtained with the treatment 150% of RDN (T_1) and it was statistically at par with 125% RDN(T_2), 100% RDN (T_3) and LCC (T_6).The data clearly revealed that higher availability of nitrogen resulted in improving growth attributing characters and the superiority of 150% of RDN was noted. Interestingly, the treatments with 125% RDN and LCC based N management also performed well in expression of growth attributes. The results are in conformity with earlier researches (Imran *et al*., 2015; Assefa and Mekonnen, 2019; Mohapatro *et al*., 2021).

Yield

The different levels of N application significantly affected the grain yield of maize (Table 2). The treatment consisting of 150% RDN (T_1) produced the highest yield of 7.95 t/ha which was about 52% more than the treatment with no nitrogen (control). Other treatments like 125% RDN (7.41 t/ha), 100% RDN (7.24 t/ha) and LCC (7.83 t/ha) were statistically at par with150% RDN. The results showed the importance of nitrogen for maize and the optimum dose of N was required to obtain a satisfactory grain yield. But interestingly the precision N management treatment with LCC (T_6) resulted in higher productivity of maize grain than and the crop under the treatment received only 115 kg N/ha which was 8% and 6% higher than 100% RDF (120 kg N/ha) and 125% RDF (150 kg N/ha). The result further indicated that split application of right quantity of fertilizer at right time was important to obtain higher productivity (Fayaz *et al*., 2021; Mohanta *et al*., 2021). The stover yield and biological yield also showed the similar trend as 150% RDN (T_1) being statistically at par with 125% RDN (T_2), 100% RDN (T_3) and LCC (T_6) showed its superiority to other N doses and control. The least grain, stover and biological yield was obtained with control and it was because of shortage of nitrogen need of the crop. The results corroborate with the findings of Mohapatra *et al*. (2021) and Nduwimana *et al*. (2020). The harvest index analyzed by considering grain and stover yield revealed that the highest value was obtained with LCC treatment (T_6). Similar findings were noticed by Ahmad *et al*. (2018) and Mohapatra *et al*. (2021).

Economics

The cost of cultivation is more in 150% RDN (T_1), and followed by 125% RDN (T_2) and 100% RDN (T_3) due to application of additional nitrogen supply. While the cost of cultivation was medium in treatments with 75% RDN (T_4), 50% RDN (T_5), and LCC (T_6), control plots represented less cost of cultivation than rest of all the treatments due to lack of external nitrogen supply. The highest gross return was obtained in treatment 150% RDN (T_1) then immediately followed by LCC (T_6). While the treatments with 125% RDN (T_2) and 100% RDN (T_3) were at par with (T_1). The lowest gross return was noticed in control plots. The obtained net returns were satisfactory while the maximum net return was obtained in 150% RDN (T_1) with 63393 Rs/ha. The remaining treatments say 125% RDN (T_2) 100% RDN (T_3) and LCC (T_6) were at par with 150% RDN (T_1). While lowest net returns were noticed from the control plots.The calculated benefit cost ratio was statistically analyzed and presented in table 4.11. The treatment plots receiving timely nitrogen application through LCC (T_6) showed the highest benefit cost ratio with 1.49% then followed by 150% RDN (T_1) with 1.48%. While 125% RDN (T_2) and 100% RDN (T_3) were at par with (T_1). The lowest cost benefit ratio was observed in the control treatment (0.9).Similar findings reported by Yang*et al*. (2002).

CONCLUSION

The experimental results clearly indicated that growth, yield and economics of maize was increased with the application of 150% RDN, however it remained on par and very close to 125% RDN, 100% RDN and LCC based nutrient management. Among these four treatments, the LCC based N management received comparatively less quantity of N, but because of right stage of application and appropriate quantity helped to boost maize yield by providing proper nutrition. Further, nitrogen content and uptake and use efficiency were also adequate with LCC-based N application. The research firmly revealed that N management in *rabi* maize can be adopted by using the handy precision tool, LCC, to obtain optimum growth, yield and economicswith judicious N use under North Easter Ghats of Odisha.

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Table 1. Influence of nitrogen levels on economics of maize

Treatments	Cost of cultivation(Rs. ha^{-1})	Gross return(Rs. ha^{-1})	Net return(Rs. ha^{-1})	B:C Ratio
T_1: 150% RDN (180 kg/ha N)	42847	106240	63393	1.4
T_2: 125% RDN (150 kg/ha N)	42456	99127	56671	1.3
T_3: 100% RDN (120 kg/ha N)	42065	97017	54952	1.3
T_4: 75% RDN (90 kg/ha N)	41673	90040	48367	1.1
T_5: 50% RDN (60 kg/ha N)	41282	66130	24848	0.6
T_6: LCC (25 kg ha-1N @ basal, 45kg ha-1 N at 21 DAS and 45kg ha-1 N at LCC <5 at 45 DAS)	41999	104500	62501	1.4
T_7: Control (0 kg/ha N)	40500	44143	36430	0.9
S.Em. (±)	-	4367.4	4367.4	0.1
CD at 5 %	-	13455.3	13455.3	0.3
CV (%)	-	8.7	16.8	16.9

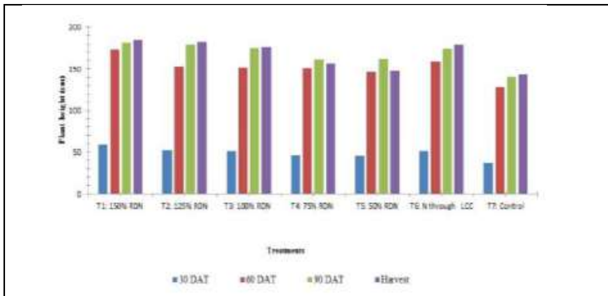

Figure 1. Influence of nitrogen levels on plant height (cm) of maize

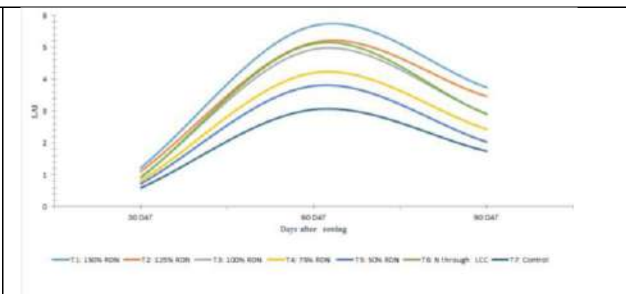

Figure2. Influence of nitrogen levels on leaf area index of maize

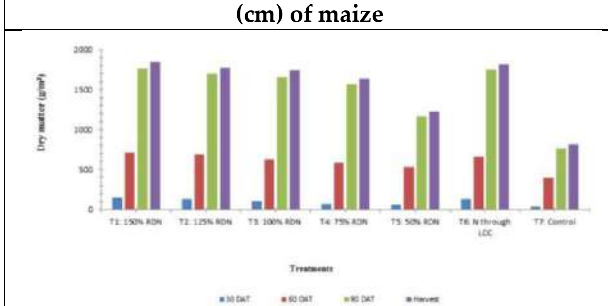

Figure 3. Influence of nitrogen levels on dry matter(g/m^2) of maize

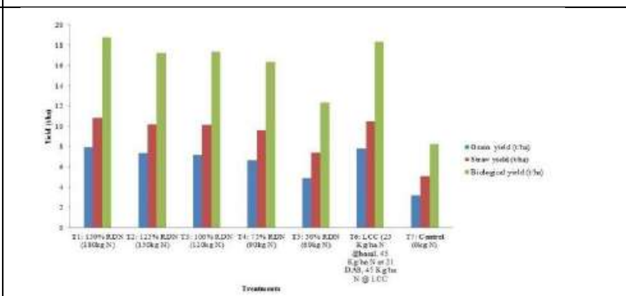

Figure 4. Influence of nitrogen levels on yield (t/ha) of maize

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RESEARCH ARTICLE

Yield, Nutrient Content and Uptake of Green Gram (*Vigna radiata* L.) as Influence by Phosphorus and Sulphur Levels

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ABSTRACT

Greengram(*Vigna radiate* L.) is a source of quality protein which content nearly 25% protein in it. The seed of greengram consumed as both in spittedor whole form as dal, sprouted seed and as well as snack. Further, it also maintains soil health by fixation of atmospheric nitrogen to the soil.The nutrient management plays a vital role in the growth and development where not only primery but secondry nutrient also have emphases on plant. In view of the above, an experiment carried outat the farm of Centurion University of Technology and Management, Bagusala during 2019-20.to study the influence of phosphorus and sulphur levels on yield and nutrient content and uptake of green gram.The significantly higher seed (979.2 kg ha^{-1}) and stover yield(1871.8 kg ha^{-1}), was produced by 60 kg P_2O_5 ha^{-1}over 30kg S ha^{-1}. However, the interaction effect of 60 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1} produced significantly more grain yield (1211.3 kg/ha) than other treatment combinations. The application of 60kg P_2O_5 ha^{-1} and 30 kg S ha^{-1} found to be higher nutrient content and uptake in the seed and stover of greengram which was closly followed by 30 kg P_2O_5 ha^{-1} and45 kg S ha^{-1}respectively. Further, in the case of uptake of P and S of seed, the interaction effect of P x S was found to be significant. Similarly, the highest uptake of P and S were recorded with the nutrient levels of 60 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1}.

Keywords: Greengram, Phosphorus, Sulphur, Yield, Nutrient Content, Nutrient Uptake

INTRODUCTION

Green gram, is well known as "Moongbean" or "Moong," and belong to the family 'Leguminosae' which contains 24.3 percent protein, a decent amount of carbohydrates, a little amounts of Riboflavin and Thiamine, and is high in P and Fe (Patel *et al.*, 2013). It also consists of a little amount of lysine (4600 mg/g N), and tryptophan (60 mg/g N), and it can be either eaten as whole grain or as a dal. Mungbean is said to be easily digested, thus patients prefer it. In India, green gram ranks third after chickpea and pigeon pea (Sahu *et al*., 2020; Mangaraj *et al*., 2022). The area coverage and production of green gram were maximum in Rajasthan (23.23 lakh ha area and 12. 87 lakh tonne production). Odisha ranked sixth in the area (0.73 lakh ha) and seventh in production (0.22 lakh tonne), respectively (DPD, 2020).

In the regard to pulses, India is the world's largest consumer and producer. The inclusion of pulses in the cropping system enhances the health and nitrogen fixation of the soil, respectively. Moreover, In India, pulse crops have been utilised as feed and fodder supplies significantly contributing towards the country's agricultural economy for centuries. India, is a world leader in the cultivation and import of pulse to supplement the proteins (Singh *et al*., 2012, Dharwe *et al.,* 2017). However, Pulses are usually grown in soils with low fertility status or with minimal amounts of integrated fertiliser source, resulting in poor soil health and productivity degradation, respectively (Kumpawat, 2010,Kumar et al.,2019). Fertilizer is the most essential input to achieve the yield potential of any crop. Soil fertility is depleting at a shocking rate in recent days, due to indiscriminate nutrient mining. Consequently, due to cultivation of traditional varieties under slightly fertile lands with low input management conditions is the cause of low pulse productivity (Zaman *et al*., 2017).

The most essential nutrient for the crop is phosphorus. It's a key aspect of ATP, the plant's "energy unit." ATP (Adenosine triphosphate) is generated during photosynthesis and is associated with a number of activities, including seedling development, formation of seeds, as well as seed maturity. Some basic growth factors linked to phosphorus are: the encouragement of root growth increased stem and stalk strength, better flower formation and production of seeds, more homogenous crop maturity, increased legume N fixation capacity, improved crop quality, and increased plant disease resistance (Prajapati *et al.,* 2013). Better nodulation and overall functionality of nodule bacteria for atmospheric nitrogen fixation to be used by the plant throughout the grain development phase are expected to result in increased seed yield, when the phosphate fertiliser is applied properly (Dharwe *et al.,* 2019, Sahu *et al*., 2020, Sahu *et al*., 2021).

The high prices of phosphatic fertilizers also demand that fixed phosphorus be recycled and exploited for improved crop production. Phosphorus available on crops can be increased by providing suitable microbial strains known to solubilize the fixed phosphorus and by their activity to relocate the depth of the phosphorus to the roots. It not only enhances the efficiency with which applied phosphorus is utilized, but it also increases the inherence of native P in the soil (Thenua and Sharma, 2011). The least mobile element in the soil that plants can use as a phosphate anion is phosphorus. P is absorbed in soil by Fe3+, Ca2+, or Al3+ oxides by an exchange of legends in the form of precipitation, i.e., orthophosphate ($H_2PO_4^{-1}$ or HPO_4^{-2})(Singh *et al.,*2018). Leguminous crops cultivated under poor phosphorus availability conditions may also suffer from nitrogen deficiency since the nodules bacteria functions normally only when the plants are provided with sufficient phosphorus (Parashar *et al.,* 2020). In Indian soil, phosphorus content is low and a large portion of the phosphorus added to the soil is in unreachable form. Therefore, it is necessary to complement the deficient amount of phosphorus and increase the effectiveness of the phosphorus applied with an optimal dose of phosphorus to improve production and productivity.

Similarly, sulphur is the fourth main nutrient for the development of agricultural crops after nitrogen, phosphorus, and potassium (Das, 2017). It is a considerable integrant of natural compounds, certain of which are incorporated distinctively by plants. Sulphur has been recognized for its role in the synthesis of carbohydrates, vitamins, proteins, oils, and flour compounds (Singh *et al.,* 2017). For a long time, sulphur has been recognised as a vital nutrient for plants. It's a component of proteins, sulfolipids, enzymes, etc., that are associated with the formation of chlorophyll, enzyme activation, and is found in biotin, thiamine, and other vitamins (Hegde and Sudhakarabu, 2007). Elemental Sulphur is not available for plants, it must be oxidized by microbes present in the soil to sulphate (SO_4^{-2}) before available for plants. Hence it takes considerably longer time than the soluble forms of sulphate fertilizers to become available (Singh *et al.,* 2017).

Plants require the same amount of sulphur as phosphorus, which is one of the most important plant nutrients. Sulphur is a key determinant of several amino acids (AA) and enables nodulation in legumes. Sulphur is an enzyme activator, a crucial nutrient for increasing legume crop productivity, and a component of some vitamins (vitamin-A). Studies have shown the regular use of S-free fertilizer in light-structured soils, low in organic matter, increases sulphur deficiencies.

MATERIAL AND METHODS

The field trial was conducted at the Experimental Farm, Bagusala, located in the Gajapati district of Odisha. The experiment was conducted adopting a split-plot design with four levels of phosphorus in main plots and three levels of sulphur in subplots and replicated thrice. The field was ploughed two times crosswise by tractor drawn harrow and weeds were cleaned thoroughly. Then the field was puddled by a power tiller and leveled properly. The layout was done by making small plots of 5m x 4m in size with an adequate irrigation facility. The bunds were formed for all the plots with 50 cm width and 1m space was left for the irrigation channel. A uniform dose of 20 kg ha^{-1} of nitrogen and 40 kg ha^{-1} potassium was given similarly to all the plots. Phosphorus and sulphur doses were applied accordingly as per the treatments. The phosphorus levels and sulphur levels were put in an application at the time of sowing through di-ammonium Phosphate (DAP), single superphosphate (SSP), and elemental sulphur respectively. Nitrogen @20 kg ha^{-1} was applied after subtracting nitrogen from DAP and the remaining dose of nitrogen was applied through urea. Potassium was applied through muriate of potash (MOP) at basal. Just before sowing the fertilizers are applied by placement method. The seed variety considered during the experiment is 'Samrat', and was sown at a spacing of 30cm × 10 cm. For the proper maintenance of the plant population. During the crop growth period total of three irrigations were given as and when required by the crop depending upon the weather situation. After 7 DAS (days after sowing), the thinning and gap-filling operations were done by keeping a 10 cm distance between every two plants to maintain an equal population of plants in all the plots. For control of pod borer spraying of endosulfan @ 15 ml per 10 lit of water was undertaken at the later stage of crop growth, and the experimental field was kept weed-free. A pre-emergence application of pendimethalin @ 3.3 lit per hectare followed by one hand weeding at 40DAS for the controlling of weeds. To draw a valid result at the end, the data on biometric observations were recorded periodically during the experimentation and then analysed statistically. Using Microsoft Excel 2010, the data were evaluated using the conventional approach for Analysis of Variance (ANOVA) (Gomez and Gomez 1984). The "F" test was used to determine the significance of treatments. To test revealing significant differences among the calculated treatment means.

RESULT AND DISCUSSIONS

Yield

The data presented in figure 1, revealing that both the seed and stover yield were influenced significantly due to various levels of phosphorus and sulphur. The yield (both seed and stover) was influenced significantly by different levels of phosphorus. The phosphorus level of 60 kg P_2O_5 ha^{-1} produced the highest seed and stover yield (1079.6 and 2025.1 kg ha^{-1}) and closely followed with 40 kg P_2O_5 ha^{-1}. The lowest seed and stover yield (696.4 and 1594.1 kg ha^{-1}) was recorded with no phosphorus applied. The sulphur level of 30 kg S ha^{-1} produced the highest seed and stover yield (979.2 and 1871.8 kg ha^{-1}) which remain statistically at par with 45 kg S ha^{-1}.30 kg S ha^{-1} significantly superior to 15 kg of S ha^{-1}. The lowest seed and stover yield (754.3 kg $ha^{-1}$and 1594.1 kg ha^{-1}) were noted with the application of 15 kg S ha^{-1}. The Interaction effect i.e., (P×S) among different levels of phosphorus and sulphur was found to be significant with respect to seed yield. The combined application of 60 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1} produced highest seed yield (1211.3 kg ha^{-1}) which was statistically at par with the application of 60 kg P_2O_5 ha^{-1} along with 45 kg S ha^{-1}. Among varying levels of phosphorus and Sulphur, P×S (interaction) was found to be non-significant in relation to the stover yield. With the phosphorus application, there may be an increase in seed yield due to the increased availability and uptake which results in good nodulation which in turn has a beneficial influence on seed output via increased photosynthetic rate. The similar findings were reported by several authors like Kumawat *et al*. (2014), Nyekha *et al.* (2015), Das (2017) and Singh *et al*. (2018).

NUTRIENT AND PROTEIN CONTENT

Phosphorus and sulphur content in seed and stover (%)

The phosphorus content in seed and stover was significantly influenced due to various levels and is represented in Table 1. The application of 60 kg P_2O_5 ha^{-1}registersignificantly increase in the content of phosphorus in seed and stover than lower level (no phosphorus) but it was statistically at par with applying 40 kg P_2O_5 ha^{-1}. The maximum content of phosphorus recorded in seed and stover (0.51 % and 0.20 %, respectively) while the minimum phosphorus content in seed and stover (0.50 % and 0.17 %, respectively) was noted where no phosphorus was applied. The application of different levels of sulphur influenced non significantly on P content in seed and stover and recorded the highest P content by stover (0.19 %) with the application of 45 kg S ha^{-1} and the lowest P content by stover (0.18 %) with the application of 15 kg S ha^{-1} while the P content in seed was (0.50 %) regarding all the sulphur levels. The interaction effect among varying levels of phosphorus and sulphur was found to be Non-Significant regarding phosphorus content in seed, stover. The sulphur content in seed and stover was significantly influenced by the different phosphorus levels. The increased content of sulphur in seed and stover resulting from 60 kg P_2O_5 ha^{-1}, though it was statistically at par with the 40 kg P_2O_5 ha^{-1}. The highest S content in seed and stover (0.20% and 0.10 %, respectively) was due to 60 kg P_2O_5 ha^{-1}.The lowest S content in seed and stover (0.11% and 0.09 %, respectively) were found where no phosphorus was applied. The sulphur content in the seed was non-significantly enhanced by the application of sulphur. However, applying 15 kg S ha^{-1} recorded the maximum sulphur content (0.10 %) by stover while the S content in seedwas (0.17%) regarding all the sulphur levels. The interaction effect among varying levels of phosphorus and sulphur was found to be non-significant regarding sulphur content in seed and stover.

Protein content (%)

The protein content in the seed was significantly influenced by the application of phosphorus levels(Table 1). The protein content in a seed is significantly increased by applying 60 kg P_2O_5 ha^{-1}, though remained statistically at par with 40 kg P_2O_5 ha^{-1} over the other 2 levels i.e., 20 kg P_2O_5 ha^{-1} and no phosphorus application. The highest protein content in seed was (23.99 %) while the lowest protein content in seed(22.49%) was recorded where no phosphorus was applied. Application of different levels of sulphur influenced non-significantly on protein content in seed and recorded the highest value of protein content (23.43 %) with the application of 45 kg S ha^{-1}. However, the lowest value of protein content (23.24 %) was recorded with 15 kg S ha^{-1}. The interactive effect among varying levels of phosphorus and sulphur was found to be non-significant with respect to protein content in the seed. The favorable impact of sulphur on protein content was due to the synthesis of 'sulphur-containing amino acids' and nutrient content and directly to the uptake. similar results were reports by Singh and Singh (2013), Dhewa *et al.* (2017) and Serawat *et al.* (2018).

NUTRIENT UPTAKE

Phosphorus and sulphur uptake (Kg ha^{-1}) in seed and stover

The uptake of phosphorus by seed and stover was increased significantly and are shown in Table 2, over the lower levels (no phosphorus) and 20 kg P_2O_5 ha^{-1}, and remained statistically at par with the 40 kg P_2O_5 ha^{-1}. The highest P uptake by seed and stover (5.46 kg ha^{-1} and 3.99 kg ha^{-1}, respectively) were seen due to applying 60 kg P_2O_5 ha^{-1}. The lowest uptake of P by seed and stover (3.45 kg ha^{-1} and 2.79 kg ha^{-1}, respectively) were obtained with no phosphorus application. The application of 30 kg S ha^{-1} has recorded significantly higher uptake of phosphorus by seed and stover (4.87 kg ha^{-1} and 4.44 kg ha^{-1}, respectively) over 15 kg S ha^{-1} and closely followed by 45 kg S ha^{-1}. The lower uptake of phosphorus by seed and stover (3.76 kg ha^{-1} and 3.06 kg ha^{-1}, respectively) were registered with 15 kg S ha^{-1}. The interaction effect among varying levels of phosphorus and sulphur was observed significant on phosphorous uptake by seed. Both combined levels, i.e., 60 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1} produced the highest phosphorous uptake by seed (6.07 kg ha^{-1}) which was statistically at par with the application of 60 kg P_2O_5 ha^{-1} along with 45 kg S ha^{-1} (5.68 kg ha^{-1}) and 45 kg P_2O_5 ha^{-1} along with 30 kg S ha^{-1} (5.73 kg ha^{-1}). The interaction (P×S) effect among varying levels of phosphorus and sulphur was statistically analysed and found to be non-significant concerning stover yield. These results were achieved because phosphorus management altered the nutritional environment in the root system and even in the plant system, contributing to increased nutrient uptake. Similar findings were also recorded from Bairwa (2014), Dhewa*et al.* (2017) and Kumar and Yadav (2018). However, The data regarding the uptake of sulphurare represented in table 2 revealing that the sulphur uptake by both the seed, and stover was influenced significantly by the application of phosphorus. A 60 kg level of P_2O_5 ha^{-1}, was significantly enhanced the uptake of S by seed and stover as related to the other treatments. The highest uptake of S by seed and stover (2.13 kg ha^{-1} and 2.09 kg ha^{-1}, respectively) was obtained with 60 kg P_2O_5 ha$^{-1,}$ and the lowest S uptake by seed and stover (0.82 kg ha^{-1} and 1.37 kg ha^{-1}, respectively) was reported with no phosphorus level. Sulphur level@45 kg S ha^{-1} resulted in a higher uptake of sulphur by seed (1.70 kg ha^{-1}) and stover (1.74 kg ha^{-1}) as comparable with the other treatments. However, the lower uptake of sulphur by seed and stover (1.24 kg ha^{-1} and 1.60 kg ha^{-1}, respectively) was obtained with the application of 15 kg S ha^{-1}. The interaction effect of different levels of phosphorus and sulphur was observed to be significant regarding the uptake of sulphur by seed(Table 3). The 60 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1}(combination levels of both P and S) produced maximal uptake of sulphur by seed (2.40 kg ha^{-1}) which was closely followed by the application of 60 kg P_2O_5 ha^{-1} along with 45 kg S ha^{-1} (2.21 kg ha^{-1}) and 45 kg P_2O_5 ha^{-1} along with 30 kg S ha^{-1} (2.04 kg ha^{-1}).The interactive effect among varying levels of phosphorus and sulphur was said to be non-significant with respect to stover yield. Sulphur enhance the translocation of nutrient in plant thus K uptake increases in stover. Similar results were seen in Choudhary *et al.* (2019).

CONCLUSION

The above results concluded that the application of 60 kg P_2O_5ha^{-1}and 30 kg Sha^{-1} resulted in higher seed yield, stover yield, nutrient content and uptake in seed and stover as well protein content in seed of green gram. Further, it can be recommended that the application of 60 kg P_2O_5ha^{-1} and 30kg Sha^{-1} enhanced the productivity, quality and nutrient uptake of greengram under south Odisha conditions.

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Table 1 Effect of phosphorous and sulphur levels on nutrient content (%) of seed and stover and protein content (%) in seed

Treatment	P content (%)		S content (%)		Protein content in seed (%)
	Seed	Stover	Seed	Stover	
Phosphorus (kg P_2O_5 ha^{-1})					
P_0	0.50	0.17	0.12	0.09	22.49
P_{20}	0.49	0.18	0.17	0.09	23.41
P_{40}	0.50	0.19	0.18	0.09	23.40
P_{60}	0.51	0.20	0.20	0.10	23.99
S.Em. (±)	0.006	0.002	0.002	0.002	0.097
CD at 5 %	0.02	0.01	0.11	0.01	0.38
Sulphur (kg S ha^{-1})					
S_{15}	0.50	0.18	0.17	0.10	23.24
S_{30}	0.50	0.18	0.17	0.09	23.31
S_{45}	0.50	0.19	0.17	0.09	23.43
S.Em. (±)	0.007	0.007	0.003	0.003	0.173
CD at 5 %	NS	NS	NS	NS	NS
S × P interaction					
S.Em. (±)	0.012	0.012	0.005	0.005	0.300
CD at 5 %	NS	NS	NS	NS	NS

Table 2.Effect of phosphorous and sulphur levels on nutrient uptake (kg ha^{-1}) of seed and stover

Treatment	P uptake (kg ha^{-1})		S uptake (kg ha^{-1})	
	Seed	Stover	Seed	Stover
Phosphorus (P_2O_5 kg ha^{-1})				
P_0	3.45	2.79	0.82	1.37
P_{20}	4.03	2.99	1.41	1.55
P_{40}	4.99	3.48	1.80	1.65
P_{60}	5.46	3.99	2.13	2.09
S.Em. (±)	0.138	0.090	0.050	0.063
CD at 5 %	0.54	0.35	0.20	0.25
Sulphur (S kg ha^{-1})				
S_{15}	3.76	3.06	1.24	1.60
S_{30}	4.87	3.44	1.69	1.74
S_{45}	4.81	3.43	1.70	1.66

S.Em. (±)	0.10	0.10	0.03	0.06
CD at 5 %	0.31	0.31	0.09	NS
P × S interaction				
S.Em. (±)	0.18	0.18	0.06	0.1
CD at 5 %	0.54	NS	0.16	NS

Table 3.Effect of both phosphorus and sulphur levels interaction on nutrient uptake of greengram seed (kg ha^{-1})

P × S interaction			
Levels of P	**Levels of S**	**P uptake in seed (kg ha^{-1})**	**S uptake in seed (kg ha^{-1})**
P_0	**S_{15}**	3.17	0.66
	S_{30}	3.53	0.84
	S_{45}	3.64	0.97
P_{20}	**S_{15}**	3.35	1.14
	S_{30}	4.14	1.46
	S_{45}	4.59	1.63
P_{45}	**S_{15}**	3.91	1.40
	S_{30}	5.73	2.04
	S_{45}	5.34	1.98
P_{60}	**S_{15}**	4.62	1.78
	S_{30}	6.07	2.40
	S_{45}	5.68	2.21
SEm(±)		0.18	0.05
CD at 5%		0.54	0.16

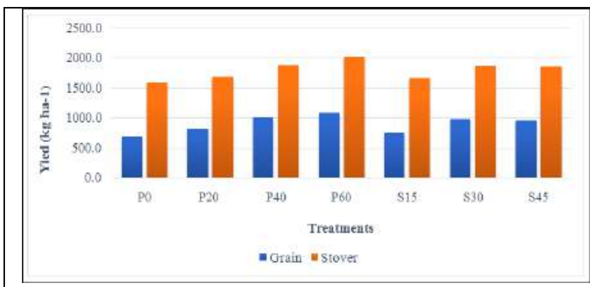

Figure. 1 Effect of phosphorous and sulphur levels on yield of green gram

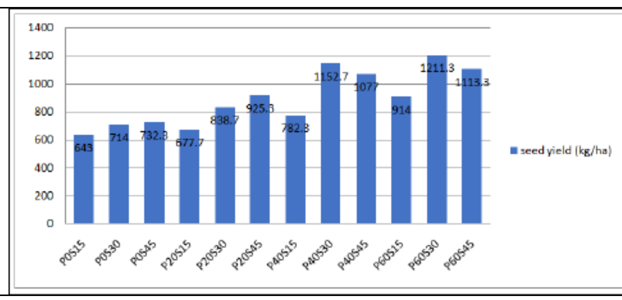

Figure 2. Effect of phosphorous and sulphur level interaction on seed yield of green gram

RESEARCH ARTICLE

Nutrient Content, Uptake and Economics of Finger Millet (*Eleusine coracana* L. Gaertn) as Influenced by Integrated Nutrient Management in South Odisha

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ABSTRACT

Finger millet (*Eleusine coracana* L. Gaertn) is a vital minor millet that is considered as 'nutri-cereal'. In the south Odisha region, it was once considered as a major food crop. Based on the above facts, a field trial was carried out to find the impact of integrated nutrient management in finger millet on nutrient content and uptake, and economics during *kharif* season of 2020-21 at Bagusala Farm (23°39' N latitude, 87°42' E longitude) of Centurion University of Technology and Management, Odisha. The experiment was laid out in a factorial randomized block design (FRBD) with two factors. The first factor was of two levels of biofertilizer seed inoculation, namely, *Azospirillum* inoculated (I_1) and un-inoculated (I_2). Another factor was five levels of chemical fertilizers, *viz*., F_1: 0% recommended dose of fertilizer (RDF), F_2: 25% RDF, F_3: 50% RDF, F_4: 75% RDF and F_5: 100% RDF. The treatments were replicated thrice. The recommended dose of fertilizer (RDF) was 40:20:20 kg N, P_2O_5 and K_2O ha^{-1} and supplied through urea, single super phosphate and muriate of potash, respectively. The results clearly indicated that nutrient content (N, P and K in %) was not influenced, but the nutrient uptake of finger millet grain and straw was significantly differed by the fertilizer doses. The chemical nutrient dose with 100% RDF registered its significant superiority over the other treatments. However, the *Azospirillum* biofertilizer inoculation neither impacted on nutrient content nor the uptake. Similarly, application of 100% RDF registered the maximum net profit and B:C ratio of finger millet. Moreover, considering the benefits of integrated nutrient management and soil health improvement, it can be recommended that 100% should be applied to obtain the maximum nutrient content, uptake and net income from finger millet with additional increment of biofertilizer inoculation under south Odisha conditions.

Keywords: Finger millet, integrated nutrient management, *Azospirillum*, nutrient content, nutrient uptake, economics

INTRODUCTION

The small millets got enough popularity due to their nutritional qualities during the recent years (Maitra, 2020; Maitra *et al*., 2020). Finger millet (*Eleusine coracanan* L. Gaertn) is the most important small millet in terms of area and production (Maitra *et al*., 1998). The crop is considered as the fourth important millet in the world (Gupta *et al*., 2012). Locally, the crop is called as ragi/marua in India (Brahmachari *et al*., 2018). India cultivates finger millet in an area of 1.27 million ha, produces 1.98 million t with a yield of 1661 kg ha^{-1} (Sakamma *et al*., 2018; Panda *et al*., 2021). The improved varieties under good management can produce up to 4 t of grains per hectare. In Odisha, 1.66 lakh ha is under finger millet cultivation, but the state produces 1.6 lakh t of grains (Agriculture Statistics, 2017).

Among other millets, finger millet is considered as a 'nutri-cereal' because it has a fairly good quantity of Ca, fibre, phenolics and essential amino acids (Banerjee and Maitra, 2020 with Maharajan *et al*., 2021). It has the potential to irradicate malnutrition, it is an important crop in the developing countries of the world. The most important amino acid, methionine is present in finger millet, which is lacking in hundreds of millions of the poor who feed on starchy staples and due to its slow digestion indicates low blood sugar level. It is highly recommended for diabetic patient and it is gluten free. Grains and the flour of the malted grain are considered as the raw material of various processed and healthy foods.

The crop requires less amount of water and it can withstand aberrations of weather. Through the adoption of improved varieties, growth and productivity of finger millets can be increased (Harika et al., 2019a,b; Maitra *et al.*, 2020). As it can be grown instress conditions in dry lands, it is considered as a 'Crop of the future'. In semi-arid regions, most of the soils where the finger millet is cultivated, are poor in fertility status (Prasanna Kumar *et al*., 2019; Rao *et al*., 2012). Therefore, nutrient management is a vital factor to achieve desired yield and economic gain under the fragile conditions.

Presently, different high yielding varieties have been developed which are fertilizer responsive and these can be adopted with proper nutrient management practices to get higher yield of quality finger millet. In the practice of supply of nutrients to the crops, it is wise to adopt integrated nutrient management (INM) by integrating the possible sources of nutrients, namely, organic manures, biofertilizers and chemical nutrients for managing the soil health and sustaining the agricultural productivity (Sai Manoj Kumar *et al*., 2021). Poor management of fertilizers is a major concern for low productivity and in order to obtain desired crop yield, nutient management by integrated method is needed (Ghaffari *et al.*, 2011; Kumar *et al*., 2019; Das *et al*., 2021). Earlier researches revealed that inoculation of biofertilizers, namely, *Azospirillum*, phosphate solubilizing bacteria and arbuscular mycorrhizal fungi has potential role in improvement of productivity of finger millet (Bama *et al.*, 2010; Singh *et al.*, 2016; Ramya *et al*., 2020). A balanced dose of chemical fertilizers was also noted to increase yield, nutrient uptake and economics of finger millet (Maitra *et al*., 1999; Maitra and Gitari, 2020; Panda *et al.*, 2021). Further, an efficient nutrient management for crop productivity enhancement has the potential to address some Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health and wellbeing) and SDG 15 (life on land)(UN, 2021).

Considering the above, the study was conducted on integrated nutrient management with biofertilizer *Azospirillum* and chemical fertilizers for enhancement of yield in south Odisha.

METERIALS AND METHODS

The field study was carried out at the Experimental Farm of Centurion University of Technology Management, Odisha, which is geographically located at $23^0 39'$ N latitude and $87^0 42'$ E longitude under typical tropical climatic conditions. The experiment was designed by following a factorial randomized block design (FRBD) with two factors. The first factor was of two levels, namely, *Azospirillum* biofertilizer inoculated (I_1) and un-inoculated (I_2) another factor was five levels of chemical fertilizers. The seeds of finger millet were sown on a well-prepared seed bed with a seed rate of 5 kg ha^{-1}. Seed treatment was done with Carbendazim@1.0 g kg^{-1} of seeds. The standard nursery raising techniques were adopted. The healthy seedlings of 21 days age were planted in the main field**.** The recommended dose of nutrients i.e., 40:20:20 kg N, P_2O_5 and K_2O ha^{-1} in 100 percent RDF. The entire quantity of phosphorus and potassium and half of the nitrogen were applied as basal at the time of transplanting. The remaining quantity of nitrogen was applied as top dressing at 21 days after transplanting. The *Azospirillium* slurry was prepared and the seedlings were treated by root dipping for 30 minutes prior to transplanting as per the treatments. The seedlings were transplanted @ one seedling per hill with a spacing of 25 cm x 25 cm. Weeds were managed by manual weeding at 10 and 46 days after transplanting. The crop remained almost free from pests and diseases. Finger millet was harvested at full maturity of grains. The meteorological data on weather condition like temperature, relative humidity, rainfall, and sunshine hour during the crop growth period from July to November, 2019 which is furnished in Figure 1.

The updated micro-Kjeldahl procedure was used to determine the nitrogen estimation of grain and straw(AOAC, 1960). The nitrogen uptake of grain and straw was measured by multiplying the nitrogen content of grain and straw with their respective yields and expressing the results in kilogram per hectare. The phosphorus content was measured by tri-acid digested grain and straw samples using the vanado-molybdo phosphoric acid yellow colour formula (Jackson, 1973). Spectronic-20 D was used to test the strength of the yellow colour that formed. The phosphorus uptake was determined by multiplying the phosphorus content of the grain and straw with respective yields, and the result was expressed in kg ha^{-1}. Using a flame photometer, the potassium content of the extract of tri-acid digested grain and straw samples was used (Jackson, 1973), and potassium uptake was calculated by multiplying the potassium content of grain and straw with the respective yields and provided in kg ha^{-1}.By taking into account the current market price of the input and output, gross and net returns per hectare were calculated. The benefit: cost ratio was calculated for various treatments by dividing net returns by the corresponding cultivation cost.

$$\text{B: C ratio} = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

The data noted were analyzed statistically by the method of analysis of variance (ANOVA) as outlined by Panse and Sukhatme (1985) and the standard error mean (SEm), critical difference (CD) was worked out at 5 per cent probability and the values are presented.

RESULTS AND DISCUSSION

Nutrient content of finger millet grain and straw

The data on nutrient content of finger millet grain and straw, namely, nitrogen (N), phosphorus (P) and potassium (K) content as influenced by INM on finger millet and presented in Table 1.

N content (%) of grain and straw of finger millet

In the experiment, it was found that there was no significant difference among both the biofertilizer inoculation in expression of N content (%) in grain and straw of finger millet. *Azospirillum* inoculated treatment slightly enhanced N content in straw. Similarly, there was non-significant variation among nutrient levels in N content of finger millet grain and straw; however, a marginal increase in N content was noted with 100% RDF. The interaction between biofertilizer inoculation and fertilizer levels was also non-significant in registering N content in straw of finger millet.

P content (%) of grain and straw of finger millet

P content of finger millet grain and straw was also non-significant. In the study it showed that there was non-significant difference among different fertilizer levels in N content of finger millet grain. However, application of 100% RDF showed maximum P content in grains and remained at par among all other fertilizer doses. Asimilar trend was seen where non-significant differencewas recorded with chemical fertilizer levels in expression of P content in straw.

K content (%) in grain and straw of finger millet

Like N and P content in finger millet grain and straw, the K content did not differ between the biofertilizer inoculation treatments and fertilizer doses. But application of 100% RDF showed marginally higher K content in grain and straw of finger millet compared to other fertilizer doses

Nutrient uptake by finger millet

N uptake (kg ha^{-1}) by grain and straw of finger millet

In the experiment, it was found that there was no significant difference between the biofertilizer inoculations in uptake of N by finger millet grain. There was a significant difference among nutrient levels in N content of finger millet grains, where 100% RDF gave significantly more N uptake in grain than other different fertilizer levels. Lowest N uptake of grain was found in control with no fertilizer application which was statistically at par with 25% RDF. There was no significant difference found in N uptake by straw due to *Azospirillum* inoculation. However, N uptake by finger millet straw was influenced significantly by fertilizer levels and the application of 100% RDF showed significantly more N uptake than other fertilizer levels.

P uptake (kg ha^{-1}) by grain and straw of finger millet

There was no significant difference found in P uptake by grain as influenced by biofertilizer inoculation. However, there was a significant difference observed among different fertilizer levels. The application of 100% RDF showed significantly more P uptake by finger millet grains. In case of P uptake by finger millet straw, biofertilizer inoculation did on impact on the performance, but the application of 100% RDF showed significantly more P uptake by straw.

K uptake (kg ha^{-1}) by grain and straw of finger millet

In the current study, it was found that there was no significant difference between biofertilizer inoculation treatments in K uptake by finger millet grain and straw. However, the application of 100% RDF resulted in significantly more K uptake by grain and straw of finger millet. Higher K uptake was recorded by more grain and straw yields of finger millet with the application of 100% RDF (Maitra *et al*., 1999).

Economics of finger millet cultivation as influenced by INM

The result obtained on economics of finger millet on different biofertilizer inoculation in the experiment influenced by different fertilizer levels are computed and presented in table 3.The cost of cultivation was found to be more in inoculation; whereas, less cost of cultivation was found in un-inoculated crop. Similarly, gross return was maximum in inoculated as cost of cultivation was maximum but, net return was found to be maximum in un-inoculated. But, the benefit:cost ratio was found more in the crop inoculated with *Azospirilum*.

The gross return of finger millet cultivation was more with 100% RDF compared to other fertilizer doses. Similarly, the net return and B:C ratio were also found more with 100% RDF in compared with other fertilizer doses. The results corroborate with the results of Sairam *et al*., (2020), Lakshmi *et al*. (2021) and Panda *et al*. (2021).

CONCLUSION

The present study clearly revealed that the biofertilizer inoculation of *Azospirillum* resulted in marginal and non significant enhancement of nutrient content, and uptake and economics of finger millet cultivation. However, 100% RDF performed the best in registering significantly superior nutrient content and uptake of finger millet and it was followed 75% RDF. Similarly, 100% RDF was the best in terms of economics of finger millet cultivation. Hence, the study concludes that for cultivation of *kharif* finger millet,100% RDF can be applied to obtain nutrient content, uptake and economic benefit in sandy loam soils of south Odisha. Considering the biological health of the soil, *Azospirillum* biofertilizer inoculation may be carried out which may perform better in long run and it offers the future scope of study in the aspect.

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Table 1: Nutrient content (%) of finger millet grain and straw as influenced by INM

Treatment	Nutrient content (%)					
	Grain			Straw		
	Nitrogen	Phosphorous	Potassium	Nitrogen	Phosphorous	Potassium
Biofertilizer inoculation						
Inoculated	1.32	0.29	0.34	3.50	0.32	1.38
Un-inoculated	1.32	0.30	0.34	3.40	0.32	1.39
S.Em. (±)	0.02	0.01	0.01	0.10	0.01	0.04
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Chemical fertilizer level						
Control	1.31	0.29	0.32	3.20	0.30	1.37
25% RDF	1.31	0.29	0.34	3.20	0.31	1.37
50% RDF	1.32	0.30	0.34	3.40	0.32	1.39
75% RDF	1.34	0.31	0.35	3.60	0.33	1.39
100% RDF	1.34	0.31	0.36	3.80	0.33	1.40
S.Em. (±)	0.02	0.01	0.01	0.10	0.01	0.02
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS

Table 2: Nutrient uptake (kg ha^{-1}) of finger millet as influenced by INM

Treatment	Nutrient uptake (kg ha^{-1})					
	Grain			Straw		
	Nitrogen	Phosphorous	Potassium	Nitrogen	Phosphorous	Potassium
Biofertilizer inoculation						
Inoculated	11.7	2.6	3.0	3.5	7.3	31.7
Un-inoculated	11.6	2.6	3.1	3.4	7.2	31.0
S.Em. (±)	0.5	0.1	0.1	0.1	0.3	1.2
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Chemical fertilizer level						
Control	8.3	1.8	0.4	3.2	4.8	21.9
25% RDF	9.2	2.0	2.0	3.2	5.6	24.7
50% RDF	11.5	2.6	2.3	3.4	6.4	27.8
75% RDF	13.3	3.1	3.0	3.6	7.9	33.7
100% RDF	15.9	3.7	3.5	3.8	11.6	48.6
S.Em. (±)	0.3	0.1	4.3	0.1	0.2	0.7
C.D. (P=0.05)	0.9	0.2	0.2	0.6	0.5	2.2

Table 3: Economics of finger millet as influenced by INM

Treatment	Economics			
	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Biofertilizer inoculation				
Inoculated	21881	33553	12253	0.56
Un-inoculated	20713	32935	12635	0.61

Chemical fertilizer level				
Control	9714	23945	2040	0.21
25% RDF	13209	26522	4095	0.31
50% RDF	11693	31725	6197	0.53
75% RDF	14764	37090	10925	0.74
100% RDF	13634	46937	15815	1.16

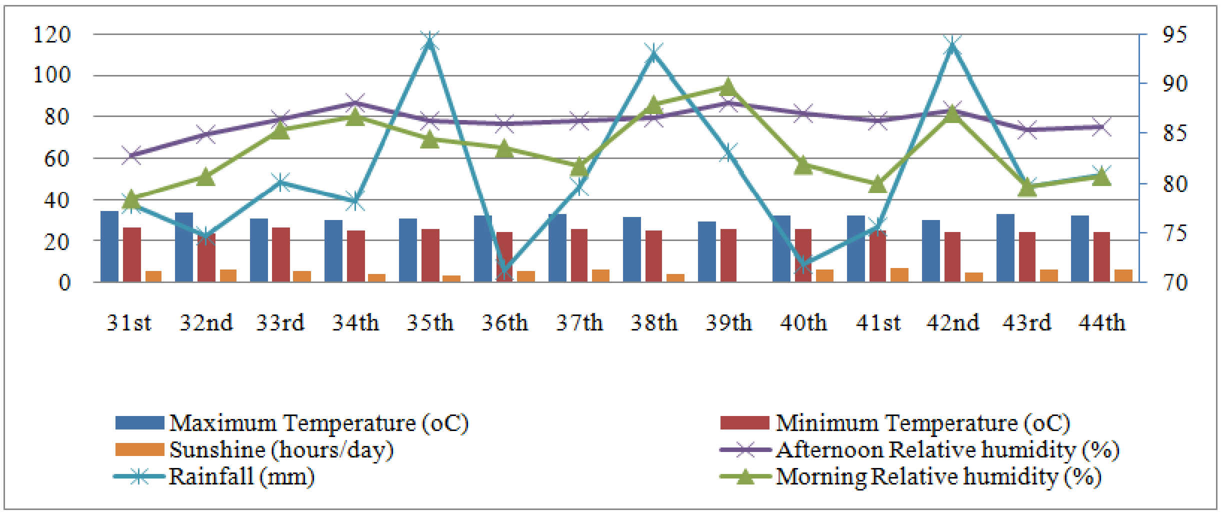

Figure 1: Meteorological data of MSSSoA, CUTM, Meteorological Observatory, Odisha (July-November, 2019)

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REVIEW ARTICLE

Integrated Nutrient Management in Jute Crop: A Review

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ABSTRACT

Jute in India is famous for its unique versatile quality, texture and ranks second in terms of production, which represents the qualitative and quantitative nature of jute crop. This article describes the importance of jute crop and the benefits of nutrient management practices in the jute crop which improves production, productivity and yield to meet the future needs of the fiber for the country. Jute fibers are a great contribution to the economy of India due to its demand for the manufacture of different products. It not only provides employment to the rural population but also serves as an income generating occupation. The integrated nutrient management practices if adopted, then the future needs of jute based products can be easily resolved along with sustaining agriculture.

Keywords: Jute, Chemical fertilizers, Organic fertilizers, Integrated Nutrient management.

INTRODUCTION

India has its own vast achievements in terms of food production with the utilization and promotion of high yield varieties since the green revolution in 1960's (Maitra and Zaman, 2017). The objective of food grain production is sufficient but there also arises a major requirement in production of fibre crops like jute and cotton to fulfill the materialistic demands in the country. The climatic conditions and fertile soils has been a blessing to the jute production in India. Jute is the most cultivated crop in different regions of the country and is the second important natural fibre crop after cotton. The Ganges Delta region of India produces about 85% of the world's total jute production. Jute favours a warm climate with temperature ranging from 25 °C-30 °C and relative humidity of 70%–90%. It requires about 160–200 cm of rainfall yearly with extra irrigation during the early growth stages.

Jute is cultivated in a larger percentage of area due to its much utilisable mechanical properties compared to other natural fibers, such as sisal, coir, and ramie (Elbadry *et al.*, 2012). The Indian Soil having fertile alluvial or loamy soils, suits best in the yielding capacity of jute crop. It requires a temperature of 20 – 40 ^{o}C and 70-80% moisture for its better growth and development. The better property of jute crop is its bio degradable and environmentally safe. Jute fibre obtained after harvesting of the crop is used as clothes and as ropes for carrying grains. Jute fibre is rich in cellulose, hemicelluloses and lignin making it highly tensile with good flexure and strength. These good quality of jute fibers make it an attractive substrate for flexible devices (Manjakkal *et al.,* 2021). Generally, there are two types of jutes – white jute and *tossa* jute. The *tossa* jute is softer, silkier, and stronger than white jute. The jute is obtained from the stems and outer skin of the jute plant. The fibre plant has many special characteristics that determine its true potentiality. The small and marginal farmers off many eastern India states like Odisha, West Bengal, Assam, Bihar, Meghalaya and Tripura have a huge marketing of Jute (*Corchorus* sp.) products making it the most economical crop in the region (Majumdar *et al*., 2019).

The variations in its usage make it a versatile plant. The leaf of Jute can be used as a therapy and its juice and whole green leaf is also used in preparation of skin care products (Islam, 2013). Overlapping of nutrients into the soil with a desire to obtain higher yield, acts as a slow poison for the environmental conditions, food quality, crop quality and soil conditions. The jute leaf is rich in different nutrient compounds including many minerals (like calcium and iron), amino acids, vitamins (like A,C E) and beta-carotene which is useful for good eyesight, healthy red blood cells, strong bones and teeth, and smooth clear skin, strong immune cells, and fast wound-healing (Sarkar *et al*., 1997; Ruhn *et al*., 2000; Das *et al*., 2021).

Retting and stripping processes are done in jute to obtain the jute fibre from the jute plant. Different techniques and procedures like mechanical retting (hammering) or chemical retting (boiling and applying chemicals), steam/vapor/dew retting and water or microbial retting are carried out to obtain the fine quality fibers from the jute crop (Elbadry *et al.,* 2012). The versatile nature of jute has been advantageous in preparation of different products. Jute can be used for making ropes, clothes, and mats and cover clothing for house hold articles. The composites prepared utilizing the raw jute has high energetic properties with weak adhesion, improving its qualitative factors. (Acha *et al*., 2005; Kumar *et al*., 2019).

INTEGRATED NUTRIENT MANAGEMENT (INM)

INM can be defined as the improvement of soil quality, nutrient concentration and soil fertility with optimum and balanced plant nutrient supply for achieving the desired productivity. The utilization of all possible nutrient supply sources of organic, inorganic and biological components in an integrated manner improves the microbial activity and provides the crop with sufficient and required nutrients. The dependence on chemical fertilizer usage has always been a matter of concern and faces enough criticism because of its harmful effects on the crop quality, nutritional imbalances in the soil, nitrate leaching and much more. INM in jute is the incorporation of manures, chemical fertilizers and biological agent together to achieve sustainable production and is the best approach for better utilization of available resources crops with less expenditure (Srivastava and Ngullie, 2009). Integrated nutrient management should be considered and adopted as an integral part of any agricultural sustainable system.

The increasing demand for variety in foods and nutrition quality by consumers has put a tough challenge for energy production and utilization of that energy in a judicious manner for sustainable management of resources (Gezahegn, 2021). INM is the boosting of soil fertility with enough supply of macro and micro nutrient supply to the crop to achieve the desirable crop productivity and enhance the soil quality. The need and alert for INM has aroused due to the misuse of chemical fertilizers, hampering the crop quality and soil fertility.

In the last 50 years, there have been many research and developmental works carried on nutrient management in jute crop and the output have been scanty due to less exploration in the advancement factors of research. The latest exploration and development into the nutrient management of jute can be much beneficial to the farmers. The available literature suggests that the integrated application of compost and biochar leads to higher growth, yield, improved nutrient status, and nutrient use efficiency of plants. The experimentation of integration of chemicals with vermicompost resulted in maximum productivity in jute, thereby representing the importance of INM in jute crop (Midya *et al.,* 2021).

The deficiency of secondary and micro nutrients due to the dominant and judicious use of chemical fertilizer has aroused the demand for the adoption of integrated nutrient management practices in the jute crop. The experiment with INM resulted in highest number of branches /plant, pods /plant and seeds /pod in plots with 75% RDF+25% N-FYM and a similar output was also produced with 75% RDF+25% N-Neem seed powder treated plot. This clearly emphasizes the benefit of INM in jute crop (Mandal *et al.,* 2015).As per the recommendation by TNAU, India, Jute crop requires about 20 kg of N, P, K fertilizers and 5 tones of FYM and requires less amount of fertilizers, if organic matter or bio fertilizers and fertilizers are applied together. This integration could prove to be very useful in increasing the production of jute crop and also maintaining the soil fertility as well. The integrated management treatments, 75% RDF+25% N-FYM proved best in obtaining highest growth and yield and balancing soil nutrients (Mandal *et al.,* 2015).

In the Textbook of Plant Nutrient Management by scientist Dr. Rishi Raj working on the project of "Integrated crop and resource management for enhanced productivity and profitability" it is mentioned that "The IPNS is the only way to make Indian agriculture sustainable. Manures are rich source of nutrients benefitting the growth of jute crop by providing essential nutrients and no harm to the soil conditions and environment. In this experiment, the highest fibre yield of jute was obtained when both organic (10 t farmyard manure/ha) and inorganic sources of nutrients (N:P:K at 40:20:30 kg/ha) were incorporated as treatments emphasizing the importance of INM in jute crop (Majumdar *et al.,* 2019). Integrated nutrient management involves monitoring all the pathways of plant nutrient supply in crops and cropping systems and calls for a judicious combination of inorganic fertilizers, organic manures and bio fertilizers. Further, the article has the potential to address a Sustainable Development Goal (SDG), namely, SDG 15 (life on land)(UN, 2021).

Components of INM

- Fertilizers
- Manures
- Bio fertilizers
- Composts
- Green manures
- Crop residues

Advantages of INM in Jute crop cultivation

- The applied as well as native soil nutrients get enhanced and availability to plants also increases.
- The nutrient demand of the crop also gets fulfilled due to the integrated nutrient supply from native and applied sources.
- A balanced nutrition to crops is provided and the chances of nutrient deficiencies and imbalances get recovered.
- The physical, chemical and biological functioning of soil gets sustained.
- The carbon sequestration also increases which reduces the loss and degeneration of soil conditions, water resources and ecosystem.
- The loss of nutrients (macro and micro) also reduces.

RESULTS FROM PREVIOUS RESEARCHES ON INM IN JUTE

A higher yield of jute was found to have obtained with the Integrated nutrient management practice of 75% fertilizer NPK + 25% organic N. The Nutrient uptake and nutrient productivity numbers were also highest in crops with 100% INM (Ghosh, 2008). The integration of inorganic, organic and bio – fertilizers nutrient sources is the only method to resolve the soil related issues coming at present and he also mentioned that IPNM is the only method of sustainable agriculture. When the chemical N-fertilizer was combined with water hyacinth compost and farmyard manure, it increased the fibre productivity in jute and also maintained the initial fertility status of the soil (Mitra *et al.,* 2010). The advantage of integrating both chemical and organic fertilizers is, it increases the activity of soil microbes along with providing all nutrients in the sufficient quantity to the jute crop. Integrated nutrient management is the only method by which the sustainability of agriculture can be maintained with better crop production and enriched soil quality. Indian states having a greater potentiality in Jute fibre production but the demand of import of the most vital and critical input i.e., seed from South and West Indian states of India like Maharashtra, Andhra Pradesh, Telangana and Karnataka, has been a concern in carrying further research and increasing production (Ghosh *et al.*, 2018).

INM is a major source of energy, providing maximum organic carbon, and available nitrogen for the growth of soil microbes and improvement of physical properties of soil. The efficiency of residual nutrients on subsequent crops also increases thereby promoting it as an eco-friendly practice. The enormous use of chemical fertilizers gets decreased with the substitution of organic nutrient sources and this maintains the nutritional balance in the soil. The crop nutrient requirement also gets fulfilled and maximized profit is obtained, ultimately, reducing the environmental pollution. It is a better option to judiciously combine and use the organic, inorganic and bio – fertilizers together in the soil so that it can enhance the biological properties of the soil (Ghanbari and Nejad, 2021). The proportion of Carbon-storage was higher with INM, indicating long-term soil stability and yield sustainability for jute crop (Mazumdar *et al.*, 2021).

A review of many research works represents that the integration of chemical and organic nutrient sources (50% reduction of N and P fertilizer along with bio-fertilizer) recorded higher net return and B:C ratio as compared to 100% NPK application through chemical fertilizer. The integration of both chemical and organic nutrient components is very much useful in application for jute crop as it can be seen that the nutrient efficiency is high and nutrient uptake by crops is also higher. The experiment represented that the nutrient uptake by jute crop and soil nutrients status was highest even after three years when NPK was combinely applied with FYM. The combination of inorganic and organic (FYM) fertilizer achieved targeted yield and maintained the soil fertility status (Singh *et al.*, 2015). The jute crop uptakes much more nutrients when it is applied in integrated manner. It is also understood that despite of applying all the nutrient sources at a time, it can be applied in a number of split doses so that the nutrients can be completely up taken by the crop. It has also been proved through many researches that with the inclusion of integrated approaches the soil nutrient status and nutrient uptake rate by plants have also shown an increasing graph.

The research carried on INM in jute with the application of 50% N and P fertilizer with organically inoculation of seed with bio-fertilizer (Azotobacter and PSB) obtained maximum fibre yield and produced higher net return. The B:C ratio of soil nutrient status was also improved with INM practice in comparison with the application of 100% recommended NPK fertilizer (Guha *et al.*, 2008). Looking at the present trend it could be estimated that in future the requirement of plant nutrients will increase to larger scale if the same trend of inorganic dependent nutrition practices is followed. Jute is an ideal source of pure nanocellulose, nano-lignin, and nanocarbon preparation because of its chemical compositions of jute fibers and sticks rich in, cellulose, hemicelluloses, and lignin (Shah *et al.*, 2021).

CONCLUSION

By multiple large scale soil testing we have seen the results of micronutrient deficiencies in the Indian soils and this can be a new danger for crop growth later. So to overcome the micro nutrient deficiency problem, usage of organic products can be regarded as a beneficial way. The main focus should be given to enrich the soil rather than crops by increasing the utilization of organic inputs which will be very useful in supporting sustainability in agriculture for a longer period of time. Integrated nutrient management appears to be one of the most beneficial techniques in agriculture in saving the soil quality and enhancing the soil properties.Lastly, INM can act a wand of magic in agriculture offering much better economic choices to farmers in the country by providing sufficient quantity of enriched nutrients and creating a favorable soil physiochemical conditions and healthy environment with elimination of the constraints, safeguard the soil nutrient balance.

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RESEARCH ARTICLE

Low - Cost Technologies for Sustainable Agriculture

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ABSTRACT

Sustainable agriculture is to meet society's current food and textile demands without compromising future generation's ability to meet their own. On the farm, growers can utilize measures to improve soil health, reduce water use, and reduce pollution. Sustainable agriculture frequently combined biology, economics, engineering, chemistry, community development, and other disciplines in their work. It is more than a set of procedures. Major and micronutrient for plants are also provided by well-decomposed FYM, compost, and vermin-compost. In organic farming, high–yielding straight varieties are preferred over hybrids, and such seed should be grown on the farm. Before sowing seed- treatment is necessary to ensure early germination, protect the crop from seed and soil-borne illness, and facilitate sowing. Sowing over a slant or contour is another a low-cost method. Land treatments such as opening furrows in crop rows and sowing on broad beds and furrows help to retain moisture in the soil. Non monetary inputs such as timely sowing, optimum plant population, optimum depth of sowing, inclusion of legumes in crop rotation etc. also improves the yield.

Keywords: Sustainable Agriculture, low-cost technology, choice of variety, seed treatment, non-monetary inputs.

INTRODUCTION

The purpose of sustainable agriculture is to meet society's current food and textile demands without compromising future generation's ability to meet their own (Horrigan *et al*., 2002). Sustainable agriculture practitioners strive to achieve three key goals in their work: a healthy environment, economic profitability, and social economic equality. Growers, food processors, distributors, retailers, consumers, and waste management all have a responsibility to play in creating a sustainable agricultural system (Smith, 2008; Maitra *et al*., 2018; Palai *et al*., 2021). People engaged in sustainable agriculture and sustainable food systems employ a variety of techniques (Ackerman *et al*., 2014; Maitra *et al*., 2019, 2022). On the farm, growers can utilize measures to improve soil health, reduce water use, and reduce pollution. Consumers and businesses interested about sustainability might seek out "values- based" food cultivated in ways that promote farm worker well-being, are environmentally begin, or help the local economy (Hinrichs and Allen., 2008; Maitra and Gitari, 2020; Das *et al*., 2021). Researchers in sustainable agriculture frequently combine biology, economics, engineering, chemistry, community development, and other disciplines in their work. Sustainable agriculture, on the other hand, is more than a set of procedures. It's also a negotiating process: a tug of war between an individual farmers or a community's sometimes conflicting interests as they attempt to address a problem (Moore *et al.,* 2006; Singh *et al*., 2021; Pramanick *et al*., 2020). Sustainable agriculture is defined as an integrated system of plant and animal production practices with a site-specific application that will, overtime, meet human food and fibre needs, improve environment quality and the natural resources based on which agricultural economy is based, make the most efficient use of nonrenewable resources and on-farm resources, and integrate, where appropriate, natural biological cycles and controls, and maintain the economic viability of the agriculture economy (National Research Council, 2010). The article also addresses some of the Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), and SDG 15 (life on land)(UN, 2021).

LOW-COST TECHNOLOGY

The components on low cost technology for sustainable agriculture are explained below and represented in fig.1.

Choice of variety and good quality seed

The use of good quality seed of appropriate variety is one of the most important low- cost inputs in modern agriculture (Waddington *et al*., 2010). Only if quality seed is used will other inputs such as irrigation and organic manures serve as catalysts. Simply by selecting an appropriate variety with high quality seed, pulse yields might be boosted by10% to 15%. In organic farming, high–yielding straight varieties are preferred over hybrids, and such seed should be grown on the farm (Kyeyune and Turner, 2016). Modern varieties and seed technologies have played a vital part in agriculture's evolution. The availability, accessibility, and utilization of high-quality seed of adaptable crop varieties are crucial for realizing the benefits of agriculture research investments (Bishaw *et al*; 2007).

Efficient use of manures

Major and micronutrient for plants are also provided by well- decomposed FYM, compost, and vermin-compost (Naik and Babu, 2005). These organic sources also increase soil structure, soil fertility, and soil aeration, as well as water holding capacity and soil temperature regulation, all of which help to improve soil biological activity (Karhu *et al*., 2011). If there is a scarcity of organic manures, the basal or spot application approach should be used. Oilseed cakes are also a good source of nutrients and should be utilized in high-value crops using the ringmethod. No grass or weeds, including weed, should be burned; instead, they should be recycled in situ or heaped in pits for decomposition (Matthäus, 2002; Harika *et al*., 2019; Shankar *et al*., 2020). Manure includes allof the macro and microelements necessary for plant growth, but it is one of the most underused resources in the united-states. (Chatzissavvidis and Therios, 2014). The direct influence of manure composition on application cost is the fundamental issue with its use on crops. This price is determined by the mineralization of organic materials. The quantities of the manure, the properties of the soil, moisture, and temperature all influence the mineralization process. (Guntiñas *et al.,* 2012).

Bio-fertilizers

Bio-fertilizers have been shown to increase yield by 15% to 20%. Increased crop yields have been recorded with Rhizobium inoculation in pulses, *Azospirillium* in sorghum, pearl-millet, barley, wheat, and finger millet (Maitra *et al*., 1997) and *Azotobacter* in rice, wheat, sorghum, maize, vegetables, and cotton. PSB (Phosphate Solubilizing Bacteria) is another key bio-fertilizer that increases the availability of native P to crops (Nosheen *et al.,* 2021). Biofertilizers contain microorganisms that ensure that the host plants receive an adequate supply of nutrients and that their growth and physiology are properly regulated (Mishra *et al*., 2013). Bio-fertilizers, which have specific activities to increase plant growth and reproduction, are made with living microorganisms. Biofertilizers are important components of organic farming since they help to maintain soil fertility and sustainability over time. (Mahdi e*t al*., 2010; Ramya *et al*., 2020).

Seed treatments

Before sowing, seed treatment is necessary to ensure early germination, protect the crop from seed and soil-borne illness, and facilitate sowing(Ashraf and Foolad., 2005). Seed bornedisease is protected by fungicides sprayed at a rate of 2-3g/kg seed. Because cotton seed is fuzzy, it must be delinted with conc. H_2SO_4. Because seedling, it is additionally treated with soil paste. To eliminate immature, damage seed, pearl millet and rice are dipped in 3%salt (NaCl) solution (Roy and Basu, 2009). Seed treatment have played, and continue to play, a critical role in long term agricultural productivity, as proven by human history. Many diverse crops have benefited from seed treatments that provide protection from pre- and post- emergence insects and disease, (Ashraf and Foolad, 2005) as well as the assurance of a uniform stand across a wide of soil types, cultural techniques and environmental circumstances (Malcolm *et al*., 2001).

***In-situ* water conservation**

It is not uncommon for excessive rainfall to result in flow and soil loss (Jetten *et al*., 2005). Crumb breaking is required after very rain to improve soil aeration and allow more rainwater to penetrate. Sowing over a slant or contour is another a low-cost method. Land treatments such as opening furrows in crop rows and rows and sowing on broad beds and furrows help to retain moisture in the soil (Temesgen *et al*., 2009).

Crop sequence

If rainfall is adequate and late (September-October) rains are heavy, on thick soils(Ruibal*et al*.,1969). After green gram/black gram/soybean/groundnut/cowpea/pearlmillet, double cropping is conceivable; chickpea/safflower can be harvested successfully after green gram/blackgram/soybean/groundnut/cowpea/pearl millet. The main benefit of successive cropping is the very complementing production of safflower (Andrews, 1976).

Water management

When crops are cultivated under irrigation, water management is epically crucial (Bouwer, 2000; Zaman *et al*., 2017). For various crops, critical growth stages for irrigation have been discovered. If two irrigations are available, the pre-flowering and grain filling periods are the most critical in most field crops. Irrigation failures at these phases results in yield reduction of 30-40%in wheat, as well as other crops (Fischer and Stapper., 1987).

Bio-pesticides

Insecticidal qualities of bio-pesticides such as neem have been known, and neem extract is suggestion for controlling bollworm and other pests (Sarwar, 2015). It's also used to protect pigeon pea and chickpea pods against borer. In summary, instead of artificial pesticides, organic farming allows the use of insecticides derived from naturally existing plant parts or creatures (Brandt and Mølgaard., 2001). The application and methods for delivering biocontrol agents in a formulation product are directly related to the performance of biopesticides (Boyetchko *et al*., 1999). Various biopesticide formulations are currently available for seed dressers, soil mixers, and foliar treatments. Seed coating is a simple and cost-effective strategy for controlling soil borne phytopathogens, but its effectiveness is highly reliant on the technology and type of coating material utilized. Seed-coating has significant technological problems in retaining viable microbial cells during seed treatment and storage on a commercial scale (O' Callaghan., 2016).

NON-MONETARY INPUTS

Proper planting time

Only when a genotype is discovered at the right time can it reach its full potential (Melo *et al*., 2016). Bad growth/excessive growth, poor yield ascribed characteristics, and yield are all consequences of delayed or early socialization. Because of the optimum temperature and soil moisture, sowing at the right time assures good germination and a faster start. Cotton, black gram, and green gram have all been proven to benefit from dry seeding. Early sown crops benefit from early rans, avoid pest damage in the future, and may withstand drought better than late sown crops (Jiménez-Díaz *et al.,* 2015).

Depth of sowing

The depth of sowing should be varied according to the seed size. Smaller seeds should be placed at a shallower depth in general. Groundnut is best sown at a depth of 3-5cm in soybean. Seeding depth for chickpeas should be 8-10cm (Hemmat and Eskandari, 2004). For a solid crop stand and higher yields, the optimal planting depth is required. The yield components of wheat have been found to have improved dramatically as a result of a difference in sowing depth (Wang *et al*., 2014). Sowing depth varies by:

1. Crop: The optimal depth for most field crops is 3-5cm, but this varies per crop. Rice is 3-4cm, maize is 5-6cm, wheat is 5-6cm, and pearlmillet is 2-4cm (Zhang *et al*., 2013).
2. Soil types: deeper sowing is preferred in sandy soils, whilst shallow sowing is indicated in heavy soils (Håkansson and Etana, 2002)
3. Moisture availability: crops should be seeded in deeper layers in dryland conditions (Dıaz-Zorita., 2000).
4. Seed size: large- seeded crops should be sown deeper (upto 10 cm), whereas small-seeded crops should be sown up to 3cm (3-4cm) (Laidlaw and Frame., 2013).

Optimum plant population

The yield per unit area is determined by the yield per plant as well as the number of plants per unit area. Extra inputs will not be able to compensate for the loss of plant stand. Excessive plant population may result in a higher yield, but it lowers the economical the economic yield (Lithourgidis *et al.,* 2011). The following approaches should be used to maintain an optimal plant population: proper seed bed preparation; row and bed arrangement; row spacing maintenance; accurate planting time and methods seeds of high quality and viability; ensuring a high germination rate (Thompson *et al.,* 1984).

Intercropping:

Intercropping entails increasing productivity both in terms of time and space (Gebru, 2015). The benefit is calculated as a land/income equivalent ratio. It includes effective low-cost technology for increasing crop productivity, especially in arid and semi-arid rainfed areas. Cotton+ green gram /black gram/cowpea/soybean/pigeon pea are some of the most common intercropping systems. Green gram/black gram/cowpea/soybean etc. (Machado, 2009). Intercropping benefits the system in a variety of ways, including increased resource efficiency (Mousavi and Eskandari, 2011; Maitra *et al*., 2019), a reduction in the population of hazardous biotic agents, improved resources conservation and soil health, and increased production and long- term sustainability. More than one crop is production on the same piece of land in an intercropping system, which takes use of soil nutrients, soil moisture, atmospheric CO_2, and sunlight (Maitra *et al* ., 2021). An intercropping method also has significant effects on resources conservation and soil health, since it reduces run-off, soil erosion, and nutrient loss from the soil. Furthermore, when small millets are intercropped with legumes, it improves soil fertility and allows for a greater diversity of beneficial soil microbes. Complementary among the farmed species is critical for enhancing crop yield in an intercropping system (Brooker *et al*., 2015).

Legumes in rotation

Cotton-sorghum-groundnut, green gram–chickpea/sunflower, soybean/green gram- wheat-groundnut, and sorghum-wheat-summer green gram are important rotations. Crop rotation helps to reduce pests and diseases, weeds, and improve the recycling of plant nutrients (Shah *et al.,* 2021). Grain legumes grown in rotation with annual cereal crops increase the total nitrogen pool in the soil and boost cereal yields (Ahmad *et al*., 2001; Jena *et al*., 2022). However, depending on the legume species and its interaction with the environment, the expected N advantages of the bean may be positive or negative. Excessive water used by the legume phase, its symbiotic performance, the impact of soil pH on legume growth and biomass returning N, harvest index, and nitrate immobilization during decomposition of legume residues may all contribute to this unpredictable reaction (Dawson *et al.,* 2008).

Recycling of farm wastes

NPK and other micronutrients are removed in significant quantities in the form of grain, straw, and green fodder and are not returned to the soil. After adequate decomposition, all farm leftovers, such as straw or stubbles, slaughterhouse waste, and human excreta, should be returned to the soil (Singh and Longkumer., 2018). Except for the mobilization of human resources, this contribution does not necessitate any financial investment. Cow dung is used to make fuel cakes in part. This can be mitigated to some extent by using a gobar gas plant, which will offer both cooking gas and nutrient-rich slurry (Demirbas, 2008; Nandi *et al*., 2022). Recycling organic waste as compost/ vermicompost in agriculture fields has a number of advantages, (Sharma *et al*., 2019). including sustainable alternative to chemical fertilizers and the conservation of limited and-renewable rock phosphate used as chemical P fertilizer, improved soil nutrient profile, structure, and reduced soil erosion, climate change mitigation due to reduced GHG emissions from waste decomposition in opendumps, and land resource conservation due to reduced amounts of organic waste.

Crop rotation and clean cultivation

Crop rotation and clean cultivation are critical for soil management as well as reducing the insect-pest complex and disease risks (Altieri *et al*., 2004).

Crop substitution

In a variety of conditions, traditionally low-yield crops could be substituted by higher-praying crops such as oil seeds (Patil *et al*., 2018). Under rainfed conditions, rabi oil seed such as mustard or safflower can be a good alternative for wheat, with returns three to four times that of wheat. Crop selection should be based on soil capacity classifications. Conventional crops are uneconomical in shallow, eroded soil. Dryland fruits like tamarind, aonla, ber, custard apple, and grasses like stylo have proven to be cost- effective (Kumar *et al*., 2009).

Weed control at critical stages of weed competition

Weeds, if not treated in a timely manner, can deplete crop plant nutrients, soil moisture, and air space, resulting in insect pest problems in the crop. Weeding at the critical period of crop weed competition is inexpensive effective, and profitable (Chauhan and Mahajan, 2012; Samanta *et al*., 2021; Zahan *et al*., 2021).

Organic mulching

Mulch is a technique word that refers to the covering of soil (Sharma and Bhardwaj., 2017). Mulching is the practice of covering the soil or ground in order to conserve soil water while also promoting plant growth, development, and crop production. Farmers can use any locally accessible organic substance in the field for mulch, such as dried leaves, straw, previous crop residues, stubbles, and so on. These are both environmentally friendly and cost- effective. Mulch plays an essential function in improving the physical, chemical, and biological quantities of the soil, according to research (Steinmetz *et al*., 2016).

Pest and disease management

It is critical to discover alternate strategies to keep insect populations under control in the context of sustainable agriculture and increased awareness of food and environment quantity (Francis *et al*., 2003). A better understanding of the bioecological linkages of cropping systems is the key to more appropriate environmental designs and skill-intensive ecofriendly management approaches for pest-predator population balance while cultivating a healthy and high-quality crop (Bhattacharya and Bandopadhyay, 2020).

CONCLUSION

In today's agriculture, input costs are quite expensive, and marginal farmers are unable to employ these inputs on a regular basis. Low-cost technology and nonmonetary techniques can be highly efficient in achieving one of the goals of sustainable agriculture, namely low input and high output.

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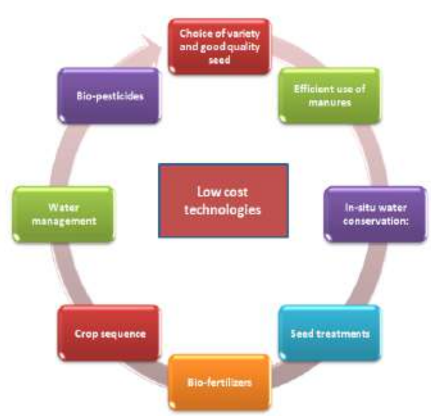

Fig. 1: Low cost technologies for sustainable agriculture

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RESEARCH ARTICLE

Effect of Cultivars and Planting Variables on Yield Performance of Some Deep-Water Rice Cultivars in New Alluvial Zone of West Bengal

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ABSTRACT

Spacing treatments were made deep-water rice cultivars though a large number of deep-water rice cultivars are now available in the world wide to find out optimum time of transplanting and depth of planting with several other deep–water rice cultivar. An investigation was carried out at Instructional Farm, Jaguli, B.C.K.V., Nadia, West Bengal, situated at 22°56′ N latitude, 88°32′ E longitude and at an elevation of 9.75 m above the mean sea level during the *kharif* season of 2006, regarding studies on the effect of planting variables on some deep-water rice (*Oryza sativa* L.) cultivars in New Alluvial Zone of West Bengal. The soil of the experimental site was endowed with typical Gangetic Alluvium (Entisol) having sandy loam texture with medium fertility. The experimental site falls under sub-tropical humid. The average maximum temp was 34.15°C and minimum was 21.31°C. The rainfall was 0.04 mm to 326.6 mm. The relative humidity was 53.53% (minimum) to 98.84% (maximum). The experiment was laid out in the split plot design with five different deep-water cultivars viz., V1 (Sabita), V2 (Bhagirathi), V3 (CN-1231-11-6), V4 (Jaya cross) and V5 (CN-1039-9) in the main plots along with four different planting variables viz., S1 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}), S2 (20 cm × 15 cm spacing with 3 seedlings hill^{-1}), S3 (30 cm × 20 cm spacing with 5 seedlings hill^{-1}) and S4 (30 cm × 20 cm spacing with 3 seedlings hill^{-1}) in sub plots randomly allocated and replicated thrice. The gross plot area size 3m × 2m. The findings revealed that growth attributes and yield attributes differed significantly due to the deep-water rice cultivars and planting variables. Among the five deep-water rice cultivars (Sabita, Bhagirathi, CN-1231-11-7, Jaya cross and CN-1039-9), CN-1039-9 was the best. Planting variable S_1 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}) recorded better growth attributes whereas planting variable S_3 (30 cm × 20 cm spacing 5 seedlings hill^{-1}) recorded better yield attributes in semi-deep water situation in New Alluvial Zone of West Bengal.

Key words : Rice, Cultivars, Planting Variables, Deep-Water, Yield.

INTRODUCTION

Rice is the staple crop food over half of the world population. In world, rice's area is 153.953 m ha, production 618.441 mt, and productivity 4.02 t ha^{-1}(FAOSTAT 2007). In India, rice's production is 89.09 mt, area 41.92 mha, productivity 2125kg ha^{-1}(2008-09). West Bengal produce highest amount of rice (14.34 mt) from an area of 5.63 mha with productivity of 2547 kg ha^{-1}(2008-09) (GoI, 2009).The target achieved only by increasing the rice production by 2.0 mt year^{-1} and productivity has to push upto 3.2 t ha^{-1}(Bouman *et al* 2007). Deep-water rice plays an important role. Deep- water rice is the important and common crop cultivated in wetland. Deep-water rice as rice that is usually flooded deeper than 50 cm for one month or longer during the growing season (Qadir *et al.,* 2007; Midya *et al*., 2021). About 25-30% of world rice area under deep-water cultivation. Deep –water rice contributing nearly 2.4 mha, which cover more than 5% of total rice cultivated area in India. Widely cultivated in the countries like Bangladesh, India, Thailand, Burma, Vietnam, Indonesia, Guinea etc. The largest concentration is in Bangladesh with about 2 mha and adjacent area in India with about 1.7 mha (FAO 2009).

Although India has 2.4 and 12.2 percent of world's land and arable land area, respectively, it has a responsibility to feed 16.3 percent human and support 15 percent livestock population of the world. As the rice play a significant role in our food and civilization, the future of food security system in this region depends largely on the improvement in both productivity as well as profitably of rice farming system on an ecologically sustainable basis (Sairam *et al.,* 2020a; Shankar et al., 2020; Mohanta *et al*., 2021). The important rice growing state in India are West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab, Assam, Bihar, Tamil Nadu and Kerala. West Bengal produces the highest amount of rice i.e., 14.51 million tonnes with an area 5.78 million ha (productivity is 2509 kg ha^{-1}) followed by Uttar Pradesh. The highest productivity of rice (3868 kg ha^{-1}) was recorded from Karnataka which is 1768 kg higher compared with the national average (2102 kg ha^{-1}) (GoI, 2009).

But, now-a-day the most important challenge for India is sustaining the productivity growth without endangering the natural resource base. The projected target of 140 million tonnes of rice by 2025 AD, which can be achieved only by increasing the rice production by 2.0 million tonnes per year in coming decade. The productivity per se has to be pushed upto 3.2 tonnes / hectare. Area under cultivation being dynamically static, there is not much scope for increasing the land under cultivation. But to increase our food grain production per unit area, per unit time without causing damage to our environment is very important today (Fischer 2003).

So, introduction of modern, promising deep-water rice in low laying and flood prone area are one of the important steps towards augmentation of yield of rice. Deep water paddy is the most important and common crop cultivated in wetland. About 25 – 30% of world rice area under deep water paddy. The is widely cultivated in the countries like Bangladesh, India, Thailand, Burma, Vietnam and Indonesia Guinea, Mali and Sierreleone. The largest concentration is in Bangladesh with about 2 m ha and the adjacent region in India with about 1.7 m ha. Deep water rice is grown in areas usually flooding deeper than 50 cm for one month or longer during the growing season. The definition therefore includes all rice adapted to water deeper than 50 cm in this situation rice survives by their tall stature and long leaves. Deep water rice cover 3.0 m ha and which contribute 7.0% of total area and deep water contribute 2.4 m ha, which cover 5.7% of total rice harvested area in India (Calpe 2006).

Different deep & semi-deep water rice varieties have been released recently for cultivation in several states in India. Now, it's essential to know whether the agronomic practices recommended for semi-deep water rice varieties hold good during kharif season (Sairam *et al.,* 2020b; Shankar *et al*., 2021). The major problems assailing the farmers of the lowland areas are uneven distribution of rainfall during June, July and August; moreover, variation in intensity and distribution of rainfall from year to year and yielding varieties with poor management, poor establishment of seedlings due to partial submergence; deeper depth of water in the field and occasional flooding and inundation; low photosynthetic efficiency of the varieties due to reduced light intensity normally prevailing in wet season; accumulation of toxic substances in soil of ill-drained fields; severe pest occurrence during the monsoon and premature lodging of the crop (Toure *et al*. 2009; Ghosh *et al*., 2020). In this experiment, 5 deep water rice varieties were taken to ding out varietal performance during kharif season in West Bengal condition and 4 planting variables were taken (20cm × 15cm spacing with 5 seedlings, 3 seedlings; and 30cm × 20cm spacing with 5 seedlings, 3 seedlings) to find most suitable planting variables. The present research addresses some Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), and SDG 15 (life on land) (UN, 2021).

MATERIAL AND METHODS

The investigation was undertaken at Instructional Farm, Jaguli, BCKV, Nadia, West Bengal, during the *kharif* season, 2006. The experimental site falls under sub-tropical humid climate being situated just south of the tropic of cancer. The temperature is neither too hot in summer nor too cold in winter. During the growing season of the experimental crop, the average maximum temperature was in the month of June, 2006 (34.15°C) and minimum average temperature was in the month of November, 2006 (21.31°C). The rainfall was 0.04 mm to 326.6 mm and the relative humidity was maximum in the month of October, 2006 (98.84%) and was minimum in the month of November, 2006 (53.53%).

The experiment was laid out in the split plot design with five different deep-water cultivars viz., V1 (Sabita), V2 (Bhagirathi), V3 (CN-1231-11-6), V4 (Jaya cross) and V5 (CN-1039-9) in the main plots along with four different planting variables viz., S1 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}), S2 (20 cm × 15 cm spacing with 3 seedlings hill^{-1}), S3 (30 cm × 20 cm spacing with 5 seedlings hill^{-1}) and s4 (30 cm × 20 cm spacing with 3 seedlings hill^{-1}) in sub plots randomly allocated and replicated thrice. The gross plot wise of each plot was 3 m × 2 m. Five raised nursery beds of 5m length, 1.5m wide and 15cm high was prepared about 40 days before. The seed treatment done with thiram @ 2.5gm kg^{-1} of seeds against externally seed borne diseases such as blast, about 3 hours in a gunny bag in shady place. 2 kg seeds of each deep-water rice cultivars were broadcasted in the five nursery beds separately and irrigation was applied. The main field was prepared with one deep ploughing was done by tractor followed by shallow ploughing with power tiller to ensure proper puddling. Finally, the land was puddle two days before transplanting and irrigation cum drainage channels were prepared. Forty (40) days old seedlings were transplanted at spacing of 30cm×20cm with 5 and 3 seedlings and at spacing of 20cm×15cm with 5 and 3 seedlings.

The crop received fertilizer dose @ 40:20:20 (N:P_2O_5:K_2O) kg/ha in form of urea, single super phosphate and murate of potash respectively. 50% N + full dose of P_2O_5 + 75% K_2O were applied as basal during final puddling, 25% N was top dressed at 30 days after transplanting and 25% N + 25% K_2O was top dressed at PI stage. To avoid the border effect, harvesting was done manually excluding border vows all around the plots and left in the field for two days for sun drying. After sun drying the bundles of the harvested crop of each plot was labeled properly and taken to the threshing floor. Threshing was done with the help of paddy thresher. Straw and grain were separately dried in the sun and weight of dried grain and straw of each plot were recorded. The statistically analysed by the analysis of variance method (Panse and Sukhatme, 1995).

RESULT AND DISCUSSION

Yield attributes

The data relating to the yield attributing characters of deep-water rice viz., number of effective tillers m^{-2}, number of filled grains panicle^{-1} and test weight of grains have been presented in Table 1,

Number of effective tillers m^{-2}

Effect of cultivars

The number of effective tillers m^{-2} different significantly due to cultivars (Table 1). Among the cultivars, CN-1039-9 gave rise to the significantly higher number of effective tillers m^{-2} (266.25) which was followed by cultivars Sabita (248.68), CN-1231-11-7 (245.84) and Bhagirathi (234.10), respectively. Number of effective tiller m^{-2} produced by Sabita and CN-1231-11-7 were statistically *at par* in this respect. Cultivar V_4 (Jaya cross) produced the least number of effective tillers m^{-2} (227.85). The results thus revealed that the number of effective tillers $unit^{-1}$ area followed the trend of number of total tillers $unit^{-1}$ area. This observation correlated the findings of Srinivasulu *et al.* (1988).

Effect of planting variables

The number of effective tillers m^{-2} was significantly influenced by different planting variables (4.5) and it increased with decrease in spacing and number of seedlings $hill^{-1}$. The highest number effective tillers m^{-2} recorded at treatment S_1 (20 cm × 15 cm spacing with 5 seedlings $hill^{-1}$) which was closely followed by treatments S_2 (20 cm × 15 cm spacing with 3 seedlings $hill^{-1}$) and S_3 (30 cm 20 cm spacing with 5 seedlings $hill^{-1}$), respectively. Planting variable S_3 and S_4 were statistically *at par*. However, the lowest number of effective tillers m^{-2} recorded with treatment S_4 (30 cm × 20 cm with 3 seedlings $hill^{-1}$). This result was in agreement with that of number of tillers $unit^{-1}$ area and was in conformity with the finding of Ramasamy *et al.* (1987).

Number of Filled Grains $Panicle^{-1}$

Effect of cultivars

The number of filled grains $panicle^{-1}$ differed significantly due to0 cultivars (Table 1). Among the cultivars, CN-1039-9 produced significantly higher number of filled grains $panicle^{-1}$ (160.38) followed by Sabita (149.40), CN-1231-11-7 (100.33) and Jaya cross (96.23), respectively, but they were not statistically *at par*. However, the lowest number of filled grains $panicle^{-1}$ was recorded with cultivar Bhagirathi (92.78) and it differed significantly with the other cultivars.

Effect of planting variables

The number of filled grains $panicle^{-1}$ was significantly influenced by different planting variables (Table 1) and it decreased with decreased in spacing and number of seedlings $hill^{-1}$. The highest number of filled grains $panicle^{-1}$ was recorded at treatment S_4 (30 cm × 20 cm spacing with 3 seedlings $hill^{-1}$), which was closely followed by treatments S_3 (30 cm × 20 cm spacing with 5 seedlings $hill^{-1}$), S_2 (20 cm × 15 cm spacing with 3 seedlings $hill^{-1}$), and S_1 (20 cm × 15 cm spacing with 5 seedlings $hill^{-1}$), respectively treatment S_1, S_2 are statistically *at par*. The lowest number of filled grains $panicle^{-1}$ was recorded at closest spacing (20 cm × 15 cm) with 3 seedlings $hill^{-1}$. This result was in conformity with Chatterjee *et al.* (1970).

Test Weight

Effect of cultivars

The test weight of grains differed significantly due to cultivars (Table 1). Among the cultivars, Sabita recorded the maximum test weight of grains (24.56 gm) which was closely followed by CN-1031-9 (23.14 gm), CN-1231-11-7 (22.57 gm) and Bhagirathi (21.23 gm), respectively, but they were not statistically *at par*. However, the lowest test weight was recorded with cultivar Jaya cross (20.50 gm) during the investigation. Varietal differences were found in view of the fact that test weight of grains happened to be a genetical character.

Effect of planting variables

There was no significant difference among the 4 different planting variable with regard to test weight of grains (Table 1). The test weight of grains could not be influenced by different spacing and different number of seedlings $hill^{-1}$ due to the fact that test weight happened to be a genetical character of a cultivar. This observation correlated the findings of Kaushik and Gupta (1973).

Effect of interaction between cultivars and planting variables

Interaction effect between cultivars and planting variables on the number of effective tillers m^{-2}, number of filled grains $panicle^{-1}$ and test weight of grains was found to be statistically non-significantly result.

YIELD

Effect of cultivars

Grain yield differed significantly due to cultivars (figure 1). Among the cultivars, highest grain yield of 4.23 t ha^{-1} was recorded in cultivar V_5 9CN-1039-9) which differed significantly over other cultivars. This was followed by cultivars V_1 (Sabita), V_3 (CN-1231-11-7) and V_2 (Bhagirathi) producing 3.90 t ha^{-1}, 3.39 t ha^{-1} and 3.33 t ha^{-1} grains respectively, and in which cultivars V_2 (Bhagirathi), V_3 (CN-1231-11-7) and V_4 (Jaya cross) were statistically at par. However, lowest grain yield of 3.03 t ha^{-1} was recorded in cultivar V_4 (Jaya cross). The highest average yield as well as potential yield of different cultivars are governed by both genetical and environmental factors. Under the environmental condition of present investigation, cultivar V_5 (CN-1039-9) came out as a superior cultivar and this finding could be explained in the light of better yield attributing characters like number of effective tillers m-2, length of the panicle and grains panicle^{-1}.

Straw yield was significantly influenced by different cultivars (Figure 1). Among the cultivars, highest straw yield of 7.59 t ha^{-1} was recorded in cultivar V_2 (Bhagirathi) which differed significantly over other cultivars. This was followed by cultivars V_1 (Sabita), V_5 (CN-1039-9) and V_3 (CN-1231-11-7) producing 7.21 t ha^{-1}, 6.94 t ha^{-1} and 6.59 t ha^{-1} straw, respectively and of which cultivars V_5 (CN-1039-9) and V_1 (Sabita) were statistically at par. However lowest straw yield of 6.19 t ha^{-1} was recorded with cultivar V_4 (Jaya cross) and it differed significantly with other cultivars.Under environmental condition of present investigation, cultivar V_2 (Bhagirathi) came out as superior cultivar in terms of straw production and this finding may be attributed to higher number of tiller production, highest leaf area index and dry matter accumulation by this cuoltivar in comparison to other.

Effect of planting variables

The experimental data found that when spacing of number of seedlings hill^{-1} were increased then grain yield increased significantly. Among the different planting variable, S_3 (30 cm × 20 cm spacing with 5 seedlings hill^{-1}) recorded highest grain yield (3.94 t ha^{-1}) which was followed by S_4 (30 cm × 20 cm spacing with 3 seedlings hill^{-1}), S_2 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}) producing 3.73 t ha^{-1} and 3.41 t ha^{-1} grain respectively, which were not statistically at par. However, the lowest grain yield was obtained in S_1 treatment (20 cm × 10 cm spacing with 3 seedlings hill^{-1}) producing 3.23 t ha^{-1}. Grain yield increased by 5.54 cent^{-1} and 9.35 cent^{-1} by increasing planting variable from S_1 (20 cm × 15 cm spacing with seedlings hill^{-1}) to S_2 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}) and from S_2 (20 cm × 15 cm spacing with 5 seedling hill^{-1}) to S_4 (30 cm × 20 cm spacing with 3 seedlings hill^{-1}), respectively. However, S_3 treatment (30 cm × 20 cm spacing with 5 seedlings hill^{-1}) produced 5.7 cent^{-1} extra yield over S_4 treatment (30 cm × 20 cm spacing with 3 seedlings hill^{-1}). Grain yield was higher in wider spacing (30 cm × 20 cm) with 5 seedlings than the same spacing with 3 seedlings or closer spacing (20 cm × 10 cm) with 5 or 3 seedlings. With decreasing spacing and seedlings, the panicle number m-2 increased but the grain panicle-1 and 1000-grain weight decreased. Vijayakumar *et al*, (2006) made such type of observation.

Straw yield was significantly influenced by different (Figure 1) and it decreased with increase in planting variables. Among the different planting variables S_1 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}) recorded highest straw yield (7.47 t ha^{-1}) which was followed by S_2 (20 cm × 15 cm spacing with 3 seedlings hill^{-1}), S_3 (30 cm × 20 cm spacing with 5 seedlings hill^{-1}) producing 7.28 t ha^{-1} and 6.54 t ha^{-1} straw, respectively. However, the lowest straw yield of 6.31 t ha^{-1} was obtained in S_4 (30 cm × 20 cm spacing 3 seedlings hill^{-1}). Planting variables S_3, S_4 were statistically at par. Straw yield increased by 3.63 cent^{-1} and 11.29 cent^{-1} by increasing planting variable from S_4 (30 cm × 20 cm spacing with 3 seedlings hill^{-1}) to S_3 (30 cm × 20 cm spacing with 5 seedlings hill^{-1}) and from S_3 to S_2 (20 cm × 15 cm spacing with 3 seedlings hill^{-1}) respectively. However S_1 treatment (20 cm × 15 cm spacing with 5 seedlings) produced 2.63 cent^{-1} extra straw yield over S_2 treatment. Similar results were recorded by Kumar et al. (2006).

Closest spacing (20 cm × 15 cm) with 5 seedlings hill^{-1} accommodated more number of hills unit-1 area than same spacing with 3 seedlings or widest spacing 930 cm × 20 cm) with 5 or 3 seedlings hill^{-1} and this was reflected in hectare-1 straw yield. This result was in conformity with the observation of Mishra and Salokhe (2010).

CONCLUSION

From the above experiment it can be revealed that among the five deep-water rice cultivars (Sabita, Bhagirathi, CN-1231-11-7, Jaya cross and CN-1039-9), CN-1039-9 was the best. Planting variable S_1 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}) recorded better growth attributes whereas planting variable S_3 (30 cm × 20 cm spacing 5 seedlings hill^{-1}) recorded better yield.

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Table 1. Effect of cultivars and planting variables on Yield attributes

Treatments	Yield attributes		
	Number of effective tillers m^{-2}	Number of filled grains $panicle^{-1}$	Test weight (g)
Cultivars			
V_1 (Sabita)	248.68	149.40	24.56
V_2 (Bhagirathi)	234.10	92.78	21.33
V_3 (CN-1231-11-7)	245.84	100.33	22.57
V_4 (Jaya cross)	227.85	96.23	20.50
V_5 (CN-1039-9)	266.25	160.38	23.14
S. Em (±)	1.05	1.15	0.20
C.D. at 5%	5.43	3.76	0.65
Planting variables			
S_1 (20 cm × 15 cm with 5 $hill^{-1}$)	252.63	115.25	21.94
S_2 (20 cm × 15 cm with 3 $hill^{-1}$)	249.80	117.23	22.26
S_3 (30 cm × 20 cm with 5 $hill^{-1}$)	228.24	121.74	22.53
S_4 (30 cm × 20 cm with 3 $hill^{-1}$)	225.85	126.00	22.86
S. Em (±)	1.16	0.90	0.40
C.D. at 5%	3.35	2.60	1.16

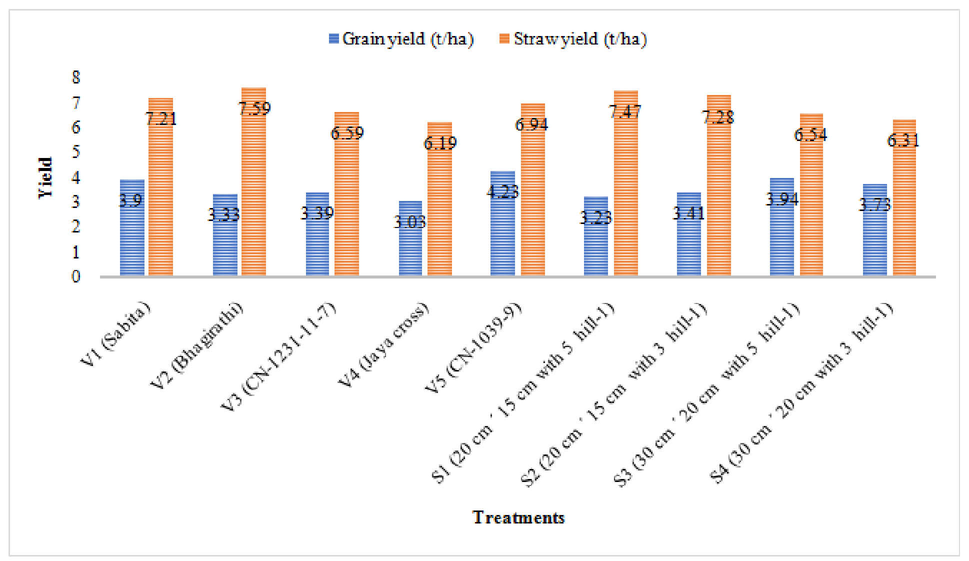

Figure 1 Effect of cultivars and planting variables on grain yield, straw yield grain straw ratio and harvest index of deep-water rice cultivars

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REVIEW ARTICLE

Role of Information and Communication Technology (ICT) in Agriculture: A Review

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ABSTRACT

Information technology is a compilation of technological tools as well as resources that are used to transmit, disseminate, deposit, and for the management of data. Computers, the internet, networking hardware and software, broadcasting technologies (radio and television), satellites and telephones are all exemplar of information technology. This emphasizes the current initiatives towards the enhancement of information technology in agriculture and various apps that works based on this technology. The paper also highlights the key advantages of Precision Agriculture and its components. The usage of the internet and cellphones is steadily increasing with each passing day. The future of farming in both the developed and developing worlds is cloud-based services for big data analytics in agriculture and data sharing applications with links to integrated platforms and models.

Keywords: Agriculture, Information and Communication Technology (ICT), Internet of Things (IoT), Precision Agriculture, Agriculture UAVs

INTRODUCTION

ICT is the combination of technology and procedures used to disseminate and transmit desired information to a target audience while also making them more interactive, the broad application of information technology to boost agricultural output. Satellite technologies, geographic information systems, and agronomy and soil science approaches are being used to boost agricultural productivity (Kashem *et al*., 2013). In 2009, Byerlee and Sadoulet accredited the potency of agriculture in a country's economic success. Despite several attempts, the production and productivity of crops of emerging nations have dropped in recent decades (Maitra, 2018). One of the disadvantages of decreasing yield in developing nations after 1970 is farmers' inexperience of contemporary and sophisticated agricultural practices. The momentum of digital technology in the remodeling of agricultural practices has been determined by various studies (Anderson and Feder, 2007; Maitra and Pine, 2020). Generally agricultural infrastructure and man power were believed to be as the important factors for agricultural improvement. But the most important reason which provides growth and expansion is "Information" using modern technology. Information Technology (IT) can help by providing continuous flow of information to the farm sector for improvement in manufacturing and extension services (Singh *et al.*, 2014; Bhattacharyay *et al*., 2020a). Indian government accentuate on "Digital India" programme. Out of the 17 SDGs suggested by UNDP, rice-based cropping system with resource conservation technologies has potential to fulfill SDG 2 and 3 (FAO, 2021). The major goal is to give individuals electronic access to various government and income-related services. The digital India programme ensures that 2,50,000 Indian villages will be connected to broadband and universal phone connectivity. During 1980 the government of India under the supervision of Prime Minister Rajiv Gandhi began to adopt information concept (Pandey, 2017).

Classification of IT

Farmers need relevant and new information collected through research and innovation to deal with harsh weather and illnesses, even if they have a good understanding of room conditions and substantial practical experience or competence of using the environment to get the most out of it(Correa *et al.,*1997). Thus the media plays a significant role in spreading of information related to agriculture. With the help of mass media messages can be broadcasted simultaneously to a large number of populations in a given period of time. To make this possible, mass media can make use of printing press, radio transmission, movies, exhibitions and audio visuals. The importance of mass media in intensification of agricultural productivity with time has been recognized in the last few years. The information technology is classified into two types [Figure 1].

Traditional ITs

Radio, television, and print media are all part of it. Different nations can gain from television and radio in aspects of informal education based on their educational needs. Television is the most essential medium for communicating with the rural population in developing countries (FAO, 2001). Carpenter in 1983 stated that the combination of audio visual can change the human behavior and improve the learning skills of farmers. It possesses the capability to spread information to a large number of audiences and highly distinct geographical area where there is no possibility of personal contact (Calvert, 1990). Another important and effective tool for mass media is Radio. After independence initial experiments of ICT in agriculture began with Radio. All India Radio (AIR) stations helped in the broadcasting of programmes in local languages that were established post-independence. Following the adoption of mass media, a growth in educational system knowledge and production has been noted in recent decades. Aside from it, print media also plays an important role in agriculture production. Print media uses picture and diagrams to grant detailed information for the mass scale. Farmers can use the printed media articles for a longer time and repeatedly. Print media becomes more effective when the contents are customized based upon the target audience. Attention and popularity is acquired by the print media when it solves and talks about the problems faced by agriculturists and come up with a practicable solution. Extension workers along with the media channels can use the printed media to strengthen the farmers learning process. Printed media is considered to be a permanent message in agriculture extension (Oakley and Garforth, 1985). Regardless of how the illiteracy is a major problem with print media so only educated or literate farmers are benefited with such kind of information.

New or Modern ITs

It comprises of internet, portals, mobiles, community radio, video, digital photography and call centers. With the introduction of internet services and more frequently utilized communication medium such as rural audio, the information and communication resources available to rural people would be enhanced. Employees of countryside radio stations in every section of the region or country can benefit from regional and national marketplace information systems or extension information systems available on the internet. Farmers can use information on current market prices aired by rural radio stations to negotiate better prices from local purchasers, which includes both national variation and international figures. Except for this, online buying and selling began to be admired in the world. However, communication continues to make a significant contribution, and the internet has equipped us to do so. Some ICT initiatives taken by various government and private organizations are ITC-E-choupal, Kisankerela, aaqua Rice Knowledge management portal, e-krishi, Mahindra kisanmitra, IIFCO Agri-portal, Village Knowledge centers (VKCs)-ISRO etc (Nehra *et al*., 2018).

Internet of Things (IoT)

The phrase "Internet of Things" (IoT) was coined in 1999 by a British futurist named Kevin Ashton. The Internet of Things paradigm will create a technological universe in which many physical objects or "Things," such as sensors, everyday tools, and materials enhanced by computing power and networking capabilities, will be able to take part, either as individual units or as a networked collaborating group of embedded systems, as the phrase "Internet of Things" suggests. Agriculture has become one of the areas that IoT improvements are expected to have a significant impact on. According to the United Nations' Food and Agricultural Organization (FAO), the global population will reach 8 billion by 2025 and 9.6 billion by 2050. (FAO, 2009). This effectively means that global food production must increase by 70% by 2050. The rapid growth of the world population, as well as the growing demand for high-quality goods, necessitate the modernization and improvement of agricultural operations. Precision agriculture is one of the most promising technologies, with the potential to make a large contribution to the needed increase in food production while remaining sustainable. Precision agriculture focuses on optimizing and improving agricultural processes for maximum productivity, and it necessitates quick, reliable, decentralized measurements in order to provide growers with a more detailed picture of the current situation in their cultivation area and to coordinate automated machinery in a very way that energy, water, and pesticide use are reduced (Zhang *et al*., 2002). After collecting data from a variety of different systems, well-evaluated scientific knowledge can be presented in the form of smart algorithms to improve understanding of ongoing processes, perform current situation reasoning and predict outcomes based on diversified inputs, generate timely alerts about potential cultivar dangers, and improve automated control signals based on plant responses. The algorithms necessary to deal with remote data in real time are just too complex to perform on a low-power Wireless Sensor Network (WSN) node locally. However, because all of the objects in the IoT will be connected, the computational overhead may be easily moved to the cloud or distributed among multiple networked devices (Tzounis *et al*., 2017).

The following are the main benefits of adopting IoT to improve farming:

1. Improving water management.
2. Land is being continuously monitored so that early-stage safeguards can be done.
3. Agriculture becomes more productive as time is saved, labour costs are decreased, and productivity is increased.
4. Crop monitoring is simple.
5. The farmer can quickly determine the moisture content and pH level of the soil, and seeds can be shown accordingly.
6. Plant and crop diseases can be identified with the use of sensors and RFID chips. The reader receives the EPC (information) from RFID tags, which is then transferred over the internet. A farmer or scientist can receive this information remotely and take necessary action to protect crops from disease outbreaks (Arunlal and Rajkiran, 2018).
7. Crop sales in the global market will increase. Farmers may connect directly to the global market no matter where they are in the world.

IoT Agriculture Apps

Agricultural IoT apps monitor sensor data and prepare it for predictive analytics. Here are a few IoT farm apps that are leading the way in the green revolution's second wave:

Phenonet Project (Open IoT)-Phenonet is an Internet of Things network of wireless sensor nodes that collect data from an area of experimental crops. Phenomics is the study of how an organism's genetic makeup influences its appearance, function, growth, and performance. Plant phenomics is a multidisciplinary method that investigates the relationship between cells, leaves, and the entire plant, as well as the relationship between crop and canopy. The Phenonet's purpose is to provide a platform for enhanced crop analysis in real-world growing circumstances for scientists and farmers. Analyzing the size, development, and performance of plants in a greenhouse or on the farm may be time-consuming and tedious. More specifically, when a field site is located in a remote location, sending workers out to the field becomes prohibitively expensive. For plant scientists and farmers, the capacity to collect data from faraway sites and transmit it back to the lab in real time is a priceless tool (Jayaraman *et al*., 2015).

CLAAS Equipment- CLAAS is a world leader in agricultural engineering tools, producing equipment that runs on autopilot and gives recommendations on how to increase crop flow and reduce losses. Farmers can tailor the programme to their own needs or let it optimize the equipment for them automatically. The major goal of Claas' Telematics system is to boost overall fleet productivity. This is performed by using a time analysis to optimize the process performance, adjusting the parameters of the equipment used, capturing, collecting, and analyzing data, increasing machine operational dependability, and enhancing maintenance work planning. The location of the machines is determined using GPS satellites, and over 200 distinct characteristics such as GPS coordinates, time and nature of the work performed, and technical indicators of the machines are relayed to the unified server at regular intervals via mobile communications (Goltyapin and Golubev, 2020).

Precision Hawk's Eye UAV Sensor Platform- Precision Hawk has developed an unmanned aerial vehicle (UAV) that can undertake a variety of land-related jobs that were previously performed by humans. This entails land surveying, imaging, and mapping (Puri *et al.,* 2017).

Precision Agriculture

"Precision agriculture is a management technique that uses information technology to gather useable data from a variety of sources in order to aid crop production choices" (Shankar *et al*., 2020). The geographical and temporal variability of each agricultural unit must be identified, verified, quantified, and recorded. In this way, tailored agronomic management for each unique location in this manner is provided. PA dates back to the early 1980s and is defined by its ability to effectively use resources, reduce wasteful financial investments and environmental damage, and reap economic, social, and environmental benefits (Salcedo *et al*., 2011).Precision agriculture comprise any agricultural strategies that employ information technology to alter supply usage in order to achieve the desired result, or to monitor the outcome. IT for PA includes things like variable rate technology, yield tracking, and various sorts of sensors. PA's solutions consist of both hardware and software components that interpret the data acquired by the sensors and give critical information for decision-making (Cisternas *et al*., 2020). The decrease in the usage of water, fertilizers, herbicides, and pesticides, as also the needed personnel, are among of the most important advantages of PA. Rather to managing the entire field based on hypothetical average circumstances that may or may not be accurate, a PA strategy identifies the unique characteristics of the lands and changes the needed management activities accordingly. PA has the ability to make data collection and analysis more automated and simple. It even enables speedy decision-making and execution of management activities for tiny sections in large fields (Mutale and Xianbao, 2021).

Remote Sensing

Remote sensing is the science and art of obtaining data about real-world objects or regions at a distance without physically touching them. Remote sensing is a method of monitoring the earth's resources that combines satellite technology with terrestrial observations for greater precision and accuracy. Remote sensing distinguishes plants, bare soil, water, and other comparable characteristics by utilizing the electromagnetic spectrum (visible, infrared, and microwaves) for assessing the earth's properties. They can be used to distinguish between plants, bare soil, water, and other similar phenomena because the usual responses of the targets to various wavelength regions change. It can be used for crop growth monitoring, land use pattern and land cover changes, water resources mapping and water status in field conditions, disease and pest infestation monitoring, harvest date forecasting and estimation of yield, precision farming, and weather forecasting purposes, as well as field observations (Shanmugapriya *et al*., 2019). There are two forms of remote sensing:

Passive remote sensing- Electromagnetic radiation reflected (blue, green, red, and near-infrared light) or emitted (thermal infrared radiation) from the Earth's surface is recorded by passive remote sensing devices.

Active remote sensing- Active remote sensing systems are not reliant on the Sun's electromagnetic radiation (EMR) or the Earth's thermal characteristics. Active remote sensors generate their own electromagnetic energy, which is:

- Delivered from the sensor toward the landscape
- Interacted with the environment, resulting in energy backscatter
- Recorded by the remote sensor's receiver (Guo *et al*., 2020).

Application of Remote Sensing in Agriculture

- Recognition of the Crop.
- Estimation of crop acreage.
- Crop health analysis and stress detection.
- Dates for planting and harvesting are planned ahead of time.
- Modeling and estimate of crop yields.
- Detection of pests and disease outbreaks.
- Estimation of soil moisture.
- Irrigation management and monitoring.
- Soil mapping through remotely sensed images.
- Droughts are being monitored.
- Mapping of land cover and degradation
- Identification of Problematic soil.

Drones and the Indian Agriculture Industry

India is primarily an agricultural country, with agriculture employing more than half of the people. The rise in population leads to an increase in agricultural output and protection. Insects have a tendency to harm crops, lowering yield, and are thus eliminated with pesticides. Agricultural fields sometimes suffer devastating losses owing to crop disease. Quad copters might therefore be utilized for automatic fertilizer spraying and agricultural surveillance, as well as other uses including search and rescue, Hazmat, police, code inspections, Emergency Management, and firefighting. Quad rotors offer quick mobility, increased payload, great lifting force, and stability. Quad copters are easier to fly than other aircraft. Quad copters are employed in high-risk situations as well as indoor and outdoor environments. It has a universal sprayer that can be used to spray liquid as well as solid objects. Although the stress pump is only used for pesticide spraying and not fertilizer spraying, the universal nozzle is used to spray pesticides and fertilizers. In wide regions, the GPS may be used to autonomously direct the quad copter and control it remotely (Bhattacharya *et al*., 2020b). The autopilot controller controls the quad copter, while the RF Transmitter and motors control the payload (Devi *et al*., 2020). Figure 3 depicts a diagram of crop monitoring using unmanned aerial vehicles (UAVs).

Agricultural Drone Applications Examples

Seedling Emergence Assessment

A popular agricultural use of images captured with sUAS is seedling emergence monitoring and mapping. If crop germination is sluggish or ineffective in some areas of the plot based on environmental factors, the producer generally has a small window of opportunity to replant following plant emergence. The field may be mapped at extremely high resolution in the early phases of crop growth to examine seedlings and identify zones where germination was failed (Sankaran *et al*., 2015). Some crops, such as wheat, have thin, wispy leaves that are difficult to distinguish from above during emergence, necessitating the use of spatial drones in agriculture have a resolution of 19 pixels, although other crops have bigger leaves that do not require the same precise resolution to map well. Prior to canopy coalescence, aerial imaging of the field should be done so that individual plants may be seen clearly in the imagery. While RGB photography may be used for emergence mapping, multispectral imaging allows for more flexibility when computing other vegetation indices that use a near-infrared spectral range. When spectrally distinguishing tiny leaves from the surrounding soil backdrop, vegetation indices frequently produce superior results (Merwe *et al*., 2020).

Weed Detection and Mapping

"Weed mapping is a commonly used application of remote sensing in agriculture and drones has an advantages in this application due to the high spatial resolution flexibility" (Roslim*et al*., 2021). In terms of how the aerial mapping phase is accomplished and how the data is processed, weed mapping is comparable to seedling emergence mapping. Multispectral imaging is typically the best solution for mapping weeds in an agricultural area. To guarantee that the weed's morphology and phenology, as well as how they differ from the crop species, the agronomist must work closely with the image analyst (Merwe *et al*., 2020). Some weeds are morphologically and spectrally similar to crop species, making differentiation difficult or impossible, while others are physically and spectrally different, allowing weed identification and categorization using aerial imagery (Singh *et al*., 2020).

Crop Damage Assessment

Crops currently in production Agriculture can be harmed in a number of ways, resulting in structural and spectral changes. Wind and hail may cause physical damage to the crops. Drone mapping can help locate and quantify agricultural damage caused by weather events, as well as a range of other factors such as insects and diseases. These changes can vary from a little change in the vegetation index to a full change in colour, such as when sorghum leaves are covered in sooty mould. Drones are being employed in studies to determine appropriate inspection intervals, which will be used in conjunction with current mapping assets such as satellites and manned planes. The improvement of this sensor ecosystem will facilitate early detection of pest infestations and disease propagation, as well as a reduction in their consequences, as a result of better-informed management efforts (Koparan*et al*., 2018).

Water Management

Water shortage is currently the most pressing issues of agriculture, and future demands on water supplies are likely to increase. Water management technologies that respond to changing water needs in near real time, as well as trustworthy data that indicates rising water shortages before they cause production loss, are required to protect crops from drought-related losses.To evaluate soil moisture loss in the soil profile, soil moisture sensors are generally put at a few specified points throughout the field. Irrigation system managers assessed water demands using data from soil moisture sensors, as well as prior knowledge of crop type, soil properties, and climatic factors such as temperature, precipitation, and humidity (Merwe *et al*., 2020).

Livestock Application

The use of drones in livestock production systems has grown significantly as a result of the increasing availability of low-cost consumer drones that are simple to operate and canprovide high-quality video and still images. With a few notable exceptions, such as the use of thermography, the use of drones in animal mustering, and the use of drones to track animals tagged with radio transmitters, the vast majority of livestock applications revolve around the simple observation of livestock and livestock production systems from the improved perspective of a drone, using visible light cameras to stream video directly to the operator or to generate aerial images, with visible light cameras to stream video directly to the operator or to generate aerial images (Merwe *et al*., 2020). Documenting animal numbers and whereabouts, pasture quality and indicators of degradation owing to causes such as woody plant invasion and erosion, feedlot fill status, and monitoring the supply status of bulk feeding items which including silage and hay bales are just a few of the responsibilities. Although most of these duties may be done from the ground, drones have the potential to considerably improve the efficiency of regular observations required in livestock production systems management (Thani*et al*., 2020). Because high body temperature is often associated with infectious disorders in cattle, body temperature monitoring is an important approach in the monitoring of livestock for the detecting infections in livestock. Local variations in blood flow patterns linked to inflammation can be applied to detect inflammatory lesions, and skin surface temperature can also be used to identify heat stress in cattle (Silva *et al*., 2020).

NarendraModi's government has launched Android apps for farmers (www.sarkariyojna.co.in)

Farmers may get the Android applications from the official website mkisan.gov.in or the Google Play store. The following is a list of all Android applications for farmers that NarendraModi's government has released.

KisanSuvidha

This app was created to assist farmers by providing information on current weather or forecasted weather for the next five days, market value, traders, agro counselling, plant safety, and IPM methods, among other things.

Agri Market

This smartphone app uses GPS technology to report crop market prices within a 50-kilometer radius. By turning off the GPS, you may get the market price of any other market.

Farm-o-pedia App

This software was created for rural Gujarat and is beneficial to agriculturists and anybody else interested in the agricultural industry. It contains useful information on crops according to soil and season, crop-specific information, meteorological data, and domestic animal management.

M Kisan Application

Agriculturists and stakeholders can use this Android app to access information from experts and government authorities. It is possible to use the portal without registering.

PusaKrishi

The PusaKrishi app assists farmers in learning about the cultural traditions and facts associated with various types of crops.

Crop Insurance Application

This programme can compute insurance premiums for notified crops depending on area, coverage amount, and loan amount in the case of loanee farmers. It also includes facts on the sum insured, premiums, and subsidy information for the recommended crop in the advised location.

ShetkariMasik Application

The software may be used to download ShetkariMasik magazine and read it without having to be connected to the internet. Since 1965, the Maharashtra Department of Agriculture has produced the "ShetkariMasik" magazine in the agricultural sector.

Other Android Applications developed for farmers in India

AgriApp

This app is developed by Criyagen, AgriApp communication and it can provide information related to crop, helps in videos and calls and to place orders. It is available in English, Hindi and Kannada.

Kisan Books

It provides E-books magazines and booklets for agriculture and this app was developed by Kisan forum Pvt. Ltd. It is available in English and Hindi and five different local languages of India.

KisanYojna

It gives information about various government schemes and it is developed by ANN India.

Water Reporter

It helps to track, discover and examine pollution issues that effects our ecosystem and human health through user-initiated monitoring programs.

AgriSmart

It is developed by Punjab Agricultural Department and it focus on effective agriculture developments and pest warnings.

myRML

It is available in 18 states of India in 9 different languages and aims at agriculture advisory, information related to market price, various government schemes, weather forecasting and unit converter.

Digital Mandi

Devoloped by Appkiddo, it provides information about Indian agricultural commodity and market price list, it is available in 15 states of India.

Fertilizer Calculator

Helps in estimating and calculating the fertilizer requirement of various crops by the correct input by farmers. This app was developed by Dr. VishwanathKoti.

Future Perspectives

The current research goal is to find areas where information technology development can be used to boost the effectiveness of these services and technologies, as well as to develop cost-effective information technology-based systems that improve the living standards and agricultural production of the rural population. The art of communication, in the form of ICT, has a great untapped potential that has to be fully developed and disseminated in order to tackle a slew of challenges affecting Indian agriculture in the modern day. The Indian agriculture industry has a bright future thanks to ICT and the different applications that are being developed.

CONCLUSION

The field of information and communication technology has seen enormous advancements in the recent decade. These advances aiming at fusing the ICT and agriculture sectors have a lot of potential to deliver some surprising and exciting outcomes. The new ICT-based distribution system appears to be the most potential addition to the current systems. ICT implementation in rural regions and agriculture cannot be accomplished by a single entity. As a result, sectors that have a significant impact on agriculture, such as fertilizers and food, should collaborate to begin and encourage the use of ICT in agriculture.The unique agro-ICT applications discussed in this study resulted from a greater understanding of the agricultural and associated technologies involved on the one hand, and current ICT breakthroughs on the other. There is little question that the agro-ICT method will continue to grow and expand at a rapid pace in the future, with new applications appearing.

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Figure1. Types of Information Technology (Nehra*et al.*, 2018)

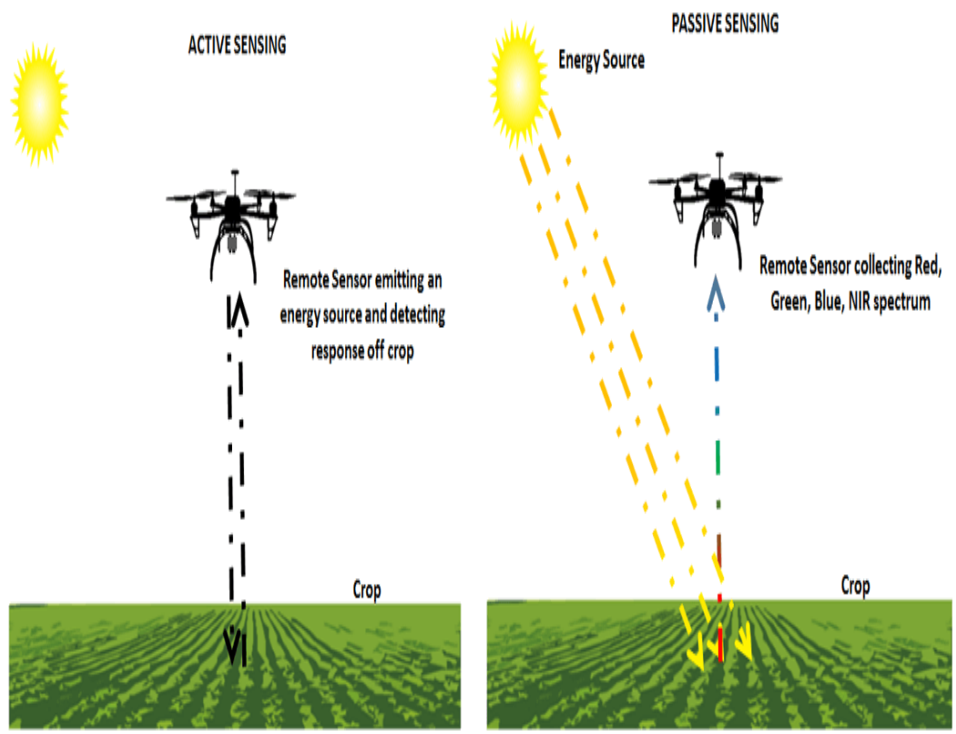

Figure 2. Types of Remote Sensing (Source- GeoBipod.com)

Figure 3. UAV-assisted crop monitoring

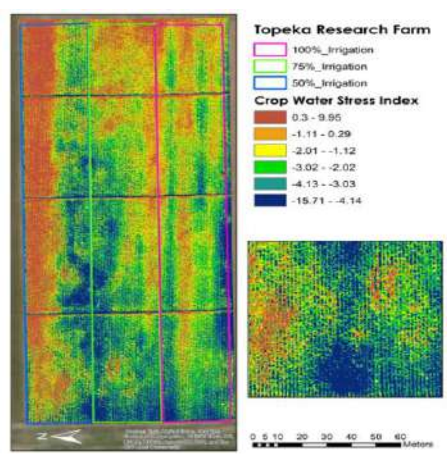

Figure 4. Environmental parameters and thermal infrared imagery of a corn field were used to build a map of crop water stress. Solid pink, green, and blue lines distinguish the three irrigation regimes (Sharda*et al.*, 2018).

REVIEW ARTICLE

Importance of Millets as Nutri-cereals for Nutrition Purpose in Present Scenario: A Review

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ABSTRACT

Millets are drought-resistant and able to survive a variety of environmental conditions. Small-seeded grains rich in proteins, minerals, and bioactive compounds, these grains have several health benefits as well as protection against chronic and degenerative conditions caused by modern living. Millets are popular as functional ingredients for developing novel food products of commercial significance due to their hyperglycaemic profile and bioactive composition. The coarse nature of millets makes them unpopular and underutilized in developed countries, despite their benefits and agro-economic potential. The present article reviews research investigations about nutritional composition (macro- and micro-nutrients) of millets.

Keywords: Millets, nutri cereals, nutritional properties

INTRODUCTION

Increasing population and water scarcity around the world, attracted interest of scientists in finding drought-tolerant crops having agrarian sustainability and nutritive composition. Earmarked funding and interest in research for increased production and valorisation of these crops are being increased in many parts of the world (Laik *et al*., 2021; Das *et al*., 2021; Saleh *et al*., 2013; Chandra *et al*., 2016). To fulfil food demand and enhance farmers' economic situation, sustainable crop choices is to berequired. Millets have been proposed to be a part of staple diet owing to their biological and techno-functional characteristics (Saleh *et al*., 2013). Interestingly, millet have been documented as the oldest cereals, ingested throughout the early phase of human civilization, as evidenced by the production of millet flour noodles around 4000 years ago in Northern China. (Lu *et al*., 2005). Millets are small seeded warm season cereal grains comprising of seven types as pearl millet (*Pennisetum glaucum*), foxtail millet (*Setaria italica*), finger millet (*Eleusine coracana*), proso millet (*Penicum miliaceum*), barnyard millet (*Echino chloautilis*), *kodo* millet (*Paspalum setaceum*) and little millet (*Panicum sumatrense*) that are a potential source of food, feed and fodder in different nations (Saleh *et al*., 2013; Shahidi and Chandrasekara, 2013). These crops hold agrarian importance due to their lower water demand for growth and other biological processes in comparison with other major cereal crops and adaptability in wide range of climatic conditions (Winch, 2006; Maitra *et al*., 2020). They have also been referred to as 'Cereals of the Future' owing to their sustainability and environmental impact (Sharma and Gujral, 2019). Millets are high in macro- and micronutrients, and their mineral profile and essential amino acid composition overtake the other important grains like wheat and rice (Mal *et al*., 2010; Singh *et al*., 2012; Maitra, 2020). Millets have been associated with a lower risk of many degenerative diseases due to high content of phytonutrients and biologically active components like dietary fibre, phenolic acids, flavonoids, and phytosterols. Millets also possess other health benefits including antioxidative, anti-ulcerative, hypoglycaemic and anti-inflammatory qualities as well as cholesterol-lowering potential (Banerjee and Maitra, 2020; Dey *et al*., 2021; Pramanick *et al*., 2018; Shobana and Malleshi, 2007; Schoenlechne *et al*., 2013; Sharma and Gujral, 2019).

Millet carbohydrates have a reduced starch digestibility, which helps to regulate blood glucose levels by slowing absorption (Chethan and Malleshi, 2007). Attributing to their phytochemical profile and contribution to human wellness, they are being explored for applications in the food industry as potential functional ingredients for gluten-free and low-glycaemic products (Sharma and Gujral, 2019; Ramya *et al*., 2020). Further, enhancement of consumption of millets also addresses some Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), and SDG 3 (good health and wellbeing)(UN, 2021).The aim of this article is to review on the compositional profile (nutritional and antinutritional qualities), bioactive composition and antioxidant activity, protein and starch digestibility, as well as functional features such as pasting, thermal, and rheological performance.

Nutritional composition

Carbohydrate

Carbohydrates are necessary for all living things in our environment to survive. Humans rely on them as their major source of energy. Millets have a carbohydrate content ranging from 50 to 88 percent, depending on the type, species, agro-climatic conditions, and crop management. They also have dietary fibre in the form of arabinoxylans, cellulose, hemicellulose, lignin, and b-glucan (Serna-Saldivar and Espinosa-Ramırez, 2019). Millet carbohydrates contain60-75% starch, 15-20% non-starchy polysaccharides and 2-3%free sugars (Chauhan *et al*., 2018). Millets' compositional profile in (Table 1) shows that among millet grains, pearl millet, *kodo* millet and finger millet contain a comparatively higher proportion of starch (Serna-Saldivar and Espinosa Ramırez, 2019). Patil (2016) reported that some varieties of finger millet, proso millet and foxtail millet are glutinous owing to their waxy starches. Millet starches have been characterised as pentagonal,polygonal, spherical and round granules of diverse sizes with certain pores at the surface (Annor*et al*., 2014; Zhu, 2014). When compared to other millets, barnyard millet contains the greatest percentage of crude fibre and dietary fibre, with 6.1-10.5 percent insoluble and 3.5-4.6 percent soluble dietary fibres (Veena*et al*., 2005). The total dietary fibre content of foxtail, proso and *kodo* millets is also high when compared to other cereals. Insoluble dietary fibre components in millet grains include lignin and cellulose, whereas soluble fibre comprise glucoarabinoxylans, beta-glucans, and some hemicellulose, depending on branching and cross-linking. The most significant portion of dietary fibre is an insoluble part which induces antioxidant activity due to the presence of certain polyphenolic compounds, helping in prevention against certain degenerative diseases such as gastrointestinal disorders, cancers and neurological difficulties (Kaur *et al*., 2014). Higher amount of dietary fibre causes considerable decrease in the gut transit time generate short-chain fatty acids due to colonic fermentation and slow down the release of sugars in the blood (Kaur *et al*., 2014). Studies have indicated that pearl millet has highest concentration of soluble sugars followed by finger millet and foxtail millet (Chauhan *et al*., 2018). Furthermore, foxtail millet,pearl millet, and finger millet have been reported to comprise minor fractions of fructose as well (Serna-Saldivar and Espinosa-Ramırez, 2019).

Protein composition and their fractionation in millets

The protein content of millets presents is varied between the species and varieties due to agro-geographical and genetic variability factors. Comparatively, little and proso millet have higher quantity of protein than high protein cereal grain species ranging between 10% and 15%; however, protein content is also significantly affected by agronomic conditions and practices including content and application method and time of nitrogen, and growth environment. Millets are excellent options for developing value-added food items for malnourished and targeted groups due to their high protein content. Although the quantity of protein holds high significance, Although the quantity of protein is important, the amount of amino acid content of the protein determines the grain's quality potential. Most cereals are low in lysine, although millets, finger millet, and *kodo* millet have 2.2-5.5 g lysine/100 g protein, and pearl millet can have as much as 6.5 g lysine/100 g protein (Bean *et al*., 2019). Taylor and Taylor (2017) confirmed that the presence of albumin, glutelin, or globulin fractions that are rich in lysine verified the high lysine content of pearl millet and finger millet. High germ-to-endosperm ratio in pearl millet may also contribute to high lysine. A higher concentration of prolamin in foxtail and proso millet has been suggested responsible for lower lysine content, but they are higher in leucine. Albumin and globulin composition of millet proteins have better amino acid composition and protein quality when compared to other cereals.

Lipid composition and distribution

Table 1 shows that lipids are found in comparatively lesser amounts in all millet species. Millet's lower lipid content contributes to its longer shelf life since the majority of the fat in millets is found in the germ section, which is removed during decortication (Shobana *et al*., 2013). The fat content of millets ranges between 1-6%, and certain varieties may have higher proportions which may also sometimes compromise their shelf stability. Slama *et al.* (2019) reported 5.06 percent total lipid content in pearl millet, with mono- and polyunsaturated fat accounting for 77.22 percent of the oil. They further reported that the extracted oil was high in linoleic acid (47.5%) but low in linolenic acid (2.15 percent). Other millets also have comparable concentration range of linoleic acid (41–71%) and linolenic acid (1.1–4.1%). Millets have a low palmitoleic acid concentration (less than 1%) (Serna-Saldivar and spinosa-Ramırez, 2019). The lone exception is finger millet, which has oleic acid as the main fatty acid, accounting for 47.5 percent of total lipids, followed by palmitic and linoleic acid. (Bora *et al.*, 2019). Serna-Saldivar and Espinosa-Ramırez (2019) further documented that the nonpolar lipid fraction accounts for about 80% of the total fat in millets, with triacylglycerols accounting for more than 80% of this. They further revealed that polar lipids in pearl millet comprise phospholipids (~12%) followed by glycolipids (~3%) including phosphatidylglycerol, acyl-mono-galactosyldiacylglycerol, cerebroside, sterol glycoside,lysophosphatidylcholine, phosphatidylcholine and others.

Mineral profile

Mineral deficiency is concerning since it has a significant influence on metabolic processes and tissue structure, potentially leading to severe and chronic illnesses (Soetan *et al*., 2010). Although mineral profile of each crop is heavily influenced by soil fertility, climatic circumstances, agronomic techniques, environmental and geographical limits, potassium and phosphorus are the most prevalent minerals in all millets. Calcium, sodium, and magnesium are some of the other key minerals found in millets (Vali Pasha *et al*., 2018). As shown in Table 2, millets are rich in macro minerals, *viz.*, Ca, P, K, Na, and Mg and constitute good amounts of trace minerals,*viz.*, iron, copper, zinc and manganese. Among the millets, finger millet is the rich source of calcium and manganese while foxtail millet contains the highest amount of phosphorus. Barnyard millet contains the highest amount of potassium, sodium and magnesium compared to other millets. *Kodo* millet is rich in trace minerals including iron and copper than the other millets. Calcium and sodium content are almost similar in all the millets ranging between 0.1 and 0.7 g/kg. Zinc is highest in little millet followed by proso, barnyard, finger and foxtail millet. Gilani *et al*. (2005) reported that polyphenols found in cereals and legumes have been shown to bind positively charged molecules such as calcium, iron, and zinc, affecting their bioavailability and intestine absorption. Saldivar (2016) stated that most of the phosphorus is in the form of phytate/phytic acid (phosphate group) decreases bioavailability due to presence of polyphenols. Milling of millets reduces the concentration of minerals in the flour; however, their availability can be enhanced by the elimination of antinutrients (Oghbaei and Prakash, 2016). Phytic acid content is reduced by several processing treatments such as germination, fermentation, soaking and enzymatic treatment (phytase) which release the chelated minerals and increase their intestinal absorption (Gupta *et al.,* 2015; Rasane *et al*., 2015). Several nutritional interventions including bio fortification and enrichment have been implemented to deal with mineral deficiency, and millets have the potential to deliver a sufficient amount of nutrients to overcome malnutrition Vinoth & Ravindhran, 2017.

Vitamins profile

Millets are an important dietary source of vitamin B complex except for B_{12}, which is mostly found in yeast and animal products. Most of the vitamins are concentrated in the bran, pericarp and aleurone layer of millets (Saldivar, 2016). Millets have a thiamin and riboflavin level of 0.25-0.57 mg/100 g and 0.05-0.23 mg/100 g, respectively. Asharani *et al.* (2010) also reported that tocopherols and tocotrienols are also present in minor fractions. The total tocopherol content in minor millets ranged from 1.2 to 4.1 mg/100 g, with finger millet (3.6 mg/100 g) having the greatest concentration. The presence of carotenes has also been reported in pearl millet flour with a concentration of 5.4 mg/kg (Kumar et al., 2021; Dey et al., 2021; McDonough *et al*., 2000).

CONCLUSION

Grains with specific nutrients are required to deal with micronutrient deficiency and disorders arising out of malnutrition. Millets have been part of human diet since thousands of years and still serve as important cereal grains owing to excellent tolerance to climatic challenges. This article reviews research reports up to date evaluating the compositional profile. Millets are truly superior to other cereals in terms of nutrient, health benefits and phytochemical composition due to high content of phenolic compounds, fibre, flavonoids and phytosterols. These dietary constituents benefit the host health *via* prebiotic properties, antioxidative mechanisms, anti-inflammatory actions and hypoglycaemic profiles. Although they are underutilised in certain parts of the globe, but not underestimated as significant efforts are being done for the valorisation of millets to enhance their functionality and utilisation in products of commercial importance.

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Table 1:Compositional profile of whole grain millets

Millets	Carbohydrate (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)
Pearl millet	63.0–78.0	8.6–19.4	1.5–6.5	2.7–3.6	1.4–11.0
Finger millet	85.0–88.0	7.7–10.9	1.3–1.4	2.9–3.3	3.7–3.9
Foxtail millet	60.9–75.2	11.3–12.9	3.6–3.9	3.0–3.2	4.5–8.0
Little millet	69.7–78.5	10.2–13.4	3.7–4.1	3.0–3.4	4.0–8.0
Kodo millet	66.0–72.0	6.2–13.1	3.2–4.9	3.0–4.1	8.4–11.0
Barnyard millet	51.5–65.0	11.2–12.7	2.5–6.3	4.7–5.0	13.9–14.7
Proso millet	65.82–78.59	10.65–14.7	1.54–3.77	2.0–4.0	2.0–9.0

Sources: Chauhan *et al*., 2018; Shen *et al.,* 2018; Vali Pasha *et al*., 2018; Embashu and Nantanga, 2019; Jayawardana *et al*., 2019; Nithiyanantham *et al.,* 2019; Serna-Saldivar and Espinosa-Ramırez, 2019

Table 2: Mineral composition of millets

Millets	Major minerals (g/kg)					Trace minerals (mg/kg)			
	Ca	P	K	Na	Mg	Fe	Cu	Zn	Mn
Pearl millet	0.29-0.42	2.40-3.72	3.90-4.42	0.10-0.12	1.30-1.37	50-110	6-10.6	29-31	11.5-18
Finger millet	0.90-3.44	2.83-5.84	4.08-11.23	0.11-0.68	1.37-3.74	377-695	4.7-13	23-93	54.9-165
Foxtail millet	0.19-0.31	2.90-7.15	3.64-9.23	0.02-0.62	1.43-3.02	208-386	5.9-15	35-84	11.6-39
Little millet	0.17-0.24	2.20-6.98	1.26-5.04	0.07-0.72	2.33-3.44	457-515	9.0-12	37-161	26-33
Kodo millet	0.22-0.35	1.80-4.73	1.41-6.40	0.61-0.65	2.10-3.01	1082-1413	17-20	59-76	47-89
Barnyard millet	0.20-0.22	2.80-6.17	7.34-7.92	0.68-0.69	2.40-3.08	301-381	10-11	60-103	36-42
Proso millet	0.15-0.22	2.06-5.54	1.95-5.32	0.57-0.60	1.97-2.97	423-550	14-18	74-91	21-45

REVIEW ARTICLE

Chemical Management of Weeds in Wheat (*Triticum aestivum* L.): A Review

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ABSTRACT

Weed is a problem since the starting of agriculture. Wheat is a major crop of India in the past as well as at present. Hand weeding was a major weed controlling technique followed by the growers before the commencement of herbicidal research in our country in 1948 with 2,4-D. During the last 30 years, researchers have done many experiments and field trials on different herbicides, evolved new commercial herbicide formulations and conveyed to the farmers with the help of various procedures by which growers got some benefit. In spite of that, weeds are still a considerable issue as they are dynamic in nature. Therefore, consistent effort is essential to look after the ever-shifting weeds in different ecosystems and form proper herbicides for different crops under changing ecosystems. In this review, the research works carried out till date on the chemicals for controlling weeds in wheat have been tried to accumulate for planning of future research on herbicides for wheat for continuously keeping the crop-weed balance.

Keywords: Herbicide, weed, wheat

INTRODUCTION

Weed is a considerable hazard in crop cultivation. But it remains underrated in agriculture. Weeds are responsible for higher decrement in economic return from crops than any other pest, insect attack and even disease problem. Yaduraju (2006) reported that weeds roughly responsible for the annual loss of 37% of the total loss of agricultural produce in a year in our country. After analyzing 10 years data (1978-88), Sahoo and Saraswat (1988) reported that the losses in annual crop yield in line of 9.3 MT in cereal crops, 0.8 MT in pulse crops, 0.6 MT in oilseed crops and 7.2

MT in fibre crops valued at Rs. 2799 crores occurring in our country. Wheat is the most valuable cereal after rice in India occupying about 29 million hectare area and contributing 37% to the total national food grain production. Wheat is a major cereal crop covering 17% of the world's cultivated area which jointly contributes 35% of the major food as well as 20% of the calories (Chhokar *et al*., 2006).

Different weed flora associated with wheat

Wheat field is generally infested from grasses such as *Phalaris minor, Avena fatua, Cynodon dactylon, Digitaria sanguinalis etc.*, sedges like *Cyprus rotundus, Cyprus esculantusetc.* and broad leaf weeds like *Chenopodium album, Physalis minima, Polygonum hydropiper, Polygonum arviculer, Pnephalium indicum, Alternanthera alternata, Centela asiatica etc.*(Prasad, 2012). *Chenopodium album*, *Convolvulus arvensis*, *Thlaspi arvense*, *Polygonum spp. Setaria viridis* and *Avena fatua* appeared in conservation agriculture system before in conventional tillage system. But emergence of *Sinapis arvensis* and *Amaranthus retroflexus* was much sooner in the conventional tilled condition as reported by Bullied *et al.* (2003).

Dominant weed flora in wheat

Tewari (1990) reported that *Chenopodium spp.* had greater intensity (38%) among dicot weeds and *Phalaris minor* and *Cyperus roundus* were higher under monocot with an intensity of 10.5%and 7.14%, respectively in wheat. Gogoi *et al*. (1993) found that *Cynodon dactylon*, *Chenopodium album*, *Eleusine indica* and *Ageratum conyzoides* were dominant weeds in wheat on sandy-loam soil at Jorhat (Assam). Singh *et al.* (1995a) reported the prevalence of grasses (*Avena ludoviciana and Phalaris minor*) in the eastern part of Haryana under moisture retentive soils while in the western parts, there was a preponderance of *Medicago denticulate, Asphodelus tenuifolius, Fumaria purvijlora, Rumex maritimus, Trigonella polycerata, Cirsium arvense, Melilotus indica, Chenopodium album* and *Convolvulus arvensis* where the soils were light and moisture was less. Singh and his co-workers (2005) reported that the plots of wheat crop was ruled by *Phalaris minor* and some dicot weeds like *Anagallis arvensis, Melilotus indica, Medicago denticulate* and *Rumex dentatis* in Karnal. *Phalaris minor* was also problematic weed of wheat preceded by paddy in the north-western part of India (Singh *et al*., 2015). Mishra and his co-workers (2005) reported from Jabalpur about the weed infestation in wheat field where *Chenopodium album* (88.6%) and *Physalis minima* (8.5%) were mentioned as the major weed species.

Critical crop-weed competition in wheat

Singh and Malik (1992) observed that the first one third of crop duration is critical for crop-weed competition in wheat whereas Gogoi *et al.* (1993) revealed that the most critical time of competition between weed species and wheat crop was 30-45 days after sowing (DAS).

Effect of weed infestation in wheat

Cereal crops like wheat requires well furnish of major nutrients such as nitrogen (N) for desirable growth (Mandal *et al*., 1992) and productivity(Krylov and Pavlov, 1989) which is uptaken mostly by weeds in their presence. Shahi (1978) estimated a depletion of 32 kg/ha of mineralizable N each year through *Chenopodium album* alone in dryland conditions. Physically mimic weeds are more competitive than physically different weeds. They may deplete 30 to 60% of the applied nutrients depending upon the intensity (Walia and Gill, 1985). Weeds also compete greatly with crop for moisture and light. Shahi (1978) calculated the transpirational use and evaporational use of water together for *Chenopodium album* as 550 mm against 479 mm in wheat production. Light is required by plant leaves for photosynthesis. In a weedy crop, weeds will deduct the light penetration towards crop, hence, reducing its photosynthetic efficiency. So, when weeds cover the crop, availability of light becomes limiting factor (Walia, 2003). Therefore, weed control is highly necessary for successful crop production. For every 1.0% increase in grain yield, weed infestation should be eliminated to the extent of 2.0% in wheat as delineated by Reddy and Reddy (2012). Herbicides have proved very effective against weeds but their associated effects such as development of resistant biotypes, predominance of perennial weed species, weed flora shift, residue problems and pollution to the environment have necessitated the development of alternate means of weed management such as integrated weed management (IWM), biological weed control *etc.*

Chemical weed management in wheat

Hand weeding gives best results regarding the enhancement of yield of wheat as suggested by (Prasad, 2012). Hand weeding treatment had the maximum weed control efficiency along with superior yield performance in wheat as revealed by Mitra *et al.* (2019). But hand weeding always provides lower net return and benefit-cost ratio as observed previously under some major crop production by Soni *et al.* (2020) and Dutta and Mondal (2021).

According to Walia et *al.* (1978), 2,4-D is ineffective herbicide against grassy weeds. Singh and Gautam (1992) while judging the efficacy of pendimethalin at two different levels *viz.*, 0.75 kg/ha and I kg/ha in wheat found significantly higher grain yield after application over weedy check. Pandey *et al.* (1996) concluded that pre-emergence spraying of pendimethalin in wheat was found highly effective against both grassy and non grassy weeds. After some years, Tomar*et al.* (1999) reported that pre-emergence spraying of pendimethalin at the rate of 1.0 kg/ha + hand-weeding once at 35 DAS of wheat was statistically *at par* with hand weeding twice at 20 DAS and 45 DAS, respectively in lowering weed dry weight and nutrients uptake over pendimethalin at the rate of 1.0 kg/ha alone as pre-emergence, 2,4-D Na at the rate of 1.0 kg/ha at 35 DAS and 2,4 D Na at the rate of 1.0 kg/ha at 35 DAS in combination with hand-weeding once at 20 DAS.

To control the broad-leaved weeds, application of 2,4-D Na and florasulam at 28 days after emergence (DAE) at the rate of 1 lit/ha and 0.06 lit/ha, respectively showed their efficacy through higher yield over untreated control treatment (Mohammed and Addisu, 2016). But 2,4-D also had less efficiency against hardy broad-leaved weeds like *Rumex retroflexus*, *Cirsium arvense*) and *Convolvulus arvensis* and some wheat varieties like HD-2009 (Arjun), WH-283, WH-416 and Sonak had developed malformed spike as a result of the application of 2,4-D, led to reduced productivity of wheat as per the earlier report of Panwar *et al.* (1993). Instead of 2,4-D Na, 2,4-D Ethyl Ester (EE) was applied at the rate of 0.9 kg/ha, 0.675 kg/ha and 0.45 kg/ha in wheat which showed no phyto toxicity at any of these rates and minimum weed dry weight *vis-à-vis* maximum grain yield was obtained with the spraying of 2,4-D EE at the rate of 0.9 kg/ha among all the herbicidal options (Kundu *et al.*, 2017).

A problematic weed species of wheat, *Phalaris minor* showed resistance against the herbicide isoproturon (Malik and Singh, 1994) due to its intensive use in wheat fields. Application of isoproturon at the rate of 1.0 kg/ha did not effectively control *Phalaris minor*. Balyan and Panwar (1997) and Kurchania and his co-workers(2000)revealed that metsulfuron methyl at the rate of 2 g/ha and 4 g/ha killed some broad-leaved weeds (*Chenopodium album, Melilotusindica, Melilotus alba, Anagalis arvensis, Vicia sativa Chicorium intybus* and *Lathyrus aphaca*) efficiently and provided statistically *at par* grain yield of weed free option. Spraying of metsulfuron-methyl at the rate of 4 g/ha for destroying weeds in wheat field was considered safe by Thakur *et al.* (2019). But metsulfuron methyl was also ineffective against *Phalaris minor* (Kurchania *et al.*, 2000). However, metribuzin controlled this problematic weed efficiently (Singh, 2001). Sharma and Pahuja (2001) observed that the highest decrement in weed density was in metribuzin applied plots at the rate of 200 and 400 g/ha which was followed by chlorsulfuron and metsulfuron methyl treated plots at the rate of 30 and 8 g/ha, respectively. They also found the lowest nutrient uptaken by weeds under metribuzin applied treatments among all the herbicidal treatments.

Alone application of carfentrazone ethyl at the rate of 20 g/ha at 35 DAS provided higher grain yield of wheat than carfentrazone ethyl at the rate of 10 g/ha at 35 DAS treatment (Punia *et al.*, 2018). But tank mix application of metsulfuron-methyl at the rate of 4 g/ha + carfentrazone-ethyl at the rate of 20 g/ha along with surfactant showed highest broad-leaved weed control efficiency and best herbicide efficiency index *vis-à-vis* maximum grain yield among all the herbicide applied treatments (Mitra *et al.*, 2019). A non-ionic surfactant (NIS) was needed to enhance the effectiveness of metsulfuron-methyl + carfentrazone-ethyl mixture. Ready mix of metsulfuron-methyl + carfentrazone-ethyl at the rate of 25 g/ha with 0.2% NIS decreased the intensity of weeds by 97-99%, provided 95% decrement of weed infestation, lowering their dry weight by 98-99%, enhancing the number of tillers by 26%, biological yield by 28% and economic yield by 31% over untreated check. Crop injury (5 to 15%) by the spraying of carfentrazone-ethyl + metsulfuron-methyl with 0.2% NIS or carfentrazone alone was temporary and showed zerodecrement in grain productivity of wheat crop (Singh *et al.*, 2011). Punia *et al*. (2006) and Punia *et al.* (2018)

reported no residual toxic effect of carfentrazone on the following crop. Infestation of *Chenopodium album, Melilotus indica, Anagallis arvensis Melilotus alba,* and *Rumex denatus*in wheat were nicely reduced byMetsulfuron-methyl + carfentrazone-ethyl (50g/ha + 0.2% surfactant) followed by metsulfuron-methyl + carfentrazone-ethyl at the rate of 25 and 30 g/ha + 0.2% surfactant.

Malik and his colleagues (2004) revealed that clodinafop propargyl at different rates failed to reducethe intensity of broad-leaved weed species. With increasing its application rate of upto 60 g/ha, the population and dry weight of grassy weeds were decreased gradually irrespective of application timing. Spraying of clodinafoppropargyl at the rate of 60 g/ha after first irrigation showed significantly more grain productivity than weedy check plots. (Shehzad *et al*., 2012) also found that clodinafop propargyl at the rate of 60 g/ha reduced the grasses in more efficient way in comparison with pyroxasulfone alone and in different combinations with clodinafop propargyl and pendimethalin. Clodinafop-propargyl should not mixed with 2,4-D Na as tank mixed because of their antagonistic effects (Yadav *et al.,* 2002c). Therefore, application of these weedicides is done in a sequence at certain interval.Application of an herbicide mixture (tank mix) of Clodinafop-propargyl at the rate of 60 g/ha + Carfentrazone-ethyl at the rate of 20 g/ha as post-emergence at 30 DAS to kill both grasses and broad-leaved weeds of wheat revealed not only higher productivity than tank mixture of pendimethalin at the rate of 1 kg/ha + Carfentrazone-ethyl at the rate of 20 g/ha as pre-emergence at 2 DAS (Oyeogbe *et al*., 2018) but also reduced the problem of application of one after another.

In conservation agriculture (CA), the various weed species present in the field must be destroyed before sowing of wheat seeds by applying the non-selective weedicides like paraquat, glyphosate and ammonium glufosinate (Singh *et al*., 2015; Zahan *et al*., 2021). Non-selective herbicides can also be applied after sowing of wheat but as pre-emergence for minimizing further weed emergence. Crop residues present in zero tilled fields can absorb 15 to 80% of the applied herbicides and reduce effectiveness of herbicides (Chauhan *et al.* 2012). Chemical weed management was more effective in the conventional tillage condition (80 to 96%) over the zero tillage condition (50 to 61%) as investigated by Chauhan and Opena (2012). Post-emergence application of herbicides should be done once the weed infestation become prominent under CA systems.

CONCLUSION

The conclusion can be drawn from this study is that an herbicide should be applied at recommended rate. Increasing or decreasing the application rate may show reduction in its workability or residual toxicity or development of resistant biotypes of weed species. Herbicide rotation may be a good option instead of using a single herbicide year after year to reduce the chance of developing resistance in the present weed population of a field. Chemical weed management along with hand weeding can give higher yield. But labour availability and cost involvement in weeding are some major problems associated with it. Farmers may go for ready mixture or tank mixture application of herbicides for getting better results regarding weed control and yield of wheat.

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Table 1. Some herbicide recommendations for wheat

Herbicide	Dose (g/ha)	Application time	Remarks
Clodinafop-propargyl	60 g/ha	25-40 DAS	Grassy weeds
Sulfosulfuron	25 g/ha	25-30 DAS	Grasses and broad-leaved weeds
Fenoxaprop-p-ethyl	100-120 g/ha		Grassy weeds
Mesosulfuron+Iodosulfuron (ready mix)	14.4 g/ha	30-35 DAS	Grassy weeds, broad-leaved weeds and sedges
Sulfosulfuron+Metsulfuron (ready mix)	32g/ha		
Pinoxaden	50 g/ha	25-30 DAS	Grassy weeds
Metsulfuron-methyl	4 g/ha	30-35 DAS	Broad-leaved weeds
Carfentrazone-ethyl	20 g/ha		

Ammonium glufosinate + Flumioxazin (tank mix)	2500 ml/ha + 125 ml/ha	Pre-plant application or 0-2 DAS	Grassy weeds, broad-leaved weeds and sedges
Trifluralin	1200 g/ha	Pre-plant incorporation (PPI) or 0-2 DAS	Grasses and broad-leaved weeds
Pendimethalin	1000-1250 g/ha	0-2 DAS	Grasses and some broad-leaved weeds
Isoproturon	1000 g/ha		
Oxadiazon	500-1000 g/ha		
2,4-D Na	500-750 g/ha	30-35 DAS	Broad-leaved weeds
2,4 D Ethyl Ester	900 g/ha		
Metribuzin	200-400 g/ha		Grasses and broad-leaved weeds

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RESEARCH ARTICLE

Impact of Precision Nitrogen Management on Growth and Productivity of *Rabi* Maize

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ABSTRACT

INTRODUCTION

India has developed its agriculture arena to new heights with incorporation of innovative and developed technologies. The focus on development of hybrids, improving seed qualities, awareness among farming communities and many other latest technologies has enabled agriculture in India to uplift its levels in achieving sustainability (Pramanick et al., 2020; Das et al., 2021; Lakshmi *et al., 2021*). Maize is widely cultivated in almost all states of the country representing its market demand and improved yield output (Manasa et al., 2018, 2019). Maize crop has spread its wings of cultivation from one continent to other due to its unique taste, quality, flavor and consumer demands. A Cereal like maize belongs to the Poaceae family and has versatile uses (Maitra et al., 2019). Maize crop justifies as the 'queen of cereals' and uses as food, fodder and industrial purposes. Nutritionally, maize is rich in carbohydrates (70%), protein (10%) and oils making it one of the nutrient rich crops among all cereals. The market demand for maize crop has been always high.

There are many cropping systems and technologies being implemented for maize and a lot of researches have also been carried out on the crop (Ghosh *et al*., 2021). The nutrient uptake by a maize plant is more in comparison to other cereals. Maize usually grows well when considerable amount of nitrogen(N) is applied because of its high nutrient exhausting nature (Asibi et al., 2020; Nduwimana et al., 2020; Cheptoek et *al., 2021*). Considering the low nutrient use efficiency of crop cultivation by conventional methods along with pollution of soil and environment, there is need for precision nutrient management (Bhattacharyay et al., 2020).Precision agriculture is one of the efficient and developed technologies which have a greater scope for advancements in agriculture in India. Precision agriculture technologies in large provides significant information for understanding the biophysical and biochemical properties of agricultural plants (Geng *et al.,* 2019). The precision N management involves measured and optimum N applications with the help of certain tools like SPAD meter and green seeker (Mohanty et al. 2017; Ghosh et al., 2020). The rapid enhancement of precise monitoring of agricultural growth and its health assessment is important for sensible use of farming resources and as well as in managing crop yields (Mohapatro *et al.,* 2019). Based on the above facts, the current experiment was conducted to study the impact of precision nitrogen management on growth and yield of maize.

MATERIALS AND METHODS

An experiment was carried out in the *rabi* season of 2020-21 at the Agricultural Research Farm of Centurion University of Technology and Management, Gajapati, Odisha (located at 23 39'N latitude and 87 42'E longitude and at an altitude of 145 meters above mean sea level). A mild wintery condition prevailed during the crop growth period with maximum and minimum temperature ranging from 24º to 36º C. The field preparation included two ploughings, harrowing and leveling to prepare a better and loose bed for good seed germination. The hybrid maize "Kavery" was selected for sowing due to its better adaptability to the local field conditions. The field was divided into a total 24 plots, each with a size of 7 m x 6 m. A total of 8 treatments (150% RDN, 125% RDN, 100% RDN, 75% RDN, 50% RDN, LCC and SPAD and control) were considered for the study with 3 replications. The recommended dosage of NPK for maize crop was considered to be 12:60:60 kg/ha, as recommended by the state agricultural board of Odisha. The spacing between two crop rows was maintained at 60 cm x 60 cm and the spacing between two plants was 25 cm x 25 cm. The statistical method followed was randomized block design (RBD). The doses of nitrogen (source: urea) fertilizer applications varied based on the treatments. The fertilizer urea was applied as per the readings of the precision tools used in the study, namely, LCC and SPAD. Different parameters of growth and yield were calculated from each and every treatment and standard statistical analysis was done with the obtained data from different treatment plots and replications. The plant height, dry matter, LAI, CGR were calculated at regular intervals of 30 days till harvest and finally the data was analyzed using statistical procedures and rules. The obtained output data were analyzed following the standard analysis procedure as described by Gomez and Gomez (1984). The significance of treatments was tested by F test. The standard error of the mean was computed in all cases. The difference in the treatment means was tested by using critical difference (CD) at 5% level of probability.

RESULT AND DISCUSSION

Growth parameters

The growth attributes of maize, namely plant height, leaf area Index (LAI) and dry mater accumulation (DMA) were recorded, statistically analyzed and represented in different figures. The growth parameters of maize were significantly influenced by different doses of nitrogen fertilizer applications and with the use of precision N management tools (Figure 1). The significance of utilization of LCC and SPAD meter was observed in this experiment on maize crop. The plant height during harvesting was highest (203.5 cm) in the treatment with 150% RDN and treatments receiving 125% RDN (197 cm), 100% RDN (189.9 cm), LCC based (189.9 cm) and SPAD meter-based (196.3 cm) also showed similar trend and outputs of plant height. This result resembled the effect of using precision tools in treatments T_7 and T_8 in comparison with treatments T_2, T_3 and T_4 respectively. The results are in conformity with the findings of Hammad *et al.* (2011), Matusso *et al.* (2014) and Naik *et al.* (2019) who noted the earlier similar type of effects of N management on maize crop. The Dry matter accumulation (DMA) was progressed in an increasing trend from 30 DAS till the harvesting stage (Figure 2). At the harvesting stage, the maximum DMA (1693.5 g/m^2) was obtained with the treatment receiving 150% RDN and the treatments receiving 125% RDN (1685.8 g/m^2), 100% RDN (1653.8 g/m^2), LCC based (1550.5 g/m^2) and SPAD meter-based application (1557.5 g/m^2). The result of DMA in maize crop was found to be nearly similar in treatments receiving the highest N application (T_2) and as well as in treatments (T_7, T_8) where precision tools were utilized for N application. These obtained results are similar to the previous research findings (Biradar *et al.*, 2012; Jat *et al.*, 2013).The leaf area index (LAI) of maize was also obtained in a similar pattern as noted in plant height and DMA, *i.e.*, the highest LAI was found in T_2 (5.5), T_3 (5.0), T_4 (5.0) as well as in LCC (4.8) and SPAD based treatments (5.4), respectively (Figure 3). The data revealed that the treatment receiving 150% RDN (T_2), 125% RDN (T_3), 100% RDN (T_4) produced the highest grain yield of 6.65 t/ha, 6.41 t/haand 6.34 t/ha, respectively. The precision N management treatments LCC-based N application (T_7) and SPAD meter meter-based N application (T_8) also produced a grain yield of 6.06 t ha^{-1} and 6.09 t ha^{-1} which was very similar with the treatments T_2, T_3 and T_4 receiving high amounts of N applications. The stover yield also showed the same trend as recorded with the grain yield output, emphasizing the advantageous effect of usage of precision tools for N application in maize. A similar observation was also obtained by scientists Biradar *et al.* (2012), Suri *et al.* (2012) and Selassie (2015) in their experiments carried previously on N management in maize crop.

CONCLUSION

Maize is a nitrogen demanding crop, but the efficiency of applied nitrogen is less. As the excess nitrogen application causes issues like pollution of soil and water, there is need for application of nitrogen in precise quantity to maize. The study clearly indicated that LCC and SPAD based application is good enough to obtain higher productivity of maize. Thus, the present research concludes that rabi maize cultivation in south Odisha conditions can be done by precision nitrogen management to obtain satisfactory growth and productivity.

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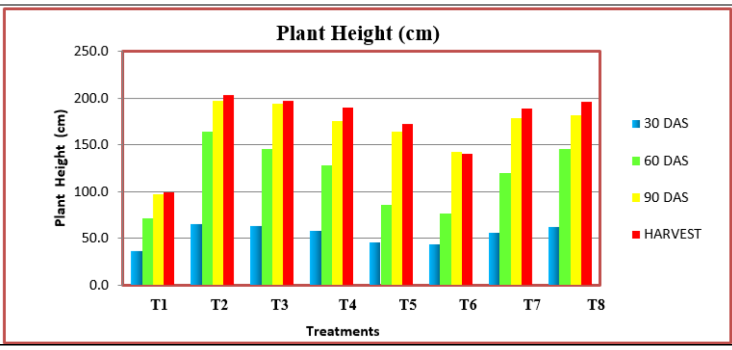

Figure 1. Effect of different N levels and precision N management tools on plant height of maize

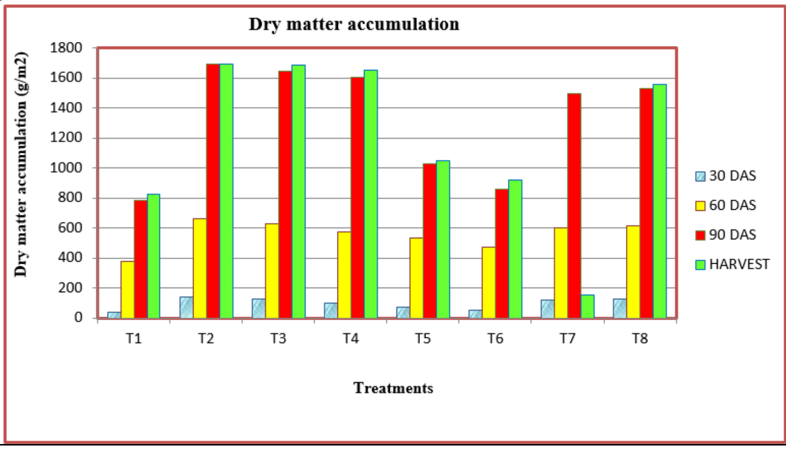

Figure 2. Effect of N management on dry matter accumulation (DMA) of maize

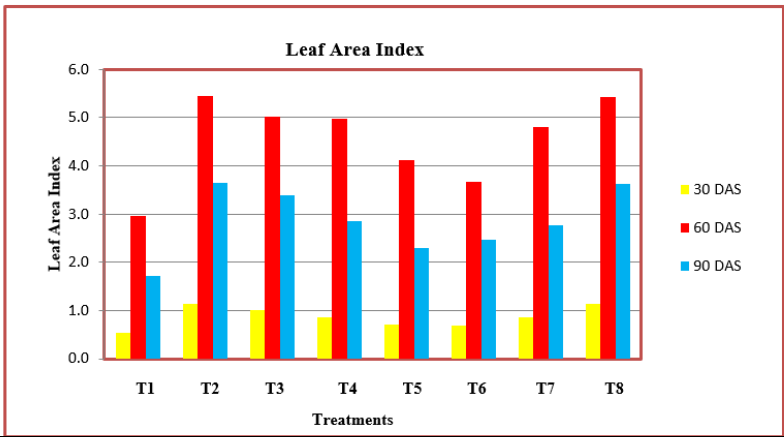

Figure 3. Effect N management on leaf area index (LAI) of maize

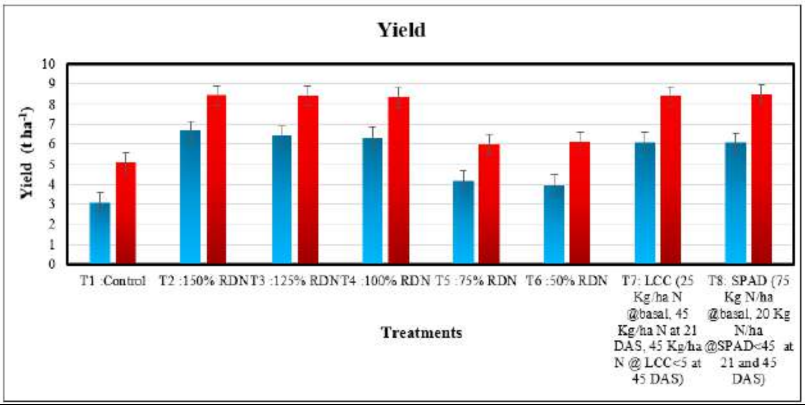

Figure 4. Effect of different N doses and precision N management tools on the grain and stover yield of maize crop.

REVIEW ARTICLE

Seaweed Sap Can Reduce the Chemical Fertilizer Load in Agriculture without Hampering the Crop Productivity: A Review

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ABSTRACT

Any advance in agricultural system that results in higher production should reduce the negative environmental impact and augment the sustainability of the system. During post green revolution era, indiscriminate use of agro chemicals jeopardizes the entire environment and the overall ecological balance. Thus climate on the earth changes hastily to a very alarming condition day by day. So, the time has already come to reshape our present package of practices for the agrarian area and bring in some alternative approaches that can save our environment vis-à-vis food security. One such approach is the use of biostimulants, like seaweed extracts. The bioactive substances extracted from marine algae are used in agricultural and horticultural crops, and many beneficial effects may be attained in terms of enhancement of yield and quality. With these outlooks keeping in background many field experiments were conducted on farm and on-station basis to assess the efficacy of these marine algal products especially *Kappaphycus* and *Gracilaria* saps on various agricultural and horticultural crops with special reference to crop yield and quality, soil health management and environmental issues. Superior crop growth vis-à-vis yield was recorded when seaweed extracts were used. System efficiency was also increased with these seaweed saps. These saps can replace 25% of the chemical fertilizers without reducing any further yield of the crops.

Keywords: Seaweed sap; Growth; Yield; Chemical fertilizer.

INTRODUCTION

In the early 60's of the previous century, it was a very urgent surge for the agricultural scientists to give an immense push on the so-called package of practices to ensure the food security for the ever-escalating population of the nation. Thus, a phenomenon like green revolution was must for the entire nation at that time. But during post green revolution era, unsystematic exploitation of chemical fertilizers, pesticides, herbicides etc put the entire environment and the overall ecological balance in danger (Pramanick *et al.,* 2020; Sairam *et al.,* 2020; Mohanta *et al.,* 2021). Fertilizers and pesticides both have definite pros and cons associated with their use. Both types of chemicals tend to increase yields and thus make a significant difference in food production (Kumar *et al.,* 2021). On the other hand, both of them can cause water pollution when erosion carries the chemicals off of the farms along with eroded soils after each rainfall. There is also concern by some authorities that pesticides pose a risk, not only to non-target animal and plant species, but to human being as well. The downside of fertilizers is that some portion inevitably washes into waterways along with eroded sediments. This nonpoint source runoff occurs nationwide and the nitrogen fertilizer finds its way into rivers, lakes and the ocean where it causes eutrophication and "dead zones" that kill aquatic life (Singh *et al.,* 2017). Eutrophication is a process whereby nitrogen feeds an algal bloom; but when the short-lived algae die, decomposing bacteria consume most of the available oxygen and thus suffocating the aquatic life. Additionally, use of artificial fertilizers in place of animal or 'green' manure makes the cover crops plowed into the soil and eventually can deplete soils of organic matter by making them lose their ability to hold water and more subject to erosion. Runoff of synthetic fertilizer can enter the waterways, causing water to be polluted and to lose oxygen. Over time, chemical fertilizers can degrade the quality of the soil by building up toxins or leaching away natural nutrients, making the soil unfit for growing plants (Pramanick *et al*., 2012). Using too much fertilizer can damage plants by chemical burning of roots and leaves. If we grow edible crops, synthetic fertilizers may contain unnecessary even sometimes harmful chemicals that will end up in our food (Pramanick *et al*., 2018). According to the National Institute of Environmental Health Sciences, pesticides have as yet incompletely understood effects on humans.

It is a cruel reality that developing countries like India accounts for less than 30% of global pesticide consumption. The vast majority of pesticide poisonings occurs in developing countries. In India agro-chemicals account for as much as 25% of all occupational injuries in the agricultural sector and 15% of all fatal injuries. 69.4% pesticides are used in agrarian sector of India whereas in case of public health 30.6% pesticides are used. The ill impacts of excessive pesticide uses are the contamination of the environment, soil and ground water causing serious human health hazards vis-à-vis narrow nutrient holding capacity, severe micronutrient deficiency and sharp declination in carbon stock of soil (Kumar *et al.,* 2021a). All these things ultimately offer directly or indirectly more and more crucial problems to the environment ultimately acting as some of the important agents in changing the climate as a whole.

So, it is the high time for reshaping our present package of practices in agriculture and introducing some alternative approaches to mitigate the hectic hazards of changed climate vis-à-vis sustaining the food security. One such approach is the use of biostimulants, which can enhance the effectiveness of conventional mineral fertilizers. Disadvantages of chemical fertilizers are going to compel the farmers to turn towards organic manures (Garai *et al.,* 2019; Pramanick *et al.,* 2014). To meet increasing demand of organic manures, among many viable options, one is the use of seaweed extracts as plant nutrient bearing fertilizer. The bioactive substances extracted from marine algae are used in agricultural and horticultural crops, and many beneficial effects may be attained in terms of enhancement of yield and quality (Pramanick *et al.,* 2017). Liquid extracts obtained from seaweeds have recently gained importance as foliar sprays for many crops including various cereals, pulses and different vegetable species. Seaweed extracts have proven to accelerate the health and growth of plants. It supplies nitrogen, phosphorous, potassium as well as trace minerals like Zn, Mn, Mg, Fe, etc. (Pramanick *et al.,* 2020). It also contains natural plant growth substances like auxins, gibberlins and cytokinins. As it is an excellent source of almost all plant nutrients, it can substitute the conventional chemical fertilizers to some extent.

Keeping these in background several studies were conducted to find out the effect of seaweed saps on growth, yield of different crops and positive yield enhancement was observed.

Improvement of growth and quality through the application of seaweed sap

Several field studies conducted in different parts of the country showed that the application of seaweed sap along with chemical fertilizer can improve the growth of many crops like rice, wheat, maize, green gram, black gram etc. Table 1 represents the crop wise requirement of the liquid seaweed fertilizer.

Several findings of the previous study represent that application of liquid seaweed extracts increased yield by 26%, 39%, 57%, 61% and 20% of rice (Kavitha *et al*., 2008), green gram (Pramanick *et al*., 2013), soyabean (Rathore *et al*., 2009), tomato (Zodape *et al*., 2011) and okra (Zodape *et al*., 2008) respectively. Superior yields after seaweed treatments were measured in watermelon (Abdel-Mawgoud *et al*., 2010), wheat (Zodape *et al*., 2009), Potato (Pramanick *et al*., 2017) and grape (Norrie *et al*., 2006). Besides, quality characters of different crops like cereals, pulses, oilseeds and tuber crops are largely influenced. Pramanick *et al.* (2017 and 2020) demonstrated that the application of seaweed sap can increase the protein, amylose, amylopectin, carbohydrate, and sugar content of rice, potato and greengram. It has also been found that use of seaweed as soil treatment substances results in strong and healthy growth vis-à-vis disease-resistance. From the study conducted by many scientists previously, it has been perceived that combined application of marine algal extracts, *Kappaphycus* and *Gracilaria*, and chemical fertilizer increase the yield by 35%, 40%, 45%, 50%, 33%, 30% and 48% of rice, greengram, blackgam, maize, sesame, potato and soybean respectively. The on-farm experiment also confirms that the foliar application of *Kappaphycus* and *Gracilaria* extracts can successfully substitute the hazardous chemical fertilizer up to 50% and trim down pest and disease occurrence to some extent. Table 2 represents the quality improvement of many crops through the application of seaweed saps.

From the Figure 1, it is clear that the application of seaweed sap can substitute the chemical fertilizer load from the agriculture systems. In most of the cases, 75% recommended doses of chemical fertilizers along with foliar application of seaweed saps like *Kappaphycus*, *Gracilaria* etc. at 15% concentration during active crop-growth and flowering stages showed at par results concerning crop growth, yield and quality of the crops with the application of 100% recommended doses of chemical fertilizers (Pramanick *et al*., 2017, 2020; Laik *et al.,* 2021; Das *et al.,* 2021; Dey *et al.,* 2021). Such results also confirmed the economic boost-up of the farmers through the application of seaweed saps.

CONCLUSION

From this review, it can be concluded that the seaweed extracts are effective in increasing the yield *vis-à-vis* quality of different crops without impeding the environment and ecological balance as it can replace the chemical fertilizer load from the agricultural systems to the tune of about 25%.

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Table 1. Crop wise requirement of liquid seaweed fertilizer (LSF)

Crop	LSF concentration % (volume/volume)	Average volume of dilute fertilizer per spray per hectare (Liters)	Total volume of neat LSF required for the crop per hectare (Liters)
Rice	2.5	650	48.75
Potato	5.0	650	97.50
Greenram	2.5	650	48.75
Blackgram	2.5	650	48.75
Maize	12.5	650	162.50
Sesame	7.5	650	146.25
Soybean	12.5	650	125.00

Table 2. Yield and quality improvement of different crops in the experiment

Crop	% increase in yield over control	Quality parameters
Rice	35.00	Amylase content increased
Potato	33.00	Starch content increased
Greenram	40.00	Protein content increased
Blackgram	45.00	Protein content increased
Maize	50.00	Total carbohydrate content increased
Sesame	33.00	Oil percent increased
Soybean	48.00	Oil percent and protein content increased

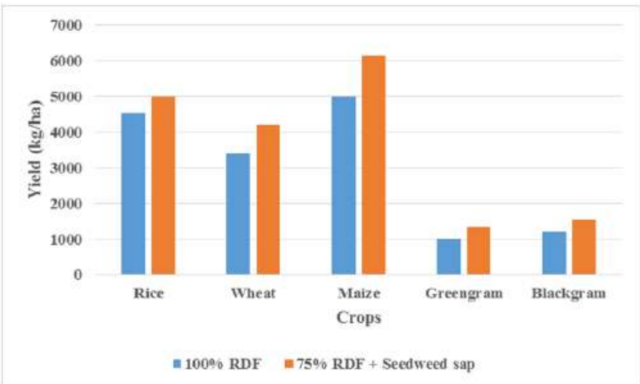

Figure 1. Comparative yield improvement using 75% RDF + seaweed sap over 100% RDF in different crops

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REVIEW ARTICLE

Crop Diversification and its Importance in Agriculture: A Review

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ABSTRACT

In agriculture crop diversification has a remarkable influence on the social and economic condition and helps to increase resource of the poor population dependent on farming. It provides employment and earning to the youth population throughout the year thus it is beneficial for the farmers. It gives more importance on the use of local resources. Crop diversification is basically a shift from low profitable cropping system to high profitable cropping system. It is a mix of several components like different cropping system along with aquaculture, horticulture, and other non-farm inputs of rural agriculture. After the market globalization, crop diversification has become one of the most important components to increase the quality and quantity of the production and obviously earning from the production. Crop diversification has different approaches. Different government policies and strategies has been taken for crop diversification. There are some constraints in crop diversification but its present need and future thrust has made it more impactful to be implemented.

Keywords: Crop diversification, food security, sustainable agriculture, nutritional security, government policies

INTRODUCTION

In India during 1990 the most important cause of agrarian calamity was low level of income and huge difference of income between the farmer and non-agricultural worker and it has become a serious problem in the recent years. In such condition a target has set in double the farmer`s income by 2022-23 that will help to flourish farmer`s prosperity, reduce agrarian calamities and will maintain the equality between the income of farmer and non-agricultural worker. In order to increase the income strong measures should be taken to improve the agricultural productivity, efficient use of resources, and saving in production cost. In such condition crop diversification comes into existence to provide sustainability in the production as well as to improve farm income. Crop diversification may be defined as the shifting from one crop or cropping system of traditionally grown less profitable crops to another crop or cropping system that consists more profitable crops (Feliciano, 2019). Crops diversification is an example of sustainable agriculture. It helps the farmers in producing a wide type of crop under a certain area as well as to increase production-oriented functions on different crops and it helps to reduce the possible risk. Crop diversification is a demand and need based and situation oriented continuous and dynamic concept that involves the spatial, temporal, and value addition approaches (Singh *et al*., 2018). It helps to increase the total productivity in terms of quality and quantity and also helps to increase the profitability. In dry-land areas crop diversification can be used to minimize the chances of crop failure due to the climatic abnormality. Diversification helps to increase nitrogen in the soil and thus improve the soil fertility (Ali *et al*., 2012). It helps in employment generation as farmers including their family members remain busy in different farming operations. One of the most important advantages of crop diversification is that it ensures frequent cash flow that is very much beneficial to the small and marginal farmers. Out of the 17 SDGs suggested by UNDP, crop diversification and its importance in agriculture has potential to fulfill SDG 2 and 3 (FAO, 2021).

Concept of crop diversification

Crop diversification is basically consisting of shifting of one cropping system or crop to other cropping system or crop. It is a shift from less remunerative and less sustainable crop or cropping system to more remunerative and more sustainable crop or cropping system (Barman *et al*., 2022).

Different approaches of crop diversification

Horizontal diversification

Crop intensification

It is the process of adding more crops to the present crop or cropping system in order to enhance the total production as well as productivity of a farm or a whole region (Nayak and Kumar, 2019).

Crop substitution

It is the process that includes the substitution of less suitable crops or cropping system with more suitable crops or cropping system based upon the agro-climatic condition of a specific location. In crop substitution high risk prone crops are basically substituted with short growth duration pulse and drought and less rainfall resistant oilseed crops (Nayak and Kumar, 2019).

Vertical diversification

It is an approach in which in order to enhance the product range farmers or others add value to products through processing, regional branding, packaging, merchandising or other efforts (Barman *et al.,* 2022).

Land based approach

Crop must be selected depending upon the problem e.g. on sloppy land which is susceptible to soil erosion, under such condition erosion resisting crops like legumes should be cultivated. Fertile land with good drainage system should be used for good crop rotation, comparatively less fertile soil is used for growing crops that helps in soil-improvement like legume and salt tolerant crops on different problematic soils.

Crop diversification under arable lands

Sometimes traditional cropping system fails to serve a stable productivity over a long-time duration because of unfavorable weather condition. Alternate use of land system is used to stable the productivity of such type of land.

Alley cropping

An agroforestry system that includes the growing of the food crops in alleys that is formed by the trees (Paudel *et al*., 2022; Maitra *et al*., 2021). This system provides food grain, fuel wood, mulch, fodder etc. This system is practiced to provide stability and sustainability to the farming system. This system consists of growing of food crop in the alleys prepared by the row of shrubs or trees. Arable crops for example pearl millet, maize, oilseeds, rice, legumes etc. are grown in the alley that is created by two rows of trees. During severe drought such practice ensures the production of usable material. It also acts as a conservation farming as it helps to increase the fertility of the soil and reduce the risk of erosion.

Ley farming

Here grass and legumes are rotated with food grain crops. In such farming, grasses help to improve structure of soil and legumes help to improve the soil nitrogen status (Jarecki and Lal, 2003).

Agri-horticultural system

An agroforestry system which includes fruit trees as a component. Here with these fruit trees several annual tresses are intercropped. In dry land area, this system has a valuable role particularly in semi-arid zone where low as well as unstable annual crop production is found. Suitable integration of fruit trees and agricultural crop ultimately enhance overall production of food fodder and fuel. This system also provides facilities in conserving the water and soil and stabilize the production as well as income. Fruit trees of dry land are having deep root system and they are hardy in nature; therefore, they can withstand the monsoonal aberrations. Hence fruit trees facilitate high production in drought period when annual crops face crop failure.

Crop diversification under marginal land

Marginal lands are having several problems like poor drainage, steep slope, poor soil depth etc. Such lands can be used for free farming or can be developed into pastures.

Silvi-pastural management

This system is dependent on using the lands which are degraded as trees are able to withstand in the aberrant soil and climate conditions whereas legumes as well as grasses provides a suitable land cover. Dry land farmers, having huge amount of land, can adopt this approach for production of both fuel and fodder production without keeping the land uncultivated for a long period of time. CRIDA conducted a survey in Karnataka, Maharashtra and Andhra Pradesh and according to that experiment next to food fodder is most important to sustain the wealth of animal in village areas.

Water based approach

In this approach crops require more water are shifted to crops require less water. After the harvest of kharif crops in rainfed farming system on moisture retentive soil, less moisture requiring minor crops like pulses or cereals can be grown.

Crop diversification under assured irrigation situation

Multiple cropping is most suitable in the area where soil moisture is available throughout the year. Availability of moisture throughout the year provides a suitable condition for sequential cropping. However, in crop rotation a dry crop should be taken to reduce the soil hazards condition because of continuous application of irrigation.

Crop diversification under water scarce condition

Cropping intensity changes along with the volume of obtained rainfall. 500-625 mm rainfall with shorter than 100 mm soil storage ability is suitable for single monsoon-based cropping while 625-750 mm rainfall is suitable for intercropping of the crops with difference in maturity periods. 900 mm rainfall with greater than 200 mm soil storage capacity is suitable for double cropping (Zaman *et al*., 2017). There may be some situation where enough moisture is present to grow one crop but moisture content is not enough for growing two crops. Under this condition intercropping leads to increase the cropping intensity over the single crop.

Crop diversification under high rainfall area

Root type crops are grown well under humid lowland condition than legumes and cereals because high rainfall, humidity, affect the reproduction, drying, storage as well as chances of insect pest attack also increases. In upland area with a rainfall of 200 mm/month for a period of 5-6 months is suitable for growing upland rice (De Datta, 1981).

Need of crop diversification

Crop diversification is now a necessary component to meet different objectives. It offers scope for employment at the time of performing the value addition process of the farm products. It enhances the scope of agricultural industrialization. It provides better conditions for food security of the community and helps the farmers to grow surplus product for selling in the market (Georgeou *et al*., 2022). Thus, it helps to increase the income of the farmer which helps to meet the household requirement (Gunasena, 2001). Crop diversification helps to maintain ecological balance. It helps in efficient utilization of farm inputs thus provides a dynamic economy. It helps to overcome the risk factors related to the mono cropping. Actually, it is more important for offering employment, increasing income and keeping safe the environment.

The major driving forces for crop diversification

Main reasons of crop diversification are it helps to increase the income of small farm holders. It helps to reduce the ill effects of aberrant weather and reduce the environmental pollution and maintain the ecology. It leads to improve fodder for livestock animals as well as helps in balancing food demand. It is most important in increasing the food security of community and decrease the chances of occurrence of insect, pests, diseases and weed problem. Moreover, it decreases the investments in agricultural sector throughout the year (Hazra, 2001)

Factors affecting crop diversification

Crop diversification is the outcome of interaction of several factors. Those factors affect the crop diversification mostly. These factors are environmental factors which includes irrigation, rainfall, temperature, light interception, and soil fertility; technology related factors including fertilizer, crop protection, seeds, post-harvest issues like marketing, storage, agro-processing, value addition, distribution etc. and water technologies; house-hold related factors which includes mainly fuel, fodder, regional food; institutional and infrastructure oriented factors including location of farm and size, in-field technical infrastructure, marketing system, policies regulated by government etc.

Crop Diversification and its Opportunities

Crop diversification and Globalization

With the appearance of WTO and as India is a member of GATT, the condition of agricultural sector has been developed. Importance of diversification in agriculture is increasing due to the access of agricultural produce in the market of different countries. The import market must be separated for those crops having enough area and production. This should be adopted to facilitate some comparative advantage which will ultimately help to protect the interest of farmers. Expansion of area and enhancement of quality should be done for traditionally exported material like basmati rice, condiments, spices etc. In order to increase the opportunity of export, production as well as post-harvest activities of vegetables and tropical fruits are required which can be achieved by diversification of crop. To provide improved nutrition to the population a fast growth in the production of vegetable and fruit is required. In the coming future with the improvement of the living standard of the population, demand for the nutritional and good quality of food will also increase which will ultimately lead to a massive crop diversification.

Crop Diversification and Rising Technology

In this situation agriculture is not practiced to meet the family requirement. Industrialization in agriculture has already been taken place that helps in production of biomass through the utilization of genetic material, water, land and latest technologies. In this century there is a scope with agriculture to start an entrepreneurship that will definitely help the farmers to earn more net income from their production. Genetic engineering and biotechnology play a great role in increasing the productivity by introducing several new traits that helps to increase the yield of the crops and also develop the characteristics of crops. Several other technologies are there that also promotes the utilization of crop diversification. Different policies of government, GIS, precision agriculture etc. promotes crop diversification in terms of economic point of view (Zaman and Maitra, 2017; Bhattacharyay *et al*., 2020).

Major constraints of crop diversification

In India crop diversification is using in commercial crop production including vegetables and fruits. Day by day the area under crop diversification is increasing. The major limitations of crop diversification are because of some reasons. In India about 63% of the cropped area is totally dependent on rainfall (Joshi *et.al*., 2004; Gautam and Bana, 2014). Excessive utilization of the resources like land resources and water resources creating a bad effect on the environmental condition as well as on the sustainability of the agriculture. Another major problem is the presence of the poor basic agricultural infrastructure like rural roads, poor electric supply, inadequate transport and communication system etc. as well as the poor supply of good quality seed and plants of improved cultivars. In India agro-based industry is very weak and the extension worker and the farmer linkage is also very poor (Holt, 2002). There is a huge lack of trained human resources as well as the literacy among the farmers. Most of the land holders are not showing their interest in modernization and mechanization of agriculture. As a whole the amount of investments in agricultural sectors are decreasing year after year.

Crop Diversification as a Strategy for Various National Commitments

Food and Nutritional Security and Poverty Alleviation

The post-independence growth rate in agriculture of roughly 2.7% per year was substantially larger than the minimal rate of growth which is 0.3% per year in the first half of this century (Singh, 2004). Since independence, not only has the production of food grains increased, but also commercial crop production such as cotton, fruits, oilseeds, vegetables and sugar cane, as well as cattle products and fisheries has also increased. One of the main goals of plan development is to eliminate poverty. Poverty rates reduced from 54.9% in 1973-74 to 36% in 1993-94. During this 20-year period in 1973/74, 321 million people were impoverished, and in 1993/94, 320 million (Nayak *et al.,* 2010). In village areas, the figures were 261 million and 244 million, respectively. Land resources are low, with the average holding size in India being only 1.57 hectares during the 1990/91 census year (Hazra, 2001). Poverty is caused by some basic factors: i) a lack of purchasing power and revenue due to a lack of productive work, ii) Increased price of food grain, iii) Inadequate social infrastructure that reduce the living quality of people.

Under such condition the national agenda of the government is to increase the production within 10 years. The food grains are cereal (rice, wheat, maize etc.), oilseeds (groundnut, sesame etc.), sugar (sugarcane), fruits, vegetable, meat, milk etc. The main aim was to increase the production in such a way that it can meet the food requirement of the population as well as some products may remain for the exports purpose which is closely related to country`s food concern.

Agriculture Planning: An Area Approach

The Agro-Climatic Regional Planning (ACRP) was a new approach that was put into action in 1988. The ACRP is a connection between the resource base and decentralized planning (Kashyap and Mathur, 1999). It was started by dividing the whole country into 15 regions / zones and after that into 73 sub-regions / zones and after that the demarcation of the sub-region / zone within the state has been done by using district as a lowest unit. The basic principle that is used for the sub-division are those which are closely related with the agricultural economy like climate, soil, rainfall etc. According to a current study, agro-climatic zones have been defined into four agro-economic zones for discussing the issues of sustainability, poverty and productivity. The agro-economic zones are- i) Zone with high productivity (103 districts), ii) Zone with high potential and low productivity (181 districts), iii) Zone with low productivity (179 districts) and iv) Zone which is ecologically fragile (Himalayan and Desert areas).

Management of Natural Resource for Development of Sustainable Agriculture

The declination in water and land resources are in the form of degradation of land, reduction in water table and stagnation of water. In order to manage the plant nutrient and chemicals, a greater requirement of integrated approach is there and effective measures should be adopted to control pollution problem. Reduction in utilization of chemicals in agriculture can be achieved through the adoption of several technologies (Maitra and Gitari, 2020; Maitra*et al*., 2020). Several policies like proper management of water and appropriate land may reduce the degradation of environment. To save the natural resources from declination, participation is very important which is done by community and village institution. Programs should be adopted to reduce the degradation of water and land resources.

Government policies and strategies for crop diversification

Taking into account the significance of crop diversification in Indian agriculture, the government has adapted several for the development of agriculture and especially for the development of crop diversification.Implementing National Agriculture Insurance Schemeon Food crops, oilseeds, annual commercial and horticultural crops come under the coverage of this scheme. This scheme provides fifty percent subsidy to marginal and small farmers.Operational technology mission on cotton. This mission consists of Mini-Missions on generation of technology, extension and support of product, market infrastructure and modernization of ginning and pressing unit.Creation of the watershed development fund at the national level for developing rainfed lands.

Infrastructural support for developing horticulture as well as to emphasis on post-harvest management. For the construction, modernization, expansion of cold storage and storage of horticultural crop government provides a capital subsidy of 25%. Seed bank scheme around 7-8% of the total certified seeds produced in the country will be stored as a buffer stock for meeting the seed requirement during drought, floods or any other natural calamities. More attention should be paid to develop an efficient market for the domestic purpose and for the exports purpose by maintaining proper quality and standardization. All these measures will contribute in the development of crop diversification and helps to increase the production as well as the productivity of crops.

Crop diversification in Indian scenario

In India population is nearly one billion people. Among them above 70 percent people are rural people and their occupation is mainly agriculture. In Indian condition farmers are having only small farm holding. The average size of the farm is 1.57 ha (Ameh and Lee, 2022). Near about 93% of the farmers are having the area less than 4 ha and about 55% arable land they cultivate. In another case, 1.6% of farmers are having area more than 10 ha and use only 17.4 percent of the total arable land (Naresh *et al*., 2013). Due to the presence of different agro-climatic conditions in our country, a huge quantity of agricultural products is being manufactured by the farmers. They can be divided into two different groups- a) food grain crops b) commercial crops (Hazra, 2001). For meeting food requirement of the large population and keeping in mind the previous experience of food shortage during pre-independence era “self-reliance” has come into existence. Near about 66 % of the total cropped area is now under the cultivation of food grain crops like pulses and cereals. But now commercial agriculture has also been developed and it is flourishing day by day. It does not only serve to the market of the country but also it is a major way to earn the foreign money.

Crop diversification is expected to provide huge option to produce wide type of crops under a certain area. It also leads in increasing in manufacture-oriented function and reduce the hazard. In India crop diversification is actually a shift from conventionally cultivated low profitable crop to the high profitable crop. Crop diversification occurs because of policies of government and need of several crop during a period of time like Technology Mission on Oilseed (TMO) to enhance the production of oilseed to meet the country`s need as well as to reduce the dependency on imports. The development of the market infrastructure induces the crop diversification. Low volume high-value crops like spices, higher profitable crops, stability in the production leads to the crop diversification. Crop diversification is used in the rainfed area to minimize the hazard related to crop failure because of less rain and drought (Reddy and Sursh, 2009). Crop diversification is also used in the area having severe soil problem. For example, the growing of the rice in high water table area has been replaced by the oilseeds, pulses and cotton; growing of the sorghum has been replaced by soybean in vertisols.

FUTURE THRUST

High value crop should be included through horizontal and vertical approach. It is needed to identify the crops which are having short growth duration and high yield potential. Under semi-arid and arid areas, the cropping system should be chosen in such a way which will provide long term sustainability. High potential farming system should be synthesized and evaluated in on farm under the participation of farmers.

CONCLUSION

India is a country where different agro-climatic conditions are present. Such variations are the main reason of growing different crops in different region. With the development of new technologies like irrigation process, other agronomic practices it has been possible to witness a higher amount of yield. Crop diversification is new instance to maintain the sustainability in agricultural production. It helps to increase the quality, quantity and earning from the production thus secure the economic condition of farmers. Crop diversification should follow a strategy to generate higher income, higher employment, higher input use efficiency. Special attention should be given on the small and marginal farmers so that direct advantages can reach to this portion of the population.

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Table 1: District-wise Crop Diversification Index of 2001-02

Rank	Name of the district	CDI		CDI	Name of the district	Rank
5	Anugul	0.51		0.61	Kandhamal	1
11	Balangir	0.44		0.37	Kendrapara	19
21	Baleshwar	0.36		0.45	Keonjhar	10
27	Baragarh	0.32		0.31	Khordha	29
22	Baudh	0.36		0.49	Koraput	6
28	Bhadrak	0.31		0.49	Malkangiri	7
23	Cuttack	0.36		0.35	Mayurbhanj	24
4	Debagarh	0.53		0.44	Nabarangpur	14
9	Dhenkanal	0.45		0.31	Nayagarh	30
2	Gajapati	0.55		0.43	Nuapada	15
18	Ganjam	0.38		0.39	Puri	17
25	Jagatsingpur	0.34		0.55	Rayagada	3
12	Jajapur	0.44		0.47	Sambalpur	8
25	Jharsuguda	0.34		0.37	Sonepur	20
16	Kalahandi	0.39		0.33	Sundargarh	26

(*Source*: Nayak and Kumar, 2019)

Table 2: District-wise Crop Diversification Index of 2011-12

CDI	Name of the district	Rank	CDI	Name of the district	Rank
0.54	Anugul	6	0.67	Kandhamal	1
0.48	Balangir	10	0.35	Kendrapara	28
0.41	Baleshwar	17	0.51	Keonjhar	9
0.27	Baragarh	30	0.45	Khordha	14
0.4	Baudh	20	0.55	Koraput	5
0.35	Bhadrak	27	0.57	Malkangiri	3
0.4	Cuttack	21	0.38	Mayurbhanj	24
0.53	Debagarh	8	0.35	Nabarangpur	29
0.55	Dhenkanal	4	0.46	Nayagarh	12
0.54	Gajapati	7	0.41	Nuapada	18
0.38	Ganjam	23	0.37	Puri	25
0.4	Jagatsingpur	22	0.59	Rayagada	2
0.48	Jajapur	11	0.41	Sambalpur	19
0.43	Jharsuguda	16	0.37	Sonepur	26
0.45	Kalahandi	13	0.44	Sundargarh	15

(*Source*: Nayak and Kumar, 2019)

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RESEARCH ARTICLE

Efficacious Treatment of Wastewater using *Centella asiatica*, *Marsilea quadrifolia*, *Ipomoea aquatica* and *Enhydra fluctuans* Employed in Hydroponic System

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ABSTRACT

Availability of fresh and potable water has become a luxury in the crunch situation and therefore, to circumnavigate this problem wastewater can be considered as resource for sustainable development and can be reused for numerous purposes like landscaping, gardening and aqua cultural practices after adequate treatment. In this regard, in the present research hydroponics system was envisioned as a low-cost treatment technique for the treatment of low-strength wastewater with the aim of reusing the treated effluent for different activities. Four species of plants namely *Centella asiatica*, *Marsilea quadrifolia*, *Ipomoea aquatica* and *Enhydra fluctuans* were cultured in different hydroponic systems and their capability to treat wastewater was evaluated by noting the change in the concentration of nitrogen, phosphorus, chemical oxygen demand and total solids before and after treatment. The hydroponic system with *M. quadrifolia* and *I. aquatica* demonstrated higher wastewater treatment efficiency and growth rate in comparison to the other two species. Also, no ill-effects of using wastewater for the growth of plants was noted in the present research and 3 log-scale removal of coliforms was observed for the hydroponic system cultured with these plants. Therefore, the present investigation elucidated the suitability of using *M. quadrifolia* and *I. aquatica* plants species in hydroponic system for the treatment of wastewater to produce reusable quality treated water.

Keywords: Hydroponic; Nitrogen removal; Phosphorus removal; Water reuse; Wastewater treatment

INTRODUCTION

Clean water is becoming one of the scarcest and valuable resources in the twenty first century as its supply is finite and the traditional sources are easily polluted due to the industrialization and population bloom (Gupta et al., 2020; Hoekstra et al., 2012). Therefore, if wastewater can be considered as resource of sustainable development for the production of reusable water employed for non-potable purposes, then the stress on the existing potable sources of water can be diminished (Das et al., 2020b; Das et al., 2019b; Das et al., 2020e). The treated wastewater can be reused for restricted agriculture, landscaping, gardening, aquaculture, or other recreational purposes, which will reduce the dependence on fresh water sources (Das et al., 2020a; Ilyas & van Hullebusch, 2020; Tzanakakis et al., 2014). Furthermore, biogas generated during the anaerobic treatment of wastewater can also be employed as feedstock in microbial electro synthesis for the production of biofuels (Das et al., 2018; Das et al., 2020d; Das & Ghangrekar, 2018). Biological treatment techniques can not only effectively remove multiple pollutants like organic matter, xenobiotics and heavy metals from wastewater but also it is a cost effective means of dealing with contaminated wastewaters (Das et al., 2019a; Das et al., 2020c; Das et al., 2019c).

Hydroponic literally means water-working or water activation and it is a technique of growing plants in a nutrient solution (Resh, 1995). It is a cultivation technique for growing plants in highly oxygenated, nutrient enriched water, rather than soil(Herklotz et al., 2010). Hydroponic plants grow in a combination of nutrients and water, where all the nutrients are supplied to the plants in the solution phase (Ottoson et al., 2005). The plants absorb nutrients from hydroponic solutions, which acts as a media and include all macro and micro nutrients required for plants' growth. The function of a hydroponic nutrient solution is to supply the plant roots with water, oxygen and essential mineral elements in soluble form.

In hydroponic system roots are grown in inert medium such as sand, gravel, coconut coir, foam, perlite, rock wool, vermiculite, sawdust etc. and then irrigated with complete nutrient solution. This method of growing has also been referred to as nutrient-solution culture, soil-less culture, water culture, gravel culture and nutriculture. Furthermore, hydroponic approaches, such as the nutrient film technique have showed great potentials to remove suspended solids from wastewater (Jewell, 1994; Jewell, 1991). Nonetheless, hydroponic systems are ideal for recycling water and nutrients because the drainage can be easily captured for reuse. Therefore, the nutrients present in wastewater can suffice the need of the plants growing in hydroponics by employing these nutrients present in wastewater and thus treating it (Benvenuti et al., 2018).

Hydroponic watering systems are recommended for growing plants near sensitive water resources. These systems provide efficient use of water and nutrients, and minimize contaminant leaching losses to the environment that are common with intensively grown plants. Sensitive water resources include public drinking water sources, the margins of waterways and estuaries and areas within the catchments of conservation-valued wetlands (Malaguerra et al., 2013). Hydroponic system is globally accepted due to its numerous advantages like water, land and energy saving ability, no soil borne diseases, minimizes water wastage, easy cultivation etc. Hydroponic technique also employs precise water and nutrient application directly in to the roots of each plant. Water is reused in these systems and very less amount of it is lost through evaporation and run-off. Therefore, arid lands, such as deserts, can be transformed into productive lands using limited amount of water (Jensen, 1997) .

Numerous plant species like *Lycopersicon esculentum*, *Beta vulgaris*, *Cucumis sativus*, *Eucalyptus camaldulensis* etc. have been cultured in hydroponic system to elucidate their capability to adapt to this system and grow efficiently(Bellert et al., 1993; Iori et al., 2017; Lucena & Chaney, 2007; Radzki et al., 2013; Sagardoy et al., 2009). In present research, *Centella asiatica, Marsilea quadrifolia, Ipomoea aquatica* and *Enhydra fluctuans* were chosen as the plant species to be cultured in the hydroponics due to their local availability and possibility of recovering valuables from these plants after harvesting (Abbasi et al., 2018; Idris et al., 2020; Lakhote et al.; Li et al., 2009). All these plant species are small herbs commonly found in the Indian conditions and can grow effectively in hydroponics using wastewater as the nutrient solution. The aim of the present research was to elucidate the suitability of using hydroponic system as a low-cost decentralized treatment technique for low-strength wastewater generated from toilets and other household activities. Wastewater treatment efficiency in terms of all the major wastewater parameters were monitored and the performance of the hydroponic system with different plant species namely *C. asiatica, M. quadrifolia, I. aquatica* and *E. fluctuans* was also evaluated. The scope of using the treated effluent of the hydroponic system for aquaculture and landscaping purposes was also elucidated.

MATERIAL AND METHODS

Experimental set-up

Four different plants namely, *C. asiatica, M. quadrifolia, I. aquatica* and *E. fluctuans* were selected for the investigation owing to their local availability. All these plants were cultured in lab-scale aquariums and their efficiency of wastewater treatment was measured. Also, one aquarium was operated without any plant, which served as the control for the investigation. The aquariums were selected for installing floating structure like tray having dimension of 28.5cm × 23.1cm × 6.2cm. All the experimental aquariums were of the same size having length, breadth and height are 60cm × 30cm × 30cm each. Depending upon the plants cultured in them the aquariums were numbered 1, 2, 3 and 4, foraquariums with *C. asiatica, M. quadrifolia, I. aquatica* and *E. fluctuans*, respectively and aquarium 5 was operated without any plant.

Preparation of bed for plants' growth

The plant beds were prepared on the floating structure tray employing two types of scrubbers namely, small size scrubber with the dimension of 9.7cm × 6.7cm × 1.6cm and big size scrubber 15.24 cm × 10.16cm × 1.27cm (Figure 1). Four scrubbers were kept on each tray (two big and two small scrubbers in each) and after putting the scrubbers on the perforated trays with the openings of 1cm, 1cm thick layer of sand collected from the locality was poured on them so that the roots can attached properly to the bed material. Small saplings of the specified plants were collected from the locality and there root soil was removed by washing them with tap water prior to their plantation in the aquarium. After plantation the saplings were allowed to grow for 3 days, before commencement of the experiments and during this acclimatization phase, the plants were watered using tap water to prevent them from dying. During experimentation, all the aquariums were fed with low-strength waste water or grey water collected from septic tank situated at Indian Institute of Technology, Kharagpur, India (Table 1). The aquariums were fed with this wastewater every 12^{th}day and were operated at the temperature of 27 ± 3 °C for a period of 90 days in triplicates to ascertain the reproducibility of the results. All the aquariums were only fed with the wastewater and no chemical or bio-fertilizers were supplied to assist the growth of plants.

Chemical analysis

Standard methods were used to measure ammonium-nitrogen (NH_4^+-N), nitrite-nitrogen (NO_2^--N, nitrate-nitrogen (NO_3^--N), phosphate (PO_4^{3-}), chemical oxygen demand (COD), total solids (TS) and most probable number (MPN) of wastewater samples before and after every feed cycles (Association et al., 1998). Water quality parameters were analysed during initial feeding and during treatment, thrice in every feed cycle. Dissolved oxygen (DO), pH and water temperature were measured by YSI-55 DO meter (YSI Incorporated, USA) connected to a probe.

RESULTS AND DISCUSSIONS

Wastewater treatment

The removal efficiency of different wastewater parameters namely NH_4^+-N, NO_2^--N, PO_4^{3-}, COD and TS in the four hydroponic systems cultured with different plant was monitored during operation of hydroponic systems. This was done to elucidate the capacity of different plants to treat wastewater, thus facilitating reuse.

Nitrogen removal

Nitrogen, which is a vital nutrient for plants, is generally assimilated by plants and rhizopheric microbes and in the way removes them the influent wastewater. Nitrogen can be present in wastewater in all the three forms of NH_4^+-N, NO_3^--N and NO_2^--Nand also get converted into one another and finally into gaseous nitrogen through the process of nitrification and denitrification. By the process of nitrification, ammonium-nitrogen (NH_4^+-N) is first converted into nitrite-nitrogen (NO_2^--N) by partial oxidation and then finally converted to nitrate-nitrogen (NO_3^--N) by the action of aerobic bacteria (nitrosomonas and nitrobacter) followed by the conversion of nitrate into nitrogen gas by denitrifying bacteria (Gee et al., 1990; Grunditz & Dalhammar, 2001). The first step in the nitrification is oxidation of ammonium to nitrite (Eq. 1) and the second step is the oxidation of nitrite to nitrate (Eq. 2):

$2NH_4^+ + 3O_2 = 2NO_2^- + 4H^+ + {}^2H_2O$……………………………………………………………..Eq. 1
$2NO_2^- + O_2 = 2NO_3^-$………………………………………………………………………………Eq. 2

Nitrification is performed by autotrophic bacteria belonging to the family *Nitrobacteriaceae* (Hauck, 1980). Denitrification, on the other hand, is carried out by a large number of heterotrophic bacteria, and all these bacteria needs organic carbon for their growth. The microbes present in the bed soil of the plants would have used the carbon present in the wastewater for their metabolism and in the process removed nitrogen from the wastewater. Furthermore nitrogen, which is a vital nutrient, is also needed for the growth of plants and some of the nitrogen could have been assimilated by the plants through the roots therefore demonstrating very high nitrogen removal efficiency (Rogers et al., 1991). Therefore, the hydroponic system employing these plants could efficiently remove nitrogen from wastewater.

Therefore, in the present investigation the concentration and removal of NH_4^+-N, NO_2^-–N was noted. The NH_4^+-N removal efficiency of 82.59 ± 0.47 %, 81.77 ± 0.41 %, 84.64 ± 0.83 % and 84.17 ± 1.02 % was observed for the hydroponics cultured with *C. asiatica, M. quadrifolia, I. aquatica* and *E. fluctuans*, respectively (Table 2). Not much difference in the NH_4^+-N removal efficiency can be found for all these plant species; therefore, emphasizing on the fact that all the four species were equally proficient in removing NH_4^+-N wastewater. However, hydroponic system with *M. quadrifolia* and *I. aquatica* demonstrated marginally higher removal efficiency in comparison to the other two plant species. Similarly for NO_2^--N removal, all the hydroponic systems illustrated approximately similar removal efficiency however, *M. quadrifolia* and *I. aquatica* showed slightly higher removal of NO_2^--N. Therefore, *M. quadrifolia* and *I. aquatica* were more efficient in terms of nitrogen removal from wastewater.

Phosphate removal

Phosphate is a nutrient, which is present in wastewater and if wastewater containing high levels of phosphate is discharged into surface waters, it can lead to dangerous algal blooms due to the process of eutrophication (Carpenter, 2005; Conley et al., 2009). Therefore, it's essential to remove phosphorus from wastewater prior to its disposal into the water bodies. Phosphate removal efficiency of 87.11 ± 0.19 %, 86.29 ± 0.95 %, 91.28 ± 1.30 % and 89.89 ± 1.16 % were observed for aquarium numbered 1 through 4, respectively, which were respectively80 %, 78 %, 88 % and 86 % higher than the phosphate removal efficiency noted for the control aquarium operated without any plants (Table 2).Therefore, in terms of phosphate removal, hydroponic system with *M. quadrifolia* and *I. aquatica* were more efficient in the removal of phosphate from wastewater. Previously, researchers have also demonstrated similar phenomenon, where plants of this two species effectively removed phosphorus through assimilation (Abbasi et al., 2018; Li et al., 2009).

Phosphate, which is an important nutrient for plant, is converted to phosphate, prior to its direct consumption by plants (Schachtman et al., 1998). Wastewater can contain numerous metal ions like iron, calcium, aluminium etc., hence phosphorus in wastewater can also be removed by chemical precipitation as phosphate salts (Eq. 3).

$3M^{x+} + xPO_4^{3-} = M_3(PO_4)_x$…………………………………………………………………………Eq. 3

In hydroponic system phosphorus is generally removed through uptake by the plants and assimilation by bacteria residing in the rhizosphere. The turnover of phosphate is essential for the metabolic balance in plants. Typically plants store phosphorus in the vacuole as free phosphate, and this storage is remobilized when phosphate is not available to the plants in sufficient quantity. Phosphorus is taken up by plant roots as phosphate, and the main use of this phosphorus is during the formation of adinosine triphosphate (ATP). Once incorporated in ATP, the phosphate group can be transferred in reactions to form the several phosphorylated compounds (Föhse et al., 1988). Therefore, phosphorous is imperative in the growth of plants and thus, it was assimilated by plants and hence treating the wastewater in the process.

Total solids removal

Total solids denoting the summation of dissolved solids and suspended solids should also be removed from wastewater prior to its disposal into surface water bodies. Wastewater containing higher concentration of suspended inorganic solids can reduce the effective capacity of ponds and lakes whereas, wastewater containing excess dissolved organic solids could lead to DO deficit thus hampering aquatic life. The TS removal efficiency was 56 %, 53 %, 76% and 74 % higher for aquarium 1 through 4, respectively, in comparison to the control aquarium. Therefore, the effect of plants on the removal of TS from wastewater can easily be envisioned. Furthermore, the highest TS removal efficiency was noted for Aquarium 3 and 4 cultured with *M. quadrifolia* and *I. aquatica*, which can be ascertained to the intermingled root structure of these plants. Thus, proficiency of these two species in the removal of TS from wastewater was elucidated.

A number of mechanisms are responsible for the removal of dissolved and suspended solids from the wastewater. One mechanism for the removal of dissolved solids is through plant uptake (Gersberci & MAN, 1986). A second mechanism for the removal of dissolved solids is through microbial activities. In aquatic plant-based treatment systems, microbial communities are primarily associated with the surfaces of litter, sediments and submerged plant parts (root zone) or may be dispersed throughout the water column. Similar to plants, sixteen elements are also essential for microbial growth and maintenance. Dissolved organic carbon is utilized by these microbial communities as an energy source and for cell synthesis and metabolism. A possible mechanism for the removal of suspended solids is through sedimentation, a process by which suspended particles settle from a wastewater under the influence of gravity. Moreover, suspended solids can also be removed through filtration of the wastewater when passing through the rhizophere containing root mats of the plants (Tripathi & Shukla, 1991).

COD removal

The COD is the measure of the amount of both inorganic and organic matter present in the sample of wastewater. Discharge of wastewater containing higher level of COD can be detrimental to the aquatic life forms present in the receiving water body. Therefore, removal of COD from wastewater prior to its discharge is necessary from the environmental aspect. The COD removal efficiency for all the hydroponic system was noted and the aquariums with *M. quadrifolia* and *I .aquatica* exhibited around 55% higher COD removal each in comparison to the control aquarium, whereas aquariums with *E. fluctuans* and *C. asiatica* demonstrated only 43% higher COD removal each in comparison to the control. As was the case for other wastewater parameters, the competency of *M. quadrifolia* and *I. aquatica* in the removal of numerous pollutants from wastewater was well exemplified.

One mechanism responsible for the reduction of COD from the wastewater is the decomposition of soluble organic carbon by microbial communities. In aquatic plant-based treatment systems, submerged plant parts in the root zone are typically covered with an active biofilm. Microbial communities may also be associated with the surfaces of litter and sediments and may be dispersed throughout the water column. According to Bouzoun et al. 1982, plant root density and root surface area are major factors affecting COD removal (Bouzoun et al., 1982). The greater the root surface area per unit volume of the root, the higher the removal of COD owing to the greater surface area of the finer root system, which provides more sites for microbial growth and attachment. Another mechanism for the reduction in COD is the filtration of suspended particles by plant root mats and adsorption of dissolved nutrients by plant roots. The COD of the effluent for all the hydroponic system employed in the present research had COD well within the Indian wastewater discharge standard and also below the maximum permissible COD value required for the reuse of treated sewage for aquaculture and landscaping purposes. Therefore, the proficiency of these hydroponics system for producing reusable quality treated water can be envisioned.

Pathogens removal
Pathogen removal employing these plants in the hydroponics system was also investigated by determining the initial and final MPN of the wastewater samples. Pathogens and coli forms are mainly removed in the rhizosphere and the same was noticed during the present investigation (Dires et al., 2018; Ottoson et al., 2005). For all the aquariums, 3 log scale removal of coliforms was noticed with the final MPN value of $3.5 \times 10^3 \pm 2.1 \times 10^2$ per 100 mL of the sample. Coliform removal in hydroponics doesn't depend on the type and species of the plant cultured and the same also observed in the present research (Ottoson et al., 2005; Williams et al., 1995). However, for the control aquarium, only single log scale removal of pathogens was noticed, thus emphasizing on the importance of plants and their roots present in the rhizosphere for the removal of pathogens from wastewater. Moreover, the final concentration of several pollutants in the wastewater discharged from the hydroponic systems was well within the required limit for the reuse of treated wastewater for aquaculture and landscaping (Table 3). Therefore, the effluent from this hydroponics can be reused for aquaculture and landscaping, as all the characteristics of the effluent complies with water quality standard required for this reuse purposes (Jana, 1998).

Growth of plants
The growth of the plants was regularly monitored by measuring their weight and length to elucidate the detrimental effect of wastewater if any, on the plants. Furthermore the physiological structure of the plants were carefully observed to figure out any indications of nutrient deficiency in them. However, no such signs were found in them and thus it could be envisioned that the plants were able to get the necessary nutrients for their growth from the wastewater supplied to them. Both the aquarium 3 and 4, containing *M. quadrifolia* and *I. aquatica*, respectively exhibited 23 and 25 times increment in length, respectively. Whereas, aquarium 1 and 2, containing *E. fluctuans* and *C. asiatica*, respectively demonstrated only 10 and 2 times increment in length over the period of 90 days (Figure 2). Similarly, *M. quadrifolia* and *I. aquatica* exhibited higher growth in terms of increment in weight (both with approx. 5 times increment in weigh), in comparison to *E. fluctuans* and *C. asiatica* (both with approx. 2 times increment in weigh). Furthermore, DO, pH and temperature of the effluent was also measured regularly these parameters were noted to be 25.2 ± 1.2 °C, 7.23 ± 0.42 and 0.78 ± 0.06 mg/l, respectively. This values are optimal for the growth of these plants in hydroponic system and thus, increment in the length and weight of the plants was noted.

Benefits of employing hydroponics for wastewater treatment
Hydroponic is a low-cost wastewater treatment option for grey water and low-strength wastewater (Norström, 2005; Osem et al., 2007). It doesn't require any external addition of nutrients and aeration for the treatment of wastewater. The quality of the effluent discharged from the hydroponic systems complies with the water quality standard required for the reuse of treated wastewater for aquaculture and landscaping (Table 3). Hydroponics can be setup in the backyard of housing complexes and small settlements for the decentralized treatment of wastewater. In the process of wastewater treatment, the plants can also be cultured, which sequesters atmospheric CO_2 thus alleviating the nuisance of global warming. Furthermore, the treated water can be reused for gardening, landscaping and aquaculture (Khalil & Hussein, 1997). As demonstrated by the present research, the plants cultured in the hydroponic system doesn't require external supplementation of nutrients, which is also a major advantage of the process. The plants in turn not only removes nutrients like nitrogen and phosphorus but also removes organic matter and pathogens thus providing holistic treatment to the wastewater. Therefore, hydroponic system can be envisioned as a low-cost, decentralized treatment of wastewater to facilitate reuse of the treated effluent.

CONCLUSIONS

The effectiveness of hydroponic systems cultured with four different plant species for wastewater treatment and plausible reuse of the treated effluent was evaluated. Among the four different plant species cultured in the hydroponic system, *M. quadrifolia* and *I. aquatica* demonstrated most efficient wastewater treatment in comparison to the other two plant species. Moreover, the growth rate of these two species both in terms of weight and length was also superior to the other two species namely, *E. fluctuans* and *C. asiatica*. The hydroponic system with plant cultured in them also demonstrated 3 log-scale coliform removal, thus, exemplifying efficient disinfection of wastewater. Furthermore, the effluent from these hydroponic systems had all the parameters below the prescribed limit required for the reuse of treated water for aquacultural and landscaping purposes. Therefore, low-cost hydroponic system can be envisioned as a decentralized treatment option of low-strength wastewater generated from toilets and other household activities. However, numerous operating parameters affecting the performance of a hydroponic system needs to be optimized prior to the successful field-scale demonstration of this inventive technology.

Conflict of Interest

The authors declare no competing conflict of interests.

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Table 1: Characteristics of the wastewater fed into the aquariums

NH_4^+(mg/L)	NO_2^- (mg/L)	PO_4^{3-} (mg/L)	COD (mg/L)	TS (mg/L)	MPN per 100 ml
6.21 ± 0.22	0.32 ± 0.01	6.53 ± 0.33	120.6 ± 11.2	175.25 ± 15.34	$7.5 \times 10^6 \pm 3.3 \times 10^4$

Table 2: Wastewater treatment observed in the hydroponic system

Aquarium no.	NH_4^+-N removal (%)	NO_2^--N removal (%)	PO_4^{3-} removal (%)	TS removal (%)	COD removal (%)
1	82.59 ± 0.47	94.35 ±0.49	87.11 ±0.19	67.86 ± 1.15	76.40 ± 0.78
2	81.77 ± 0.41	92.28 ±1.37	86.29 ± 0.95	66.67 ± 0.95	74.03 ± 0.86
3	84.64 ± 0.83	95.29 ± 1.07	91.28 ± 1.30	76.73 ± 1.67	80.93 ± 3.23
4	84.17 ± 1.02	95.85 ±0.52	89.89 ± 1.16	75.94 ± 1.97	80.17 ± 3.39
5	50.12 ± 4.23	53.25 ± 4.45	48.47 ± 3.39	43.65 ± 3.54	51.74 ± 4.67

Table 3: Characteristics of the effluent from different hydroponic systems

Aquarium no.	NH_4^+-N (mg/l)	NO_2^--N (mg/l)	PO_4^{3-} (mg/l)	COD (mg/l)	TS (mg/l)	MPN per 100 ml
1	1.09 ± 0.08	0.02 ± 0.01	0.87 ± 0.06	28.47 ± 2.51	62.59 ± 5.34	$3.5 \times 10^3 \pm 2.1 \times 10^2$
2	1.12 ± 0.08	0.02 ± 0.01	0.99 ± 0.07	31.81 ± 3.11	63.81 ± 5.65	
3	0.95 ± 0.07	0.02 ± 0.01	0.55 ± 0.04	21.49 ± 1.78	45.35 ± 3.78	
4	0.98 ± 0.06	0.01 ± 0.01	0.69 ± 0.05	23.71 ± 2.12	46.20 ± 3.97	
5	3.01 ± 0.02	0.14 ± 0.01	3.37 ± 0.02	56.57 ± 4.26	98.14 ± 8.51	$4.3 \times 10^5 \pm 1.2 \times 10^4$

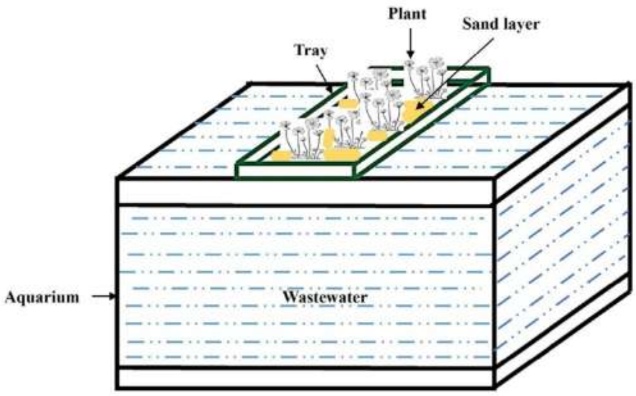

Figure 1: Schematics of the aquarium used in the research

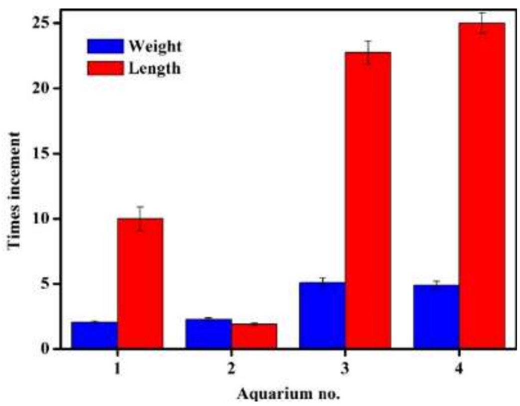

Figure 2:Increment in plants' length and weight after 90 days

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RESEARCH ARTICLE

Estimation of a Photovoltaic Cell Dimension for Irrigating Banana using Drip Irrigation System

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ABSTRACT

Maximum irrigation pumps in India are run with electricity due to its low price per unit water lift in comparison to the diesel operated pump. In recent years availability of fossil fuel is steadily declining and demand for energy is sharply growing. Therefore it is necessary to use conventional energy sources like diesel and petrol with higher use efficiency. Solar operated pump may be alternative for the small scale farmers irrigating the crops using drip system. The high initial cost of photovoltaic solar power makes it essential to calculate size of photovoltaic panel as accurately as possible. The primary objective of this study is to calculate the solar power required to operate drip irrigation system for banana orchard and to estimate the size of the solar panel required to generate the design energy. Crop water requirements of banana were estimated using Modified Penman-Monteith equation using locally recorded climatologically data. The crop water requirement of banana under drip was estimated as 1315 mm. The result found from the study shows that maximum daily irrigation water to be applied for banana in one hectare was about 50 m^3 in the month of May. The maximum daily power needed to pump 50 m^3 water from 25 m depth bore well was projected as 2.05 kWh/day. The energy required to pump irrigation water for drip irrigation may obtained by installing small size of the solar panel with 15.2 m^2 or 0.15% area of cultivable area. The current study showed positive a result for the use of solar energy as installation of solar panel to produce the designed power was occupied by very small cultivable area.

Keywords: Solar pump, photo-irrigation, crop water requirement, solar irradiation

INTRODUCTION

Banana (*Musa acuminate L.*) is best source of essential carbohydrates, vitamins, and minerals for the human diet. India secured the first position in banana production (29.6 million tons) and second in the production area (0.86 million ha) and contributes 19.71% to the global production (GoI, 2018). In recent times cultivation of banana becomes challenging risk in India as banana demands high and continuous water requirement and Indian agriculture facing acute shortage of water. The crop water requirement of banana is much higher in comparison to other fruit crops. The method of irrigation is one of the most vital thing influencing the quantity and quality of banana yield. The drip irrigation method may provide precise amount and at appropriate to get higher yield. With the drip irrigation system, water and nutrients can be applied directly to the plant at the root zone, having positive effects on yield and water savings and increasing water productivity (Sucharita *et al*., 2021). Many research studies recorded the benefits of drip irrigation systems for the cultivation of fruits and other crops (Tiwari *et al*., 2014; Sucharita *et al*., 2021; Santosh and Maitra, 2021, 2022). Owing to the beneficial effects of drip irrigation in banana crops, irrigation scheduling of banana has been studied (Santosh and Tiwari, 2019) and found a better results in terms of higher yield.

Agriculture is considered as high fossil fuel energy consuming sector in comparison to the domestic and Industries. Adequate power supply required for pumping water from source to operate drip irrigation system for sufficient time. The photovoltaic operated drip irrigation is becoming popular day by day due to increase in cost of fossil fuels. Demanding high initial costs for solar operated irrigation system make it necessary to estimate the exact power requirement to operate pump and correct dimension of solar array.Despite recent advances and an increase in the popularity of photovoltaic irrigation in India, there is a lack of information on the dimensions of photovoltaic cells based on the water requirement of different crops. Therefore, current study is aimed to determine the size of solar array for operating pump for irrigating banana crop using drip irrigation. Further, the study addresses some of the Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), SDG 6 (clean water and sanitation) and SDG 15 (life on land) (UN, 2021).

MATERIAL AND METHODS

Analyzed the available climatic data recorded at soil and water conservation field laboratory, Centurion University of Technology and Management (CUTM), Paralakhemundi to determine the crop water requirement of banana crop. The daily irrigation water requirement of a banana using drip irrigation was estimated by using the following equation

$WR = ET_0 x\ K_c\ x\ Wp\ x\ A$ ---- (1)

where,

WR = Crop water requirement (L day^{-1})

ET_0= Reference evapo transpiration (mm day^{-1})

K_c = Crop co-efficient

Wp = Wetting fraction (taken as 0.4 for banana crop)

A = Plant area, m^2 (i.e. spacing between rows, m x spacing between plants, m).

The daily meteorological data recorded for the years 2017-2021 were used to compute reference evapo transpiration (ET_0). The modified Penman-Monteith method suggested by Allen *et al*. (1998) was used to compute reference evapo transpiration (ET_0). The K_c values of banana taken as 0.5, 1.1 and 0.7 for initial, development stage and harvest stage respectively (Allen et al., 1998). The product of daily reference evapo transpiration value (ET_0) and crop growth stage-wise K_c values gives the daily ET_c values. The product of ET_c, area of plants occupied (A) and wetting percentage (Wp) gave volume of crop water requirement (WR). Total quantity of water required to irrigate banana in one day for 1 ha (Q) was found by multiplying the WR with the plant population in 1 ha (2500 plants/ha).

The pumping power required was calculated using the Equation

$E_H = \varrho gQH / 3600$ --- (2)

where,
E_H is the daily energy required to pump a volume Q to an elevation H
ϱ is the density of water, 1000 kg/m^3
g is the gravitational constant, 9.81 m/s^2
Q is the total daily crop requirement of banana for 1 ha
H is the elevation up to which water has to be lifted
Then, the maximum energy required from the photovoltaic generator, E_{el}, will be

$E_{el} = E_H R / G_d \mu_G \mu_I \mu_{MB}$ (Cuadros et al., 2004). ---(3)
where,
E_{el} is the maximum energy required from the photovoltaic generator
R = 10% E_H (Energy losses due to friction of the water in the irrigation system)
G_d = The fraction of the day during which solar radiation is above the threshold at which the pump starts to work $G_d > G_{threshold}$ (0.95)
μ_G = The yield of the photovoltaic generator (0.85)
μ_I = The yieldof the AC/DC converter (0.90)
μ_{MB} = The yield, μ_{MB}, of the pump (0.43)

Hence,
$P_p = E_{el} / h$
where,
P_p = power required for water pumping
h = is the number of hours of peak sun per day
To find out the size of the solar panel following equation is used

$A_s = Pp / I_p \eta_{sa}$ --- (4)

where,
A_s = is the required solar panel array area
I_p = is the average amount of solar radiation incident on a panel during the peak sunshine hours, 1000 W/m.
η_{sa} = is the efficiency of the solar array and its electronics, <14% (Deutsche Gesellschaft für Sonnenenergie, 2008).

RESULTS AND DISCUSSION

The FAO-56 Modified Penman-Monteith (PM) equation used for estimating reference evapotranspiration. Recorded climatic data such as temperature, relative humidity, wind velocity and sun shine radiation are primary parameters to estimate reference evapotranspiration (ET_0). The ET_0 was found on daily basis using Modified Penman Montieth equation and the recorded weather data. The estimated ET_0 values presented as monthly average of daily ET_0 values in the Table 1. From the Table 1 it can be found that the maximum daily ET_0 was found in the month of May (5.7 mm/day) and minimum in December (2.3 mm/day). The values of ET_0 were multiplied with crop coefficient values (K_c) to get the crop evapotranspiration for banana and presented in the Table 1. Maximum ET_c (4.99 mm/day) and minimum ET_c (1.46 mm/day) values found for the May and December months respectively. Multiplying ET_c with the area of banana plant i.e. 4 m (2m plant to plant spacing and 2m row to row spacing) and wetting fraction of 0.4 gave the daily banana water requirement (WR) in liter per day per plant. From Table 1 it can found that the value of WR ranging in between 5.83 L/day in December and 19.94 L/day in May month. The total irrigation water (Q) was the product of number of banana plants in one hectare and WR of single banana plant in one day. The estimated daily Q values were presented as monthly average in the Table 1. Table 1 show that maximum irrigation water required for irrigating one hectare banana was found to be 50 m^3/day.

The photovoltaic cell size was determined to meet the irrigation requirement using above given equations (Eqn. 2 to Eqn. 4). The daily sun shine hours needed for generating solar power and daily mean temperature was presented as monthly average values in Table 2. From Table 2 it can be found that the average sunshine hours ranging between 4 to 7 hours in which maximum sunshine hours recorded in May and minimum in the month of December. Peak required photovoltaic power (P_p) and area of solar panel array is determined and presented in the Table 3 for all the months. From the Table 3 it was found that P_p for different months are ranging between 938 Wh/day (January) and 2005Wh/day (April). The minimum area (7.1 m^2) of solar panel is required to pump the water required to irrigate the one hectare banana in the month of January and maximum area (15.2 m^2) of solar panel required to irrigate banana for the same area in April month. Therefore it can be concluded that the 15.2 m^2 area or 0.15% planted of solar panel is sufficient to irrigate the banana in one hectare area for whole year. The similar results were found by Persad et al. (2011) for hot pepper.

CONCLUSION

The current study shows that maximum daily water required to irrigate one hectare of banana using drip irrigation was estimated as 50 m^3/day in the month of May. The maximum solar energy needed to operate the pump for required discharge was estimated as 2005 Wh/day for the month of April. The maximum size of solar panel required to achieve the design power was estimated as 15.2 m^2 which was 0.15% of the cultivable area.

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Table 1. Monthly average of daily irrigation needs for bananaunder drip irrigation

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET_0, mm	2.5	3.0	4.4	5.8	5.7	5.3	4.0	3.7	3.1	2.9	2.9	2.3
ET_c, mm	1.60	2.72	4.29	4.94	4.99	4.29	3.67	3.36	3.09	2.04	1.95	1.46
WR, L/day	6.41	10.90	17.18	19.76	19.94	17.16	14.69	13.44	12.35	8.16	7.79	5.83
Q, m^3/day/ha	16	27	43	49	50	43	37	34	31	20	19	15

ET_0=reference evapotranspiration; ET_c=crop evapotranspiration; WR= daily water requirement of banana; Q=total water required to irrigate banana in one hectare land in a day.

Table 2. Peak number of sun hours and average maximum monthly temperatures

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sun hours, hr	4.5	5.0	6.0	6.5	7.0	7.6	7.8	7.0	6.4	5.2	4.5	4.0
***Max. Temp.**	23.3	24.4	27.9	30.1	29.8	29.7	29.6	28.7	29.1	27.6	25.3	22.3

*Maximum monthly average of daily temperature

Table 3. Pumping power and the solar size required for irrigating banana under drip irrigation

Month	Q, (m^3/day)	h (h)	E_H (Wh/day)	E_{el} (kWh)	P_{el} (kw)	P_p (Wh/day)	A_s (m^2)
Jan	16	4.5	1091.2	3840.9	853.5	938.9	7.1
Feb	27	5.0	1855.7	6532.1	1306.4	1437.1	10.9
Mar	43	6.0	2926.0	10299.3	1716.5	1888.2	14.3
Apr	49	6.5	3366.0	11848.1	1822.8	2005.1	15.2
May	50	7.0	3396.6	11955.8	1708.0	1878.8	14.2
Jun	43	7.6	2922.7	10287.9	1353.7	1489.0	11.3
Jul	37	7.8	2502.5	8808.9	1129.3	1242.3	9.4
Aug	34	7.0	2288.5	8055.6	1150.8	1265.9	9.6
Sep	31	6.4	2103.0	7402.6	1156.7	1272.3	9.6
Oct	20	5.2	1389.6	4891.4	940.6	1034.7	7.8
Nov	19	4.5	1326.2	4668.0	1037.3	1141.1	8.6
Dec	15	4.0	992.8	3494.5	873.6	961.0	7.3

Q = Gross daily irrigation rate; EH = hydraulic energy; R = friction losses in the conduit system; E_{el}= electricalenergy required in pumping; P_{el}= Electrical power required in pumping; P_p= peak required photovoltaic power; A_s = required solar panel array.

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RESEARCH ARTICLE

Influence of Chemical and Physical Method of Weed Management on Productivity, Economics and Weed Efficiency of Sunflower (*Helianthus annuus*L.)

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ABSTRACT

The field experiment was carried out to study the influence of chemical and physical method of weed management on productivity, economics and weed efficiency of Sunflower under Bagusala Farm of Centurion University of Technology and Management CUTM, Odisha. The experiment was laid out in Randomized Block Design and consisting of nine treatments which were replicated thrice. The data recorded on yield, economics and weed efficiency of Sunflower whereas, the seed yield was favorably influenced by weed control treatments. Lesser weed competition during critical period of crop growth resulted in enhanced yield. yield, economics and weed efficiency was significantly higher in Pendimethalin @ 0.75 kg/ha at 1 DAS followed by Sodium aciflurofen + Clodinafoppropargyl @125 g/ha at 21 DAS and straw mulching @ 5.0 t/ha at 30 DAS registered lower.

Keywords: Sunflower, Weed, Herbicides, Yield, Economics, Efficiency and index

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is popularly growing oilseed crops in India known as "Surajmukhi". It is the 3rdmost important producing oilseed crop in the world after soya bean and mustard. It was the first introduced crop to India as an edible oilseed crop during 1969. Poly unsaturated fatty acids (PUFA) is the major source of edible oil. Sunflower is a photo-thermo insensitive crop (Sarkar *et al.*, 2005; Sandeep Kumar *et al.*, 2019) which promises for its cultivation to enhance the oilseed production. The total cultivated acreage, production and productivity of sunflower are 2.80 lakh ha, 2 lakh tonnes and 527.5 kg/ha, respectively (Anonymous, 2018). Nowadays, sunflower increased in its production due the health conscious and income generation. India has witnessed a huge demand for sunflower oil in recent years due to its edibility, health benefits, providing a good source of income for the farmers. The southern states of

India depend on the consumption of Sunflower oil, *i.e.*, around 70 per cent. The residue of Sunflower, also called as "oil cake is also used for poultry feed. Bihar achieved the mark of highest productivity region with an average yield of 1402 kg/ha. The major sunflower producing states in India are Karnataka, Maharashtra, Tamil Nadu, Andhra Pradesh and Telangana. The aberration in biotic and abiotic factors has devasted the sunflower productivity in India (Maitra *et al*., 2022). There are different biotic and abiotic factors like weed competition being one of the major biotic constraints. The sunflower productivity gets affected mostly in irrigated conditions due to extra spacing in sowing seeds and higher dose of fertilizer applications. The intensity of weed infestation in sunflower differs with different locations and ultimately involves the competitive relationships between crops and weeds, leading to lower or higher yield losses (Vrataric, 2004; Pattanayak *et al.*, 2022; Maitra *et al.*, 2017).

Sunflower requires a wide spacing but it tends to fast weed emergence with a free growing climate, involving crop competition for different growth inputs like nutrients, light, space and water from the soil. The Critical period of weed competition in sunflower crop varies from 20 to 49 days after sowing depending on different factors influencing growth of crop (Wanjari *et al.*, 2000; Sharma *et al*., 2020). Daugovish *et al.* (2003) reported that the intensity of weed competition affects different physiological and morphological functions in the crop. Around 58 % of the functioning gets affected due to intensive weed competition (Hassan *et al*., 2012). The performance of crop in terms of seed yield or biological yield can get reduced by 50 % or higher if the focus on weed management is not considered as a priority (Mohassel *et al.,* 2009). Sunflower crop cannot act as a good competitor to weeds due to its slow growth in the initial stages thereby enhancing weed growing opportunities (Selvakumar *et al*., 2018). The effectiveness of any applied herbicide gets affected by different factors like selection of herbicide, application methods, dosage of herbicide, spray volume, weed species, soil and environment conditions (Renukaswamy Ullah *et al*., 2012; Kundu *et al*., 2020; Inuganti *et al*., 2021). The problem of productivity of sunflower and cost of cultivation can be resolved by including hand weeding as an additional and useful option rather than application of herbicide as a cultural method alone. Out of the 17 SDGs suggested by UNDP, the residual effects of weed management on sunflower have the potential to fulfill SDG 2, 3 and 15 (FAO, 2021).

MATERIAL AND METHODS

The field experiment was conducted during the *Rabi* season of 2020-21 at the agricultural research farm of M.S Swaminathan School of Agriculture of Centurion University of Technology and Management, Paralakhemundi campus, Odisha. Geographically, the experimental site was located at a latitude of 18.80°N and 84.20°E longitude with an altitude of 61 m above the mean sea level under typical sub-humid and sub-tropical climatic conditions. It lies in the agro-climatic zone of North – Eastern ghat of Odisha state, India. The experiment comprised of nine treatments namely, T_1 (Pendimethalin @ 0.75 kg/ha at 1 DAS + Inter cultivation at 15 and 30 DAS); T_2 (Oxyfluorfen @ 100 g/ha at 1 DAS + Inter cultivation at 15 and 30 DAS); T_3 (Clodinafoppropargyl @ 125 g/ha + Sodium aciflurofen at 21 DAS); T_4 (Pendimethalin @ 0.75 kg/ha at 1 DAS followed by Clodinafoppropargyl @125 g/ha + Sodium aciflurofen at 21 DAS); T_5 (Oxyfluorfen @100 g/ha at 1 DAS followed by Clodinafoppropargyl @150 g/ha + Sodium aciflurofen at 21 DAS); T_6 (Inter cultivation at 15 and 30 DAS); T_7 (Straw mulching @ 5.0 t/ha at 30 DAS); T_8 (Weed free); T_9 (Un weeded control). Weed samples were collected following the quadrate method of 0.25 m^2 from four places in each plot to find out the total weed density and dry weight of the weed.

Weed dry weight, was recorded after drying the weed samples at 72°C till constant weight was recorded.The net plots area was4.8m × 4.2m.The experimental field was ploughed thoroughly with disc plough, harrowed and plots were laid out after leveling. Ridges were formed 60 cm apart. The Recommended dose of N, P and K (80: 60: 40 kg ha^{-1}) was applied as per the guidelines of the state agricultural board. The fertilizers urea (containing 46 % N), single super phosphate (16 % P_2O_5) and muriate of potash (60 % K_2O) were applied in the different treatment plots of the experiment. Half dose of N and full doses of P and K were applied to all the treatments at first and the remaining 50% N was top dressed at 30 DAS. Gap filling is done after 7 to 8 DAS,thinning was done on 15 DAS leaving a single healthy seedling per hill to maintain uniform population in all the plots. Pendimethalin @ 0.75 kg/ha at 1 DAS and

Oxyfluorfen @100 g/ha at 1 DAS were used as pre-emergence applications. The weedicides Sodium aciflurofen + Clodinafoppropargyl @150 g/ha at 21 DAS were used as post-emergence application. The Statistical analysis was carried out following the standardized method suggested by Gomez and Gomez (2010) at critical difference (CD) of 0.05 per cent level of probability for pertaining the accurate data of the experiment.

RESULT AND DISCUSSIONS

The Seed yield from the plants and economical advantage was influenced by weed control treatments and represented in Table 1 and Fig 1, respectively. The decreased weed competition during critical crop growth period resulted in enhanced yield attributing characters. Pendimethalin @ 0.75 kg/ha at 1 DAS followed by Clodinafoppropargyl @125 g/ha + Sodium aciflurofen at 21 DAS (T_4) produced larger head diameter, maximum 100 seed weight and maximum seed yield and got significantly at par with Oxyfluorfen @100 g/ha at 1 DAS *followed by*Clodinafoppropargyl @125 g/ha + Sodium aciflurofen at 21 DAS (T_5). Muro*et al*. (2001) and Barros *et al*. (2004) revealed that the number of seeds per head is the mostly affected yield components due to various biotic and abiotic stresses and it ultimately produces lower sunflower yield. In the present study the increased percentage. Similar findings were reported by Gill and Paul (1984) in sunflower. Higher yield attributes was observed due to more conversion of source to sink due to higher translocation due to favorable growing condition. The cost of cultivation was maximum in farmers practice (Rs. 30975/ha) and was lowest due to no application of weedicides in unweeded check plot. The highest gross return was obtained from the treatment pendimethalin @ 0.75 kg/ha as PE at 1 DAS *fb*clodinafoppropargyl + sodium aciflurofen (Rs.59160/ha) and fb by oxyflurofen@100g/ha at 1 DAS fb sodium aciflurofen + clodinafoppropargyl at 21 DAS(Rs58500/ha). The application of pendimethalin @ 0.75 kg/ha as PE at 1 DAS fb sodium aciflurofen+clodinafoppropargy @125g/ha at 21 DAS, produced the highest net return (Rs.34256/ha) followed by oxyflurofen@100g/ha at 1 DAS fb sodium aciflurofen + clodinafop propargyl@125g/ha at 21 DAS(Rs.33325/ha). The cost benefit ratio was highest in pendimethalin@0.75 kg/ha applied as PE at 1 DAS fb sodium aciflurofen + clodinafop propargyl@125g/ha at 21 DAS (1.38) and the Oxyfluorfen @100 g/ha at 1DAS fb sodium aciflurofen + clodinafop propargyl@125g/ha at 21 DAS that produced the next highest value (1.32). This variation in data is due to the higher economic yield, net return and lower cost of cultivation. The increased benefit of these treatments is the increased seed yield from the sunflower crop (RahmatUllah*et al*., 2011; SathyaPriya*et al*., 2011; Zahan*et al*., 2021).

Weed control efficiency and Weed Index (%)

Weed control efficiency was estimated based on the weed count. Among the different weed management practices, Pendimethalin.@ 0.75 kg/ha at 1 DAS followed by Clodinafoppropargyl @ 125 g/ha + Sodium aciflurofen at 21 DAS (T_4) registered higher weed control efficiency followed by Oxyfluorfen @100 g/ha at 1 DAS fbClodinafoppropargyl @ 125 g/ha + Sodium aciflurofen at 21 DAS (T_4). The lowest weed control efficiency was registered in Straw mulching @ 5.0 t/ha at 30 DAS (T_7). The Higher WCE is due to the effective weed control strategy that resulted in lower weed density. This is due to effective weed control achieved due to efficient weed management methods like, reduced biomass of weeds at initial stage by early applications of herbicides and competitive effects of weed control by other herbicides in later stages. This provided weed free situation resulted in higher weed control efficiency. Singh *et al*. (2001) reported that weed free plot represented 100% WCE followed by pendimethalin at 1.5 lit ha^{-1} + one hand weeding.Weed index is referred to extent of yield loss due to severe competition during criticalcrop-weed competition period. The data worked out on weed index are presented in Table 1. The results indicated that the lower weed index (1.11%) was registered under Oxyfluorfen@100g/ha at 1 DAS fbClodinafoppropargyl @125g/ha + Sodium aciflurofen at 21 DAS. This might be due to the effective elimination of weed species by the herbicide at germination phase. The next best treatments were seemed to be Farmers practice(T_9), registered (2.23).The higher weed index value of 46.95 per cent was documented under Un weeded control (T_9) this might due to presence of more weeds. Pendimethalin@0.75kg/ha at 1 DAS fb Sodium aciflurofen + Clodinafoppropargyl @ 125 g/ha at 21 DAS (T_4) is considered to be the best treatment to calculate the weed index (Inuganti *et al*., 2021).

CONCLUSION

The stability in yield, economics and Weed control efficiency with lesser weed infestation arises the need based weed management practice of applying Pendimethalin @ 0.75 kg/ha at 1 DAS fbClodinafoppropargyl @125 g/ha + Sodium aciflurofen at 21 DAS is recommended for enhancing yield of sunflower followed by Oxyfluorfen @100 g/ha at 1 DAS *fb*Clodinafoppropargyl @125 g/ha + Sodium aciflurofen at 21 DAS. The efficient weed index was registered under Oxyfluorfen@100g/ha at 1 DAS fb Sodium aciflurofen + Clodinafoppropargyl @125g/ha at 21 DAS closely followed by Farmers practice (Two hand weedings + one hoeing). This result highlights the importance of this experiment thereby concluding the importance of weed management strategies in sunflower crop.

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Table 1. Influence of chemical and physical method of weed management on economics of sunflower

Treatments	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_1: Inter cultivation at 15 and 30 DAS + Pendimethalin @ 0.75 kg/ha at 1 DAS	50700	29205	21495	0.74
T_2:Oxyfluorfen @ 100 g/ha at 1 DAS + Inter cultivation at 15 and 30 DAS	47700	29075	18625	0.64
T_3: Clodinafoppropargyl @ 125 g/ha + Sodium aciflurofen at 21 DAS	45180	24175	21005	0.87
T_4:Pendimethalin @ 0.75 kg/ha at 1 DAS followed by Clodinafoppropargyl @ 125 g/ha + Sodium aciflurofen at 21 DAS	59160	24904	34256	1.38
T_5:Oxyfluorfen @100 g/ha at 1 DAS fbClodinafoppropargyl @ 125 g/ha + Sodium aciflurofen at 21 DAS	58500	25175	33325	1.32
T_6:Inter cultivation at 15 and 30 DAS	41220	28475	12745	0.45
T_7:Straw mulching @ 5.0 t/ha at 30 DAS	37500	27475	10025	0.36
T_8:farmers practice(Two hand weedings+ one hoeing)	57840	30975	26865	0.87
T_9:Unweeded (control)	31380	23475	7905	0.33

Table 2. Influence of chemical and physical method of weed management on weed control efficiency (WCI) weed index and of sunflower

Treatment	WCE (%)	WI (%)
T1: Inter cultivation at 15 and 30	54.33	14.30
T2:Oxyfluorfen @ 100 g/ha at 1 DAS + Inter cultivation at 15 and 30 DAS	51.92	19.37
T3: Clodinafoppropargyl @ 125 g/ha + Sodium aciflurofen at 21 DAS	44.16	23.63
T4:Pendimethalin @ 0.75 kg/ha at 1 DAS followed by Clodinafoppropargyl @ 125 g/ha + Sodium aciflurofen at 21 DAS	72.38	0
T5:Oxyfluorfen @100 g/ha at 1 DAS fbClodinafoppropargyl @ 125 g/ha + Sodium aciflurofen at 21 DAS	70.29	1.11
T6:Inter cultivation at 15 and 30 DAS	35.42	30.32
T7:Straw mulching @ 5.0 t/ha at 30 DAS	28.74	36.6
T_8:farmers practice(Two hand weedings+ one hoeing)	60.47	2.23
T_9:Unweeded (control)	0.00	46.95

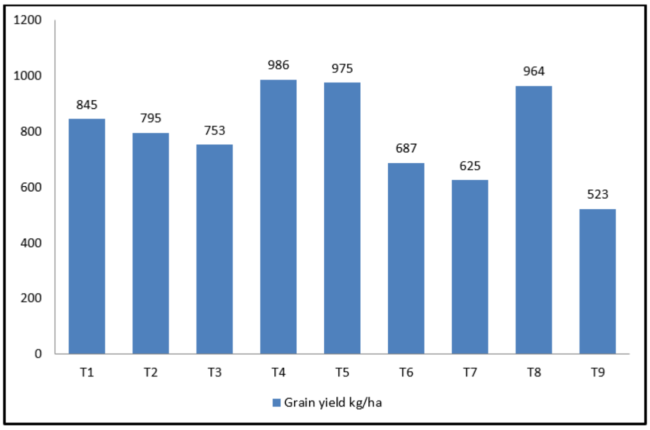

Figure 1. Influence of chemical and physical method of weed management on seed yield(kg/ha) of sunflower

REVIEW ARTICLE

Response of Plants to Water Deficit Stress- A Review

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ABSTRACT

Water is most essential for the survival of living organisms on this planet. Excess or deficit moisture for a prolonged time adversely determines the plant growth and productivity. Primarily, water stress impairs the photosynthesis, alters the pigment concentration, induces abscisic acid production which in turn leads to stomatal closure, destabilizes the harmone balance etc. Consequently, uptake and translocation of ions and water were also minimized. Plants has an inbuilt mechanism to resist this stress. The current review highlighted the mechanisms that control plant response to water stress and provides a detailed understanding on signal cascading which stimulates the counter response to water stress which in turn strengthen the application of biotechnological tools in imparting the drought stress tolerance withoutimparing the crop quality and productivity.

Keywords: ROS, drought, resistance, signalling cascades, abscisic acid

INTRODUCTION

Water is the most crucial component of the plant as it makes up 90% of the plant's body (Imadi *et al*., 2016). Water is directly involved in many morphological, biochemical and physiological processes of the plant. Excess or deficit moisture adversely affects the productivity. Water stress is commonly caused by drought resulting in lower yield and with the advancement in severity it might cause a complete crop failure. In the advent of climate change water scarcity has been a challenging issue for agricultural production. The plant is changing dramatically as a result of population growth and environmental change (Ray and Ray, 2011; Bhadra *et al*., 2021). To feed the rapidly growing population with shrinking resources it is increasingly critical to boost the productivity of agricultural crops. At the current pace of population growth, if productivity does not rise, people will starve to death (Kousar *et al*., 2021).

Morphologically the plants when supplied with inadequate amount of water for a prolonged time was reported to increase the root to shoot ratio, reduction aerial growth and shows leaf wilting etc (Othmani *et al*., 2015). However, physiologically reduction in photosynthesis and increased respiration rate are the common symptoms. These ultimately leads to affect the normal crop growth and productivity. The adaptation to deficit soil moisture stress differs from one plant to other. This difference in water stress adaptation was mainly attributed to the different short, medium and long term responses that were elicited by the plants upon exposure to water stress, respectively (Bolat et al., 2014). The pace with which these responses initiated upon stress exposure depends on the stress signal transduction pathway in that plant which determines the ability of a plant to resist stress.

Short term responses in plants to drought stress was mainly associated with closure of stomata and minimization the transpiration rate. This prevents the loss of water balance from the plant and helps in maintaining the turgidity of cells facilitating normal functioning of the plant (Martinez-Ballesta *et al*., 2009). Osmotic adjustment is a medium term response to water deficit stress. This mainly helps in establishing osmotic pressure in a right direction attributing to improve water uptake by the plant (Slama *et al*., 2011). While, the long term responses are associated with genetic responses to tolerate water deficit stress, respectively. To cope with water stress, through understanding on molecular and biochemical responses to water stress is essential. Keeping this in mind, the present review holistically covered plant signalling mechanism stimulated in response to water deficit stress and its ability to protect the plants from deleterious effects caused by drought.

Signal Transduction Pathway

In general, drought was perceived by two membrane bound histidine kinases regulated by osmolarity. Under drought, increase in osmolarity through addition of solutes stimulates the hydrolysis of phospholipase C (PLC) into diacylglycerol (DAG) and inositol 1,4,5 triphosphate (IP3). Further, IP3 triggers calcium signalling by activation of calcineurin B like protein which activates the productions of several drought responsive protein kinases which plays a protective role in protein and membrane stabilization, respectively (Shabala *et al*., 2021). On the other hand, guard cells when exposed to drought upregulates the abscisic acid concentration which binds to ABA receptors and facilitates the efflux of anions resulting in closure of stomata (Katul *et al*., 2010). Another most common response to drought stress is reactive oxygen species (ROS) secretion. The ROS secretion has both beneficial and detrimental role under drought stress. At low concentrations ROS plays a role as a signalling molecule and confers resistance to drought stress (Cruz de Carvalho, 2008). However, with the increase in the concentration of ROS attributes to lipid peroxidation leading towards increased membrane instability (El-Beltagi and Mohamed, 2013). Increased fluidity of membranes confers leaking of cellular fluids resulting in ion imbalance in the cell. Henceforth, resistant plants consists of several ROS scavengers to withstand the adverse effects of ROS upregulation beyond the optimum concentration.

Response of Photosynthesis and Respiration to Water Stress

The photosynthesis is severely inhibited due to water stress. The stomatal closure phenomenon that is associated to conserve water loss from the plant on the other hand reduces the carbon dioxide entry into the plant thereby adversely affecting the carbon assimilation process (Yang *et al*., 2021). In addition to this reduction in leaf surface area also reduces the photosynthesis. Among C3 and C4 plants the plants with C4 mechanism are more tolerant to water stress impacts (Noia Junior *et al*., 2018). Since, due to high photosynthetic efficiency more carbon dioxide can be assimilated and normalize photosynthesis with limited time span of stomatal opening. Moreover, the photosynthetic pigments were also affected negatively upon exposed to stress. The imposition of acidic nature to the stroma of chloroplast is associated with the inhibition of the activity of key photosynthetic enzyme *viz.* RUBISCO and subsequently, the activity of other enzymes were reported to be down regulated upon exposure to water deficit stress (Grieco *et al*., 2020). In contrast, the xanthophyll concentration was observed to be upregulated under the influence of drought due to its protective role in inhibiting the ROS induced due to electron instability (Roach *et al*., 2015).The response of respiration to water stress was biphasic. It depends on the species and the age of that particular plant. In general, under water deficit stress the respiration was initially reduced due to reduction in leaf area (Imadi et al., 2016). However, increased metabolic activities to adapt to these unfavourable condition later reported to increase the respiration rates under optimu, temperature ranges (Dijkstra *et al*., 2011).

Response of Water Stress on Plant Biochemicals

The soluble sugars were reported play a major role in osmotic adjustment. The plant cells with more carbohydrates were reported to withstand drought stress more efficiently than vice versa (Seleiman *et al*., 2021). Turgor is most important for normalizing various plant metabolic activities. Therefore, accumulation of solutes in the form of carbohydrates stored in the vacuoles consequently results in lowering the osmotic potential and increases the potential to pull the water from external medium (Gorai *et al*., 2011)**.** Similarly, drought responsive proteins *viz.* dehydrins, late embryonic abundant (LEA), drought responsive element binding (DREB) etc. were upregulated to prevent the disorganization of protein structure and to impart hardiness to function normally under unfavourable water deficit stress (Yu et al., 2018). Several studies indicated the upregulation of heat shock proteins (HSP) in response to water stress which act as a molecular chaperones and helps in regulating the protein structure stability (Lang et al., 2021).

ABA Mediated Response to Water Deficit Stress

Stomata are crucial structures in plant leaves that regulates the absorption of carbon dioxide, oxygen, and water from the environment. When it comes to the opening and shutting of the stomata, abscisic acid plays a crucial crucial. Stomatal opening and closing mechanism determines ion and water uptake into the plant system (Brodribb and McAdam, 2017). Plants need to open their stomata throughout the day to obtain carbon dioxide and water, but they also need to close them at extremely high temperatures to avoid water loss.Guard cells control the opening and shutting of stomata. Water stress reduces stomatal activity, which reduces carbon dioxide absorption and, as a result, decreases photosynthesis and plant development (Kamiloglu *et al*., 2014). Drought-induced ABA biosynthesis causes the stomata to close, immediately upon signal perception. The 9-cis Pepoxycarotenoiddioxygenase 3 (NCED3) enzyme is involved in the ABA biosynthesis pathway and contributed to improve drought resistance and water usage efficiency (WUE). NCED increases ABA accumulation in the xylem saps of several leaf components via promoting ABA production (Erpen*et al*., 2018). Drought stress lowers PM-ATPase activity, which raises the pH of the cell wall. The ABA is delivered to the guard cell by passive diffusion and particular receptors in response to pH. ABA transporters are ABCG 25 and ABCG 40 (ATP-binding cassette transporters) and AIT1 (Nitrate transporter family). ABCG25 is an ABA exporter in the ABA transport system, while ABCG 40 and AIT1 are ABA importers (Borghi*et al*., 2015).

Drought stress activates the ABA signalling pathway, which drives the formation of reactive oxygen species (ROS) and causes oxidative stress in plants. It also raises cytosolic $Ca2+$, which activates various channels including C+ and k+ in the vacuole and guard cell membrane (Huang *et al*., 2019). Apart from that, the guard cell membrane has a proton pump that pumps proton H+ from the guard cell to the exterior of the cell. The plasma membrane depolarizes as a result of this outflow. The potassium transporters can both ingress and efflux potassium ions, however the guard cell membrane's chloride channels can only export calcium ions (Gotoh*et al*., 2019). When the abscisic acid receptor binds to the abscisic acid ligand, the signalling is stored. Calcium ion influx into the cytoplasm of the guard cell as a result of this interaction (Kim *et al*., 2010). The rate of calcium ion influx inside the guard cell is increased by ROS. Inside the guard cell, both calcium influxes result in a high calcium concentration. Ca+ ions engage with the k+ inflow pump and deactivate it, preventing k+ from being carried within the guard cell. They also impede the activity of the proton pump, preventing proton outflow. As a result, the concentration of H+ inside the guard cell rises, making the interior acidic and the outside alkaline (Rogiers*et al*., 2017). As a consequence, the K+ pump turned on and began pumping K+ outdoors.This ion migration caused an osmotic imbalance, which reversed the impact of water moving from a low solute concentration to a high solute concentration. As a result, water travels from the guard cell to the outside via particular water transporter channels found in the guard cell, such as aquaporins. During drought stress, net water flow leads guard cells to flaccid and stomata to close.

Transcription Factors

Drought stress has an impact on plants at all levels, from phenological and morphological to molecular. Several genes are expressed in response to water stress. The drought response gene may be separated into ABA-dependent and ABA-independent genes based on their ABA induction dependence. When dehydration occurs, these genes are activated. Different transcriptional factors involved in water stress response include MYB, MYC, DREB/CBF/ABF/AREB, and NAC (Nakashima *et al*., 2014).SnRk2 regulates ABF/AREB gene expression in a direct manner (AB receptor complex). SnRk2 modulates ABA signalling and so plays a crucial part in the plant's drought adaption response. Another important transcription factor, C_2H_2 regulates the expression of genes involved in H_2O_2 homeostasis. During drought stress, transcription factors like CYP707A3 suppresses transcription. SNAC1 overexpression increases ABA sensitivity and draws stomata closer together.

CONCLUSION

Plants being sessile possess several mechanisms to withstand the unfavourable environments. Unravelling these mechanisms is essential to understand the plants response to water stress. This review clearly highlighted and provided a clear understanding on the response of water stress in morphological, physiological and biochemical characteristics of plants. Consequently, might help to enhance our ability to manage a crop under water stress.

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RESEARCH ARTICLE

Performance of Deep-Water Rice (*Oryza sativa* L.) Cultivars as Influenced by Different Planting Variables for Growth and Productivity in New Alluvial Zone of West Bengal

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ABSTRACT

The field experiment was carried out at Instructional Farm, Jaguli, B.C.K.V., Nadia, West Bengal, situated at 22°56′ N latitude, 88°32′ E longitude and at an elevation of 9.75 m above the mean sea level during the *kharif* season of 2006,The soil of the experimental site was endowed with typical Gangetic Alluvium (Entisol) having sandy loam texture with medium fertility. The experimental site falls under sub-tropical humid. The average maximum temperature was 34.15°C and minimum was 21.31°C. The rainfall was 0.04 mm to 326.6 mm. The relative humidity was 53.53% (minimum) to 98.84% (maximum).The Performance of Some deep-water rice (*Oryza sativa* L.) cultivars as influenced by different planting variables for growth and productivity in new alluvial zone of west Bengal. The experiment was laid out in the split plot design with five different deep-water cultivars viz., V1 (Sabita), V2 (Bhagirathi), V3 (CN-1231-11-6), V4 (Jaya cross) and V5 (CN-1039-9) in the main plots along with four different planting variables viz., S1 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}), S2 (20 cm × 15 cm spacing with 3 seedlings hill^{-1}), S3 (30 cm × 20 cm spacing with 5 seedlings hill^{-1}) and S4 (30 cm × 20 cm spacing with 3 seedlings hill^{-1}) in sub plots randomly allocated and replicated thrice. The gross plot area size 3m × 2m. The findings revealed thatgrowth attributes and yield attributes differed significantly due to the deep-water rice cultivars and planting variables. Among the five deep-water rice cultivars (Sabita, Bhagirathi, CN-1231-11-7, Jaya cross and CN-1039-9), CN-1039-9 was the best. Planting variable S_1 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}) recorded better growth attributes whereas planting variable S_3 (30 cm × 20 cm spacing 5 seedlings hill^{-1}) recorded better productivity in semi-deep water situation in New Alluvial Zone of West Bengal.

Keywords: Rice, Cultivars, Planting Variables, Deep-Water, Growth, Productivity

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important cereal crop in the developing world and is the staple food over half of the world's population, ranking second to wheat in terms of area (153.953 m ha) and production (618.441mt) in the world. It's generally considered as a semi-aquatic annual grass plant. Rice belongs to genus *Oryza* of Gramineae family. The genus *Oryza* includes 24 species, of which 22 are wild and two namely *Oryza sativa* (found in Asia, America and Europe) and *Oryza glaberrima* (found in Africa) are cultivated (Anonymous, 2008). Rice provides 23% of global human per capita energy and 16% of per capita protein and primarily a high – energy or high caloric food. It contains protein, fat, calcium, B group vitamins. Rice is the major of calories of Indian people accounting 80% of their calorie intake. Brown rice contains 8% protein and milled rice 7% at 12% moisture (Juliano, 1971) and nutritionally it is best because its true digestibility (99.7%) and biological value (74.0%) are higher when compared with other cereal grains (Bouman *et al*. 2007; Sairam *et al*., 2020a; Mohanta *et al*., 2021). The area under rice cultivation in the world's 153.953 million hectares producing 618.441 million tonnes. The average yield of rice in the world is 4.02 t ha^{-1} (FAO, 2009; Shankar *et al*., 2020). Among the rice producing countries, India has been identified as the most important country with the production of 91.05 million tonnes of rice in 43.70 m ha of land with the productivity 2084 kg ha^{-1} in the year 2006 – 2007 (GoI, 2009).

Different deep and semi-deep water rice varieties have been released recently for cultivation in several states in India. Now, it's essential to know whether the agronomic practices recommended for semi-deep water rice varieties hold good during kharif season. The major problems assailing the farmers of the lowland areas are uneven distribution of rainfall during June, July and August; moreover, variation in intensity and distribution of rainfall from year to year and yielding varieties with poor management, poor establishment of seedlings due to partial submergence; deeper depth of water in the field and occasional flooding and inundation; low photosynthetic efficiency of the varieties due to reduced light intensity normally prevailing in wet season; accumulation of toxic substances in soil of ill-drained fields; severe pest occurrence during the monsoon and premature lodging of the crop(Chapagain and Yamaji, 2010; Midya *et al*., 2021). In this experiment, 5 deep water rice varieties were taken to ding out varietal performance during kharif season in West Bengal condition and 4 planting variables were taken (20cm × 15cm spacing with 5 seedlings, 3 seedlings; and 30cm × 20cm spacing with 5 seedlings, 3 seedlings) to find most suitable planting variables.The present research addresses some Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), and SDG 15 (life on land)(UN, 2021).

MATERIAL AND METHODS

The investigation was undertaken at Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, situated at 22°56' N latitude, 88°32' E and at an elevation of 9.75 m above the mean sea level, during the *kharif* season, 2006.The experimental site falls under sub-tropical humid climate being situated just south of the tropic of cancer.The temperature is neither too hot in summer nor too cold in winter. During the growing season of the experimental crop, the average maximum temperature was in the month of June, 2006 (34.15°C) and minimum average temperature was in the month of November, 2006 (21.31°C). The rainfall was 0.04 mm to 326.6 mm and the relative humidity was maximum in the month of October, 2006 (98.84%) and was minimum in the month of November, 2006 (53.53%). The details of the meteorological parameters retaining to the period of experimentation are presented in Table 1.

The experiment was laid out in the split plot design with five different deep-water cultivars viz., V1 (Sabita), V2 (Bhagirathi), V3 (CN-1231-11-6), V4 (Jaya cross) and V5 (CN-1039-9) in the main plots along with four different planting variables viz., S1 (20 cm ⊗ 15 cm spacing with 5 seedlings hill-1), S2 (20 cm × 15 cm spacing with 3 seedlings hill-1), S3 (30 cm × 20 cm spacing with 5 seedlings hill-1) and s4 (30 cm × 20 cm spacing with 3 seedlings hill-1) in sub plots randomly allocated and replicated thrice. The gross plot wise of each plot was 3 m × 2 m. 3.5.4 Duration of different varieties

Five raised nursery beds of 5m length, 1.5m wide and 15cm high was prepared about 40 days before. The seed treatment done with thiram @ 2.5gm kg^{-1} of seeds against externally seed borne diseases such as blast, about 3 hours in a gunny bag in shady place. 2 kg seeds of each deep-water rice cultivars were broadcasted in the five nursery beds separately and irrigation was applied. The main field was prepared with one deep ploughing was done by tractor followed by shallow ploughing with power tiller to ensure proper puddling. Finally, the land was puddle two days before transplanting and irrigation cum drainage channels were prepared. Forty (40) days old seedlings were transplanted at spacing of 30cm × 20cm with 5 and 3 seedlings and at spacing of 20cm × 15cm with 5 and 3 seedlings. The crop received fertilizer dose @ 40:20:20 ($N:P_2O_5:K_2O$) kg/ha in form of urea, single super phosphate and murate of potash respectively. half N + full dose of $P_2O_5$and two third K_2O were applied as basal during final puddling, ¼ N was top dressed at 30 days after transplanting and one fourth of N and one third ofK_2O was top dressed at PI stage.To avoid the border effect, harvesting was done manually excluding border vows all around the plots and left in the field for two days for sun drying. After sun drying the bundles of the harvested crop of each plot was labeled properly and taken to the threshing floor. Threshing was done with the help of paddy thresher. Straw and grain were separately dried in the sun and weight of dried grain and straw of each plot were recorded.

The data obtained were analysed statistically by the analysis of variance method (Panse and Sukhatme, 1995) and the significance of different sources of variations was tested by Error Mean square by Fisher Snedecor's "F" test at probability level of 0.05.

RESULT AND DISCUSSION

Growth attributes of rice
Effect on plant height
Effect of cultivars

Plant height of varieties differed significantly at all stages of growth. Among the varieties tried in this experiment, Bhagirathi was the tallest at active tillering, maximum tillering, panicle initiation and heading stage. At active tillering stage, Bhagirathi (44.40 cm) was followed by Sabita, CN-1039-9, CN-1231-11-7 and Jaya cross. Plant height of these four cultivars were statistically at par. Bhagirathi gave rise to the significantly tallest plant of 79.38, 111.44, 162.03 cm at maximum tillering, panicle initiation and heading stages, respectively. Lowest plant height of 61.94, 80.63, 121.20 cm were recorded by the cultivar Jaya cross at maximum tillering, panicle initiation and heading stages, respectively. Plant height of CN-1039-9, Jaya cross and CN-1231-11-7 were statistically at par at all stages of observation recorded. showed that there was sharp rise in plant height between panicle initiation stage of heading stage. This is because internode elongation usually begins around the initiation of panicle primordial and continue until beading. For this reason, the reproductive growth stage is sometimes called the internode elongation stage (Table 3).

Effect of planting variable

Plant height was significantly influenced by planting variable at all stages of observation (Table 3). Among the different planting variable, S_4 treatment (30 cm × 20 cm with 5 seedlings hill^{-1}) produced the tallest plant which was closely followed by S_3 treatment (30 cm × 20 cm with 3 seedlings hill^{-1}), S_2 treatment (20cm × 15cm with 3 seedlings hill^{-1}), respectively during all the stage of observation. However, planting variable S_1 and S_2 were statistically *at par* during all stages of observation taken. Shortest plant height was observed in the S_4 treatment (20cm × 15cm with 3 seedlings hill^{-1}) during all the stages of observation. Such reduced statue with increasing plant population may be attributed to struggle for space, nutrient, water and light and showed inverse relationship of density with plant height. Vachhani *et al.* (1961) reported that plant height progressively increased with wide spacing upto 30 cm × 30 cm. Interaction effect of different cultivars with different planting variables on plant height of deep-water rice was not significant throughout the growing period Javaid *et al.* (2012).

Dry Matter Accumulation (g m^{-2})

Effect of cultivars
At the early growth stage, cultivar V_2 (Bhagirathi) produced the highest dry matter (177.36 g m^{-2}) due to higher number of tillers m^{-2}. This was followed by cultivars V_1 (Sabita), V_5 (CN-1039-9), V_3 (CN-1231-11-7) and V_4 (Jaya cross), respectively. At this stage, dry matter accumulation of CN-1039-9 (139.60 g m^{-2}) and CN-1231-11-7 (134.54 g m^{-2}) were statistically *at par*. At and after maximum tillering stage, cultivar V_2 (Bhagirathi) produced significantly the highest amount of dry matter followed by Sabita, CN-1039-9, CN-1231-11-7 and Jaya cross, respectively. Bhagirathi produced the highest dry matter accumulation of 786.45, 942.05 and 1098.30 g m^{-2} at maximum tillering, panicle initiation and heading stages, respectively. Lowest dry matter accumulation of 689.28, 737.83 and 990.88 g m^{-2} were recorded by the cultivar Jaya cross at maximum tillering, panicle initiation and heading stages, respectively. At all stage of growth stage, dry matter production of Sabita and CN-1039-9 were statistically at par(Table 4).

Effect of planting variables
Dry matter accumulation was significantly influenced by the different spacing at all the stages of observation (Table 4). Among the different planting variables, the highest dry matter accumulation was recorded at treatment S_1 (20 cm $\times$ 15 cm spacing with 5 seedlings hill^{-1}) at all the stages of observation recorded during investigation and was followed by treatments S_2 (20 cm $\times$ 15 cm spacing with 3 seedlings hill^{-1}), S_3 (30 cm $\times$ 20 cm spacing with 5 seedlings hill^{-1}), respectively. The lowest value of dry matter accumulation was recorded at S_4 (30 cm $\times$ 20 cm spacing with 3 seedlings hill^{-1}). At all stages of growth, dry matter produced at S_3 and S_4 treatment were statistically at par. Closest spacing (20cm $\times$ 15 cm) with 5 seedlings hill^{-1} produced better dry matter accumulation at all the stages of observation recorded during investigation as compared to other planting variables. This may be attributed to accommodation of more number of plants unit^{-1} area of the crop. With increase in spacing the dry matter accumulation showed a decreasing trend at all the stages of observation Kumar *et al*. (2003) reported similar result. Interaction effect of spacing with cultivars on dry matter accumulation was not significant during the course of investigation.

Tillers m^{-2}
Effect of Treatment on Tillering Pattern
Tillering is the most important manifestation of lateral growth of cereal crop. The production of tillers reflected upon the vegetative vigour of plants and ultimately the number of panicles that determine the output of grains. From this point of view of it's importance, a careful study of tillering was taken up and the results of this study have been presented in Table 5 and tiller production per unit area was recorded at active tillering, maximum tillering, panicle initiation and heading stages.

Effect of cultivars
In this experiment, the varietal differences on tillers production m-2 was significant at all the stages of growth (Table 5). Tiller number m-2 of Bhagirathi (350.16) was the highest, followed by Sabita (308.14), CN-1231-11.7 (304.58), Jaya cross (302.53) and CN-1039-9 (301.33), at the early growth stage. The number of tillers m-2 produced by Sabita, CN-1231-11-7, Jaya cross and CN-1039-9 were statistically at par. At and after maximum tillering stage, CN-1039-9 produced higher number of tillers m-2 than any other cultivars. CN-1039-9 produced the highest number of tillers m-2 of 461.34, 437.04, 342.91 at maximum tillering, panicle initiation and heading stages respectively. Lowest number of tillers m-2 of 392.45, 332.43, 318.55 were recorded by cultivar Jaya cross at maximum tillering, panicle initiation and heading stages, respectively. At maximum tillering, panicle initiation and heading stage, the number of tillers produced by Bhagirathi, CN-1231-11-7 and Jaya cross m-2 were statistically at par. Fig. 4.1 showed that tillering of all varieties increased of a very fast rate from active tillering stage to maximum tillering stage. Tiller production of all the varieties reached their maximum at maximum tillering stage. So, this stage is considered as maximum tillering stage which marked the end of tillering. Then the tiller number of all the varieties declined because of tiller mortality(Sugiyama *et al.*, 2006).

YIELD

Grain Yield

The data pertaining to the effect of treatments on grain yield hectare-1 have been presented in Tables 6,7, and 8. Grain yield was significantly influenced by cultivars and planting variables as well as their interaction.

Effect of cultivars

Grain yield differed significantly due to cultivars (Table 6). Among the cultivars, highest grain yield of 4.23 t ha^{-1} was recorded in cultivar V_5 9CN-1039-9) which differed significantly over other cultivars. This was followed by cultivars V_1 (Sabita), V_3 (CN-1231-11-7) and V_2 (Bhagirathi) producing 3.90 t ha^{-1}, 3.39 t ha^{-1} and 3.33 t ha^{-1} grains respectively, and in which cultivars V_2 (Bhagirathi), V_3 (CN-1231-11-7) and V_4 (Jaya cross) were statistically at par. However, lowest grain yield of 3.03 t ha^{-1} was recorded in cultivar V_4 (Jaya cross). The highest average yield as well as potential yield of different cultivars are governed by both genetical and environmental factors. Under the environmental condition of present investigation, cultivar V_5 (CN-1039-9) came out as a superior cultivar and this finding could be explained in the light of better yield attributing characters like number of effective tillers m-2, length of the panicle and grains $panicle^{-1}$(Mishra and Salokhe,2010; Sairam *et al*., 2020b).

Effect of planting variables

The experimental data found that when spacing of number of seedlings $hill^{-1}$ were increased then grain yield increased significantly. Among the different planting variable, S_3 (30 cm × 20 cm spacing with 5 seedlings $hill^{-1}$) recorded highest grain yield (3.94 t ha^{-1}) which was followed by S_4 (30 cm × 20 cm spacing with 3 seedlings $hill^{-1}$), S_2 (20 cm × 15 cm spacing with 5 seedlings $hill^{-1}$) producing 3.73 t ha^{-1} and 3.41 t ha^{-1} grain respectively, which were not statistically at par. However, the lowest grain yield was obtained in S_1 treatment (20 cm × 10 cm spacing with 3 seedlings $hill^{-1}$) producing 3.23 t ha^{-1}. Grain yield increased by 5.54 $cent^{-1}$ and 9.35 $cent^{-1}$ by increasing planting variable from S_1 (20 cm × 15 cm spacing with seedlings $hill^{-1}$) to S_2 (20 cm × 15 cm spacing with 5 seedlings $hill^{-1}$) and from S_2 (20 cm × 15 cm spacing with 5 seedling $hill^{-1}$) to S_4 (30 cm × 20 cm spacing with 3 seedlings $hill^{-1}$), respectively. However, S_3 treatment (30 cm × 20 cm spacing with 5 seedlings $hill^{-1}$) produced 5.7 $cent^{-1}$ extra yield over S_4 treatment (30 cm × 20 cm spacing with 3 seedlings $hill^{-1}$). Grain yield was higher in wider spacing (30 cm × 20 cm) with 5 seedlings than the same spacing with 3 seedlings or closer spacing (20 cm × 10 cm) with 5 or 3 seedlings. With decreasing spacing and seedlings, the panicle number m-2 increased but the grain $panicle^{-1}$ and 1000-grain weight decreased. The find was confirmatory with finding of Chellamuthu and Rammohan (2005).

Effect of interaction between cultivars and planting variables

The data presented in Table 4.8 revealed that grain yield was significantly influenced by interaction effect of different cultivars and planting variables. Among the cultivars, average grain yield of different planting variables were highest in cultivar V_5 (CN-1039-9) and statistically superior over other cultivars. The lowest average grain yield was recorded in cultivar V_4 (Jaya cross). On the other hand, among the different planting variables, average grain yield due to different cultivars recorded highest in wider spacing (30 cm × 20 cm) with 5 seedlings $hill^{-1}$ and statistically superior over other planting variables. This was closely followed by planting variables S_4, S_3 respectively. The lowest average grain yield was observed in closer spacing (20 cm × 15 cm) with 3 seedlings $hill^{-1}$. In respect of cultivar V_5 (CN-1039-9), planting variable S_3 (30 cm × 20 cm spacing with 5 seedlings) produced highest grain yield which was closely followed by planting variable S_4. Similarly, in respect of planting variables S_3 (30 cm × 20 cm spacing with 5 seedlings $hill^{-1}$), cultivars V_5 (CN-1039-9) produced highest grain yield which was followed by cultivars V_1 (Sabita), V_3 (CN-1231-11-7), V_2 (Bhagirathi) and V_4 (Jaya cross), respectively.

Straw Yield

The data presented in Table 8 and Table 9 revealed that straw yield was significantly influenced by different cultivars and planting variables during the course of investigation.

Effect of cultivar

Straw yield was significantly influenced by different cultivars (Table 4.9). Among the cultivars, highest straw yield of 7.59 t ha^{-1} was recorded in cultivar V_2 (Bhagirathi) which differed significantly over other cultivars. This was followed by cultivars V_1 (Sabita), V_5 (CN-1039-9) and V_3 (CN-1231-11-7) producing 7.21 t ha^{-1}, 6.94 t ha^{-1} and 6.59 t ha^{-1} straw, respectively and of which cultivars V_5 (CN-1039-9) and V_1 (Sabita) were statistically at par. However lowest straw yield of 6.19 t ha^{-1} was recorded with cultivar V_4 (Jaya cross) and it differed significantly with other cultivars. Under environmental condition of present investigation, cultivar V_2 (Bhagirathi) came out as superior cultivar in terms of straw production and this finding may be attributed to higher number of tiller production, highest leaf area index and dry matter accumulation by this cuoltivar in comparison to other Mishra and Salokhe (2010)..

Effect of planting variables

Straw yield was significantly influenced by different (Table 4.9) and it decreased with increase in planting variables. Among the different planting variables S_1 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}) recorded highest straw yield (7.47 t ha^{-1}) which was followed by S_2 (20 cm × 15 cm spacing with 3 seedlings hill^{-1}), S_3 (30 cm × 20 cm spacing with 5 seedlings hill^{-1}) producing 7.28 t ha^{-1} and 6.54 t ha^{-1} straw, respectively. However, the lowest straw yield of 6.31 t ha^{-1} was obtained in S_4 (30 cm × 20 cm spacing 3 seedlings hill^{-1}). Planting variables S_3, S_4 were statistically at par. Straw yield increased by 3.63 cent^{-1} and 11.29 cent^{-1} by increasing planting variable from S_4 (30 cm × 20 cm spacing with 3 seedlings hill^{-1}) to S_3 (30 cm × 20 cm spacing with 5 seedlings hill^{-1}) and from S_3 to S_2 (20 cm × 15 cm spacing with 3 seedlings hill^{-1}) respectively. However S_1 treatment (20 cm × 15 cm spacing with 5 seedlings) produced 2.63 cent^{-1} extra straw yield over S_2 treatment. Closest spacing (20 cm × 15 cm) with 5 seedlings hill^{-1} accommodated more number of hills unit-1 area than same spacing with 3 seedlings or widest spacing 930 cm × 20 cm) with 5 or 3 seedlings hill^{-1} and this was reflected in hectare-1 straw yield. This result was in conformity with the observation of Ahmed (1987).

Effect of interaction between cultivars and planting variables

The data presented in Table 9 revealed that straw yield was significantly influenced by the interaction effect of different cultivars and planting variables. Among the different cultivars, average straw yield due to different planting variables recorded highest in V_2 (Bhagirathi) and statistically superior over the cultivars. This was followed by cultivars V_1 (Sabita), V_5 (CN-1039-9) and V_3 (CN-1231-11-7), respectively. The lowest average straw yield was observed in cultivars V_4 (Jaya cross). On the other hand, among the different planting variables, average straw yield of cultivars were highest in S_1 treatment (20 cm × 10 cm with 5 seedlings hill^{-1}) and statistically superior over other spacing. The lowest average straw yield was recorded in S_4 treatment (30 cm × 20 cm with 3 seedlings hill^{-1}). In respect of cultivar V_2 (Bhagirathi), planting variable S_1 (20 cm × 10 cm spacing with 5 seedlings hill^{-1}) produced highest straw yield which was closely followed by S_2 (20 cm × 10 cm spacing with 3 seedlings hill^{-1}). Similarly in respect of planting variables S_1 (20 cm × 10 cm spacing with 5 seedlings hill^{-1}), cultivars V_2 (Bhagirathi) produced highest straw yield which was closely followed by cultivars V_1 (Sabita)(Vijayakumar et al 2006).

Harvest Index

Effect of cultivars

Cultivar differences in harvest index was statistically significant, significantly thereby the conversion of biomass into economic product is a varietal characteristic. Among the varieties, CN-1039-9 had the highest value of harvest index (37.86%), followed by Sabita, (35.10%), CN-1231-11-7 (33.96%, Jaya cross (32.86%) and Bhagirathi (30.49%). Harvest index of Sabita, CN-1231-11-7 and Jaya cross were statistically at par.

Effect of planting variables

Harvest index was found to increase with increasing in spacing and number of seedlings hill^{-1}. The highest harvest index was obtained in widest spacing (30 cm × 20 cm) with 5 seedlings hill^{-1} followed planting variables S_3 (30 cm × 20 cm spacing with 3 seedlings hill^{-1}), S_2 (20 cm × 15 cm spacing with 3 seedlings hill^{-1}) and S_1 (20 cm × 15 cm spacing with 5 seedlings hill^{-1}), respectively.

Interaction effect of between cultivars and planting variables on the harvest index was found to be statistically not significant.

CONCLUSION

The study revealed that growth attributes and yield differed significantly due to the deep-water rice cultivars and planting variables. Among the five deep-water rice cultivars (Sabita, Bhagirathi, CN-1231-11-7, Jaya cross and CN-1039-9), CN-1039-9 was the best. Planting variable S_1 (20 cm $\times$ 15 cm spacing with 5 seedlings hill^{-1}) recorded better growth attributes whereas planting variable S_3 (30 cm $\times$ 20 cm spacing 5 seedlings hill^{-1}) recorded better in yield in semi-deep water situation in New Alluvial Zone of West Bengal.

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Table 1.Meteorological data pertaining during the period of experimentation, 2006

Months	Temperature (°C)				RH (%)			Rainfall (mm)	
	Max		Min		CGP		LTA	CGP	LTA
	CGP	LTA	CGP	LTA	Max	Min			
June	34.15	36.60	25.49	24.85	96.97	72.70	82.80	138.2	279.1
July	31.18	32.30	26.07	24.70	98.42	81.00	78.20	326.6	281.6
August	31.88	32.60	25.94	24.70	98.03	81.71	78.50	194.2	291.1
September	32.50	32.70	25.34	25.50	98.10	78.67	84.80	482.7	267.2
October	32.20	30.2	23.20	23.80	98.84	71.48	75.40	41.0	114.7
November	29.06	30.75	21.31	17.9	98.17	53.53	57.8	0.04	49.01

CGP = Crop growth period
LTA = Long term average of preceding thirty years
Source: Department of Agricultural Meteorology & Physics, B.C.K.V., Nadia, West Bengal.

Table 2. Different deep-water cultivars with detailed operations

Variety	Date of Sowing	Date of Transplanting	Date of Maturity	Duration (days)
Sabita	19-06-06	29-07-06	22-11-06	164
Bhagirathi	19-06-06	29-07-06	26-11-06	168
CN – 1231-11-7	19-06-06	29-07-06	22-11-06	164
Jaya Cross (CN – 1866)	19-06-06	29-07-06	3-11-06	145
CN – 1039-3	19-06-06	29-07-06	22-11-06	164

Table 3. Effect of cultivars and planting variables on the plant height at different growth stages

Treatments	**Plant height**			
	Active tillering	**Maximum tillering**	**Panicle initiation**	**Heading**
Cultivars				
V_1 (Sabita)	41.89	77.06	105.96	151.22
V_2 (Bhagirathi)	44.40	79.38	111.44	162.03
V_3 (CN-1231-11-7)	40.76	64.10	88.44	128.30
V_4 (Jaya cross)	40.69	61.94	80.63	121.20
V_5 (CN-1039-9)	41.60	66.24	84.46	130.82
S. Em (±)	0.66	1.41	2.50	2.96
C.D. at 5%	2.16	4.6	8.18	9.68

Planting variables				
S_1 (20 cm × 15 cm with 5 hill^{-1})	39.05	62.21	85.87	131.69
S_2 (20 cm × 15 cm with 3 hill^{-1})	41.63	64.16	87.36	135.09
S_3 (30 cm × 20 cm with 5 hill^{-1})	42.15	71.16	100.34	138.56
S_4 (30 cm × 20 cm with 5 hill^{-1})	44.65	75.26	104.75	142.53
S. Em (±)	0.81	1.33	2.79	1.15
C.D. at 5%	2.34	3.84	8.06	3.32

Table 4. Effect of cultivars and planting variables on dry matter accumulation at different growth stages

Treatments	**Dry matter accumulation (g m^{-2})**			
	Active tillering	**Maximum tillering**	**Panicle initiation**	**Heading**
Cultivars				
V_1 (Sabita)	155.15	734.88	875.36	1058.88
V_2 (Bhagirathi)	177.36	786.45	942.05	1098.30
V_3 (CN-1231-11-7)	134.54	701.33	779.31	1027.95
V_4 (Jaya cross)	116.83	689.28	737.83	990.88
V_5 (CN-1039-9)	139.60	731.43	863.40	1044.33
S. Em (±)	2.84	4.53	4.63	10.64
C.D. at 5%	9.29	14.81	15.14	34.69
Planting variables				
S_1 (20 cm × 15 cm with 5 hill^{-1})	152.94	763.12	871.88	1058.17
S_2 (20 cm × 15 cm with 3 hill^{-1})	144.49	740.46	855.88	1050.66
S_3 (30 cm × 20 cm with 5 hill^{-1})	142.42	725.64	822.22	1033.78
S_4 (30 cm × 20 cm with 5 hill^{-1})	139.73	713.26	813.38	1027.26
S. Em (±)	2.73	4.03	4.08	10.35
C.D. at 5%	7.89	11.65	11.79	29.91

Table 5. Effect of cultivars and planting variables on the tillering pattern at different growth stages

Treatments	**Tillers m^{-2}**			
	Active tillering	**Maximum tillering**	**Panicle initiation**	**Heading**
Cultivars				
V_1 (Sabita)	308.14	425.01	391.63	326.18
V_2 (Bhagirathi)	350.16	398.05	351.07	300.62
V_3 (CN-1231-11-7)	304.58	413.75	389.62	324.12
V_4 (Jaya cross)	302.53	392.54	332.43	318.55
V_5 (CN-1039-9)	301.33	461.34	437.04	342.91
S. Em (±)	2.94	5.35	5.94	3.80
C.D. at 5%	9.58	17.43	19.36	12.38
Planting variables				
S_1 (20 cm × 15 cm with 5 hill^{-1})	314.99	467.89	397.70	329.51
S_2 (20 cm × 15 cm with 3 hill^{-1})	312.85	467.18	392.40	326.37
S_3 (30 cm × 20 cm with 5 hill^{-1})	301.35	456.41	357.42	293.54
S_4 (30 cm × 20 cm with 3 hill^{-1})	300.14	455.60	354.73	290.00
S. Em (±)	2.89	4.45	6.12	4.45
C.D. at 5%	8.35	12.85	17.68	12.87

Table 6. Effect of cultivars and planting variables on grain yield, straw yield grain straw ratio and harvest index of deep-water rice cultivars

Treatments	Grain yield	Straw yield	Grain : straw yield	Harvest index
Cultivars				
V_1 (Sabita)	3.90	7.21	0.54 : 1	35.10
V_2 (Bhagirathi)	3.33	7.59	0.44 : 1	30.49
V_3 (CN-1231-11-7)	3.39	6.59	0.51 : 1	33.96
V_4 (Jaya cross)	3.03	6.19	0.49 : 1	32.86
V_5 (CN-1039-9)	4.23	6.94	0.61 : 1	37.86
S. Em (±)	0.107	0.114	-	0.70
C.D. at 5%	0.348	0.371	-	2.29
Planting variables				
S_1 (20 cm × 15 cm with 5 hill^{-1})	3.23	7.47	0.43 : 1	30.18
S_2 (20 cm × 15 cm with 3 hill^{-1})	3.41	7.28	0.47 : 1	31.90
S_3 (30 cm × 20 cm with 5 hill^{-1})	3.94	6.54	0.60 : 1	37.60
S_4 (30 cm × 20 cm with 3 hill^{-1})	3.73	6.31	0.59 : 1	37.15
S. Em (±)	0.082	0.130	-	0.78
C.D. at 5%	0.237	0.376	-	2.26

Table 7. Effect of interaction between cultivars and planting variables on grain yield of deep-water rice cultivars

Planting variables	Cultivars				
	V_1 (Sabita)	V_2 (Bhagirathi)	V_3 (CN-1231-11-7)	V_4 (Jaya cross)	V_5 (CN-1039-9)
S_1 (20 cm × 15 cm with 5 hill^{-1})	3.53	3.06	3.12	2.65	3.77
S_2 (20 cm × 15 cm with 3 hill^{-1})	3.73	3.14	3.24	2.86	4.06
S_3 (30 cm × 20 cm with 5 hill^{-1})	4.27	3.72	3.69	3.42	4.61
S_4 (30 cm × 20 cm with 3 hill^{-1})	4.05	3.38	3.51	3.19	4.48
	V × S			S × V	
S. Em (±)	0.141			0.134	
C.D. at 5%	0.407			0.387	

Table 8. Effect of interaction between cultivars and planting variables on straw yield of deep-water rice cultivars

Planting variables	Cultivars				
	V_1 (Sabita)	V_2 (Bhagirathi)	V_3 (CN-1231-11-7)	V_4 (Jaya cross)	V_5 (CN-1039-9)
S_1 (20 cm × 15 cm spacing with 5 seedlings hill^{-1})	7.75	8.23	7.15	6.75	7.46
S_2 (20 cm × 15 cm spacing with 3 seedlings hill^{-1})	7.57	8.01	6.94	6.62	7.24
S_3 (30 cm × 20 cm spacing with 5 seedlings hill^{-1})	6.85	7.26	6.26	5.79	6.52
S_4 (30 cm × 20 cm spacing with 3 seedlings hill^{-1})	6.64	6.88	6.03	5.62	6.36
	V × S			S × V	
S. Em (±)	0.238			0.223	
C.D. at 5%	0.688			0.665	

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RESEARCH ARTICLE

Analysis of Banana Root Distribution under Drip and Black Plastic Mulch

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ABSTRACT

The water and nutrients are absorbed by banana plant through root system and roots need energy to absorb required quantity. The roots of banana are more sensitive to the oxygen deficiency during water logging condition. In contrast to the above stomata will be closed and no respiration taken place during draught situation. Therefore the optimum water should be provided to banana root to establish the healthy plant. The banana root distribution in soil profile may be influenced by the different levels of irrigation water. To know the precise amount of irrigation water applied to banana, root weight of banana was measured. Root distribution was measured by the root weight at different soil depth for different level of irrigation through drip and plastic mulch cover conditions. Analysis shows that the effective roots (72% of roots) were distributed at 20-40 cm soil depth for all the irrigation treatments. However, root weight of banana applied with plastic mulch irrigation treatments were more in the upper soil profile (0-20 cm), and lesser root weight in the 20-40 cm and 40-60 cm depth in comparison to the weight of roots at a corresponding depth of different irrigation treatments without mulch.

Keywords: Soil profile, plastic mulch, root volume, root weight

INTRODUCTION

Banana is popular among the fruits. Banana roots hairs are up to 2 mm length which occurs behind the root apex. The cord roots are measuring up to 3-5 mm which was relatively straight and cylindrical in shape and it was of 4 -10 mm diameter (Draye *et al*., 2005). Banana roots develop continuously until flowering. Banana root system is very sensitive to soil compactness, water logging, soil aeration and draught condition. Normally banana roots may reach up to the 60 cm to 90 cm soil depth in conventional irrigation system (Turner, 2007). Drip irrigation produced slightly more deep and widespread root systems due to frequent applications of water near the root zone (Santosh and Tiwari, 2019). Plastic mulch conserves the soil moisture by reducing the evaporation losses (Santosh and Maitra, 2022; Tripathy *et al*., 2022) therefore the roots distributed evenly under plastic mulch (Santosh and Maitra, 2021). The opaque nature of the black plastic mulch creates dark near the soil surface due to which roots try to emerge towards the soil surface. The higher root distribution can be found at soil surface in drip irrigated banana applied with plastic mulch in comparison to the drip irrigated banana with no mulch condition. The knowledge of banana root system can greatly assist in scheduling the irrigation particularly when irrigating plant with drip along with the plastic mulch. Considering the above points the field study has been conducted to analyse the root distribution under drip and black plastic mulch.

MATERIALS AND METHOD

A field experiment on banana using drip irrigation system was conducted at the Experimental Farm area of Precision Farming Development Centre Project located at Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, India for a crop seasons during 2019-2020. The experimental farm is located on the flat land at 22°18.5' N latitude, 87°19' E longitude and altitude of 48 m above mean sea level. The soil of the experimental plot has a higher amount of sand which varies between 45.6% and 59.7%. The profile depth characterized as sandy loam with an average bulk density of 1.63 g cm^{-3}. The saturated hydraulic conductivity of soil varies between 0.34 and 9.72 cm day^{-1}, whereas field capacity and wilting point of soil profile vary from 0.24 to 0.28 cm^3 cm^{-3} and from 0.10 to 0.11 cm^3 cm^{-3}, respectively. The soil in the experimental farm is acid laterite (type-Haplupt) and sandy loam in texture. It is low in organic C (0.3%) and available nitrogen content (72.1 ppm), medium in available phosphorus (11.8 ppm) and low in available potassium content (46.9 ppm). Banana (*Musa Paradisica)* cv. Grand Nain was selected as the experimental crop. Grand Naine variety of banana belongs to AAA group, Cavendish subgroup and it is a tall mutant of Dwarf Cavendish. It bears bunches weighing from 25 to 30 kg having well-shaped hands with straight orientation and uniform sized long fingers. Fruit quality is almost like dwarf Cavendish and this develops attractive yellow uniform color with greater shelf life and better taste than other cultivars. It takes 11 to 12 months to harvest banana fruits from the main crop after transplantation. In this study the field experiment was laid out in 2 factorial randomized block design with eight treatments and three replications (Fig. 1). The details of the treatments for experiment 1 are furnished below.

T_1 (Iw x M_1) : 100% irrigation water requirement met with drip system and BPM
T_2 (Iw x M_0) : 100% irrigation water requirement met with drip system without mulch
T_3 (0.8Iw x M_1) : 80% irrigation water requirement met with drip system and BPM
T_4 (0.8Iw x M_0) : 80% irrigation water requirement met with drip system without mulch
T_5 (0.6Iw x M_1) : 60% irrigation water requirement met with drip system and BPM
T_6 (0.6Iw x M_0) : 60% irrigation water requirement met with drip system without mulch
T_7 (0.4Iw x M_1) : 40% irrigation water requirement met with drip system and BPM
T8 (0.4Iw x M_0) : 40% irrigation water requirement met with drip system without mulch
Where,
BPM = black plastic mulch; Iw = irrigation water; M_1 = black plastic mulch; M_0 = No mulch

RESULTS AND DISCUSSION

The root system of banana crop initially spread up to 20 cm vertically and 60 cm horizontally. During development and fruiting stage root spread up to 40 cm and 80 cm vertically and horizontally, respectively. The root weight recorded from different layers of the soil profile during the second crop season (2019-20) presented in Table 1. The root weight of the banana crop showed minor differences between samples collected from the different irrigation treatments and major difference found between the irrigation treatments with black plastic mulch and without mulch. Total root mass varied between 144 and 204 g for all the treatments. The weight of the roots varying between 20 g to 32.4 g, 120 g to 141 g, 26 g to 28 g and less than 2g in the different soil profiles 0-20 cm, 20-40 cm, 40-60 cm, and 60-90 cm respectively for a different level of irrigation treatments without plastic mulch. However, root weight of plastic mulch along with irrigation treatments are more in the upper soil profile (0-20 cm), and lesser root weight in the 20-40 cm and 40-60 cm depth in comparison to the weight of roots at a corresponding depth of different irrigation treatments without mulch. The rooting system of the banana crop did not exceed 60 cm in irrigation treatments with black plastic mulch. However, a very minute quantity of roots was found in different irrigation treatments without plastic mulch. This corroborates the report by Fogain (2005), who reported that Grand Naine banana roots extend to a depth of 60 cm, and with the works of Arya (2002), who reported that banana roots don't extend beyond 45 cm.

The percentage of roots present at different layers of soil profiles by total root weight for different treatments is shown Figure 2. Figure 2 shows the maximum percentage of root present at the soil profile of 20-40 cm followed by 0-20 cm and 40-60 cm. More percentage of roots was found in irrigation treatments within black plastic mulch in comparison to the no mulch irrigation treatments at a depth of0-20 cm. At the soil depth of 20-40 cm, maximum (72%) of roots were present in almost all the irrigation treatments. Minute variation of the roots (up to 1%) was found between irrigation treatments with black plastic mulch and no mulch treatments at a depth of 20-40 cm. A lesser amount of roots (up to 16%) present between 40-60 cm soil profile compare to 20-40 cm and 0-20 cm soil profile. However, significant variation seen between irrigation treatments with black plastic mulch (<8.5 %) and irrigation treatments without mulch (<15.5 %) at 40-60 cm soil profile. Lower roots (i.e. about 1%) was found in banana plants drip-irrigated treatments without at 60-90 cm depth of soil. But, there is no trace of the root system in drip irrigated and plastic mulch treatments. All of the treatments had a similar pattern of roots distribution in the soil profile, which showed a more regular root distribution to a depth of 40 cm. Araya et al. (2002) reported that most of the banana roots develop in the topsoil (up 40 cm depth).

CONCLUSION

The analysis of banana roots distribution in soil profile under drip and plastic mulch shows that the maximum roots were situated at the depth of 20 cm - 40 cm depth and least situated at the depth of 60 cm to 90 cm. Plastic mulch covered banana shows more roots at the surface (0-20 cm) and less at (40 cm – 60 cm) depth in comparison to the respective drip irrigation and no mulch treatments.

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Table 1. Analysis of banana roots weight at different layers of the soil profile.

Depth	Root mass (g)							
	T1	T2	T3	T4	T5	T6	T7	T8
0-20	44.0	32.4	38.0	24.5	38.0	20.0	34.0	20.0
20-40	135.0	141.9	122.0	137.0	120.0	129.0	98.4	120.0
40-60	12.4	28.4	12.2	28.2	12.0	26.0	12.0	26.0
60-90	0.0	1.8	0.0	1.6	0.0	1.0	0.0	1.8
Total	191.4	204.5	172.2	191.3	170.0	176.0	144.4	167.8

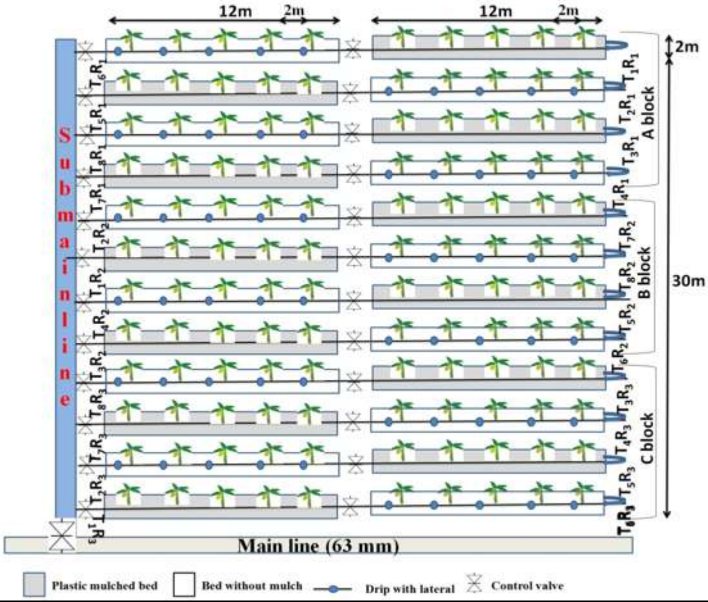

Fig 1. Layout of experimental field for standardizing irrigation water requirement of banana crop

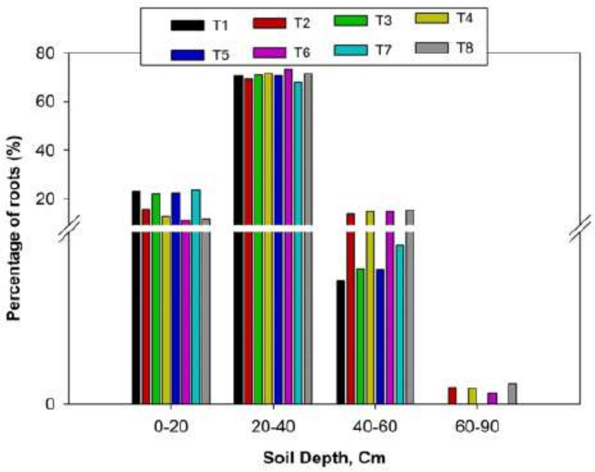

Fig 2. The percentage of roots present at different layers of soil profiles by total root weight under different treatments

RESEARCH ARTICLE

Influence of Organic Seed Priming on Seed Germination and Seedling Growth of Green Gram

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ABSTRACT

Green gram is an important pulse crop in India which is mostly cultivated in degraded lands during offseason under fragile natural resources. Subsequently it ascribes to low production per unit area. Foreseeing the role of seed priming in establishing an ideal crop stand under stressed environments. A pot experiment was conducted to find out the impact of organic seed priming on green gram in summer with following seven treatments *viz.,* control (T_1), cow urine @ 25% (T_2), cowdung extract @ 10% (T_3), beejamruta @ 25% (T_4), beejamruta @ 50% (T_5), beejamruta @ 75% (T_6) and beejamruta @ 100% (T_7), replicated thrice.. The results showed that beejamurutam @ 100% was found to perform superiorly in enhancing green gram germination and seedling growth parameters. Therefore, it can be concluded that adoption of seed treatment with beejamruta @ 100% could be an appropriate organic management practice that can assure proper seed germination and seedling establishment in green gram raised under southern Odisha conditions.

Keywords: Beejamruta, cow urine, cow dung extract, seed germination percentage, seed vigour index

INTRODUCTION

Globally, sustainable assurance of food and nutritional security to expeditiously increasing population with declining net cultivated area is a major challenge to agriculturists in the framework of climate change (Maitra *et al*., 2018; Sagar and Sultan, 2020). Cereals comprise major portion of the dietary requirement while, pulses ascribe to supply protein to all vegetarians across the globe. Besides, they are resilient to climate change and can fit into any cropping system easily that widened the scope for crop diversification (Mandal *et al.,* 2020). Moreover, pulses are low external nitrogen requiring crops which contribute to low carbon foot print and as a consequence adoption of pulse cultivation ensues ecological sustainability (Basu *et al.,* 2016). Therefore, cultivation of pulses seems to have enough potential to address SDG 1 and SDG 2 (UN, 2022). Globally, India ranks first in pulse production. However, the realized productivity of our country has been lower than many developed countries. Among the pulses, green gram is widely cultivated in India coving an area of 40.34 lakh hectares, produces 19.48 lakh tonnes annually and recorded an annual productivity of 483 kg/ha (DPD, 2021). Odisha is one among the leading producer of green gram covering an area of about 2.73 lakh hectares, production of 0.97 lakh tonnes resulting in annual productivity of 356 kg/ha, respectively (DPD, 2021). Green gram is mostly cultivated on fragile lands under rainfed conditions (Sahu *et al.,* 2021). Under these conditions proper germination and maintenance of ideal crop stand determines the productivity of the crop. Seed priming is an age old cost effective technique in which the metabolic processes of germination are initiated and prepare the seeds ready for germination. Several studies indicated that primed seeds were highly vigorous and assures ideal crop stand under unfavourable conditions (Ibrahim, 2016). However, seed priming with chemicals reported to increase the buildup of chemical residues leading towards serious health hazards. In the light of above facts, the present research was laid out to evaluate the most effective organic seed priming practice.

MATERIALS AND METHODS

The present investigation was carried out in summer season of 2021 at organic research farm, M.S. Swaminathan school of Agriculture, Centurion university of technology and management, Odisha (18°48′29′′ N , 84°08′11′′E, 182 meters above mean sea level) under irrigated condition. The soil used in the pot was sandy clay loam in texture, neutral in reaction (7.02 pH), high in organic carbon (0.8%), low in available nitrogen (176 kg/ha) and medium in phosphorus (17 kg/ha) and high in potassium (289 kg/ha), respectively. A pot experiment was laid out in randomized block design with seven treatments and three replications. The treatments compared in this experiment were control (T_1), cow urine @ 25% (T_2), cowdung extract @ 10% (T_3), beejamruta @ 25% (T_4), beejamruta @ 50% (T_5), beejamruta @ 75% (T_6) and beejamruta @ 100% (T_7), The data recorded in this investigation were germination percentage (%), root length (cm), shoot length (cm), seedling length (cm) and seed vigour index, respectively. Observations recorded were analysed using single factor randomized block design through OPSTAT online (http://14.139.232.166/opstat/onefactor.htm?flavor=One+Factor+Analysis) and treatments were compared at 5% level of significance (Gomez and Gomez, 1984)

RESULTS AND DISCUSSION

Germination (%): Seed treatment with organic amendments had a significant influence on germination percentage (Table 1). The highest germination percentage was recorded by seeds treated with beejamruta @ 100% which remained at par with beejamruta @ 75%, beejamruta @ 50%, beejamruta @ 25% and CDE @ 10%, respectively. The minimum germination percentage was observed by control which was found to be at par with seeds treated with cow urine @ 25% and beejamruta @ 25%, respectively. This might be due to the components present in beejamrita attributed to normalize the germination process under extreme temperatures. These results are in conformity with Vyankatrao (2019) and Shyamsundar (2021).

Root length (cm): The seedling root length as influenced by organic seed treatment was presented in the Table 1. Seeds treated with beejamruta @ 100% reported significantly highest root length over control. Moreover, the root length observed by beejamruta @ 75% was at par with the superior treatment and CDE @ 10%. The control treatment was found to record significantly minimum root length. These results remained at par with seeds treated with cow urine @ 25% and beejamruta @ 25%, respectively. This might be due to presence of maximum phosphorus solubulizing bacteria in beejamruta. Similar results were observed by Akarsh *et al.* (2020) in garden pea.

Shoot length (cm): The seedling shoot length as influenced by organic seed treatment was presented in the Table 1. Seeds treated with beejamruta @ 100% reported significantly highest shoot length over control. Moreover, the shoot length observed by beejamruta @ 75% was at par with the superior treatment and CDE @ 10%. The control treatment was found to record significantly minimum shoot length. These results remained at par with seeds treated with cow urine @ 25% and beejamruta @ 25%, respectively. This might be due to the relatively high concentration of phytoharmones and maximum colonies of IAA forming bacteria in beejamrit solution. These results are in conformity with Ram *et al.* (2019).

Seedling length (cm): The seedling length as influenced by organic seed treatment was presented in the Table 1. Seeds treated with beejamruta @ 100% reported significantly highest seedling length over control. Moreover, the seedling length observed by beejamruta @ 75% was at par with the superior treatment and CDE @ 10%. The control treatment was found to record significantly minimum seedling length. These results remained at par with seeds treated with cow urine @ 25% and beejamruta @ 25%, respectively. This is manifested by relative enhancement of both root and shoot length, respectively.

Seed vigour index: The seed vigour index as influenced by organic seed treatment was presented in the Table 1. Seeds treated with beejamruta @ 100% reported significantly maximum seed vigour index over control. Moreover, the seed vigour index observed by beejamruta @ 75% was at par with the superior treatment and CDE @ 10%. The control treatment was found to record significantly minimum seed vigour index. These results remained at par with seeds treated with cow urine @ 25% and beejamruta @ 25%, respectively. These results are in conformity with Vyankatrao (2019)

CONCLUSION

The present investigation indicated that seed treatment with beejamurutam @ 100% was found to perform superiorly in enhancing green gram germination and seedling growth parameters. Therefore, it can be concluded that adoption of seed treatment with beejamruta @ 100% could be an appropriate organic management practice that can assure proper seed germination and seedling establishment in green gram raised under southern Odisha conditions.

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Table 1: Effect of beejamruta on percentage germination and seedling parameters of green gram

Treatment	Germination%	Root length(cm)	Shoot length(cm)	Seedling length(cm)	Seed vigor index
Control	82.19	2.01	4.77	7.42	610.25
Cow urine @ 25%	88.80	2.04	5.16	8.02	712.41
CDE @ 10%**	92.76	3.02	5.39	8.38	781.78
Beejamruta @ 25%	90.84	2.08	5.27	8.20	745.79
Beejamruta @ 50%	94.51	3.06	5.49	8.54	810.80
Beejamruta @ 75%	95.17	4.04	5.53	8.60	819.82
Beejamruta @ 100%	100.00	4.06	5.81	9.03	903.23
SEm	3.18	0.10	0.19	0.29	52.84
CD (5%)	9.92	0.32	0.58	0.89	164.63

****CDE= cow dung extract**

RESEARCH ARTICLE

Crop Residue Management in Conservation Agriculture: Constraints and Prospects

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ABSTRACT

India produces around 500 million tons of crop wastes each year as agriculture based country. Although government imposed prohibitions, stubble burning following grain harvest from crops such as wheat, rice, and other crops is a popular practice in several Indian states. Farmers do this over time in order to save money on the cost of clearing the field of agricultural remains. However, this results in significant environmental pollution as particulate matter and greenhouse gases in the air increase, posing health risks to humans and animals, as well as global warming and climate change. It also has a negative impact on soil health, causing direct loss of macro- and micronutrients from the soil as well as a reduction in microbiological diversity and population in soil. They are in charge of the main nitrogen processing pathway in soil. Recently, attempts have been initiated to create systems for utilizing agricultural leftovers as a cost-effective and environmentally beneficial alternative to stubble burning. The residues can be utilized for a number of purposes, including livestock feed, fodder, biofuel, bio char, packaging, mushroom culture, composting, and so on. However, the use of these crop leftovers in conservation agriculture-based technologies may eliminate the problem of stubble burning. Furthermore, leftover agricultural residues may serve as a one-of-a-kind component for improving soil quality and health, and thus increasing crop output, without becoming a source of pollution. In the end, this strategy must result in agriculture that is both sustainable and resilient.

Keywords: Crop residues, residue management, conservation agriculture, carbon sequestration, stubble burning

INTRODUCTION

India is an agriculture-based country, around 60% of the land is utilized to produce various cereals, pulses, and oilseed crops. In addition to this huge amount of crop residues are produced, which is estimated to be 500 MT (). Crop residue management is usually a practice of reducing number of tillage implement pass over and the intensity of tillage operation in a land. It is designed in such a way to leave sufficient amount of residues on soil surface to reduce erosion problem. This biomass is of high importance and has different uses like mulching, maturing, mushroom cultivation, roof thatching, bio char production, feed for livestock, bedding material for animal, biomass energy production, fuel for domestic and industrial use, etc. Rice husk is mostly utilized as a boiler fuel, whereas bagasse is employed in the energy and paper enterprises (Singh, 2019). Sugarcane tops are either fed to dairy cattle or burnt in the field for ratoon cropping systems in most locations. Groundnut residues are used as a fuel in brick and lime kilns. Cotton, chilli, legumes, and oilseed leftovers are the most common sources of domestic fuel. Which includes coconut shells, rapeseed and mustard stalks, pigeon pea, jute, mesta and sunflower. Coconuts produce roughly 3 million tons of husk per year, of which 1.2 million tons are used to make coir and one million tons are burned as fuel. However, due to a lack of knowledge on proper utilization, shortage of labour, high cost of removing residues, cropping system and their patterns this vast amount of crop residue is being burnt on farm. Open field biomass burning has been used around the world for decades to clear land and enhance land usage by removing both living and dead vegetation. In 2017-2018 it emitted about 176.1 Mt CO_2, 10 Mt of CO, 0.31 Mt CH_4, 0.008 Mt N_2O, 0.151 Mt NH_3, 0.814 Mt NMVOC, 0.453 Mt $PM_{2.5}$ (particulate matter) and 0.936 Mt PM_{10} (Gaurav *et al*., 2021).**It** is the most serious problem particularly in rice-wheat system of north-west India (Punjab, Haryana, UP, West Bengal) (Surendra *et al*., 2012). The biomass can be utilized for various purposes. Conservation agriculture is a farming system that promotes minimum soil disturbance, maintenance of a permanent soil cover, and diversification of plant species (FAO) which helps in managing these residues in a productive and profitable manner. By following conservation agriculture we can improve soil health condition, increase productivity and reduce pollution. Considering the fact that these crop residues can be used in many ways to convert them into reusable resource towards sustainability. This review mainly focuses on different techniques or methods of utilizing these crop residues under conservation agriculture and its impact of abiotic stresses on cereal crops and suitable adaptation options to combat them for sustainable crop yield. The article also addresses some Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), SDG 13 (climate action), and SDG 15 (life on land) (UN, 2021).

Crop Residue Burning

Burning of crop residues is like letting the easily available treasure in vein because they are rich in carbon and bioactive compounds followed by many other uses. Traditionally it is practiced to clear off the field to sow next crop which is mainly practiced in Rice-Wheat cropping system famous in states like Haryana, Rajasthan, Punjab and U.P where farmers hardly get 15-20 days for next crop to sow so in this short period the rice straw may not get decomposed so farmers prefer to burn them on field. Punjab is considered as the breadbasket of India as it accounts for $2/3^{rd}$ of food grain production. It is also well known for stubble burning where It is estimated that about 15 Mt rice straw is burned every year in Punjab alone (Sharma *et al*.,2021) (Fig.1). Represents the crop-wise data of production, residue generated and burnt for recent years.

Even though the farmers decide to collect this biomass, the transportation cost, labour cost at the time of harvest are high. It makes availability of phosphorous and potassium and loss of nutrients like nitrogen and sulphur. There are various reasons for on farm burning which include increased mechanization like combined harvester, reduction in number of livestock utilization, time taking for composting process etc. (Bhuvaneshwari *et al.,* 2019).

The release of sooty and smokey particles which are considered to be carcinogens from residue burning causes some human and animal health issues(NPMCR). It also has some adverse effects on environment (air pollution) which reduces air quality as they involve in emission of greenhouse gases like CO_2, CH_4, NO and other hydrocarbons which bring out global warming problem as well as loss of important macronutrients like Nitrogen, Phosphorous, Potassium and Sulphur (Surendra *et.al.,* 2012). The heat released from the residue burning effects the beneficial soil microorganisms, where persistent burning endangers complete loss of microbial population and decreases carbon and nitrogen levels in the soils. The National Green Tribunal Act in 2010 have banned straw & stubble burning and in order to create awareness among farmers to reduce on field burning imposed a fine of Rs.1500 to 2500 (Anandha and Dayana, 2021).

Consequences of stubble burning

Soil fertility

Burning of stubbles reduces soil quality by destroying critical nutrients like NPK and other micro elements. This increases the soil temperature to around 42°C, which results in removal or destroying of essential microorganisms at a depth of around 2.5 cm. This results in an added cost of restoring soil fertility by fertilizer or compost application. (Abdurrahman *et al.,* 2020). The carbon-nitrogen balance of the soil may be completely lost when crop residues are burned. Open combustion of 100 kilograms of residue may result in loss of all organic carbon, 5.5 kg of nitrogen, 2.3 kg of phosphorus, 25 kg of potassium and 1.2 kg of sulphur in the soil (NPMCR). If agricultural residues are incorporated into the soil, they will improve soil quality with more C, N, P and K (Gaurav *et al.,* 2021).

Air pollution

The stubbles burnt emit different greenhouse gases (GHGs) like CO, NH_3, NO_2, SO_2, the non-methane organic compound (NMHC), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs) and particulate matter (PM), resulting in the loss of organic carbon, nitrogen, and alternative nutrients that would otherwise be retained in soil. GHG emissions contribute for 91.6% of total emissions from the combustion of 98.4 Mt of agricultural residue, with 8.4% of CO, NO_2, NMHCs and SVOCs. Aerosols are also released when stubbles are burned off. The release of harmful gases from agricultural waste burning might cause asthma, emphysema, pneumonia, eye irritation and opacity, as well as skin problems. Inhaling PM can aggravate existing cardiac and pulmonary conditions and has been linked to the early mortality of persons who already have these conditions. Rising CO_2 and CO levels in the blood can cause hemoglobin to become abnormal, resulting in mortality in animals. More than 60,000 individuals living in rice-growing areas are at risk of air pollution due to rice stubble burning (Gaurav *et al.,* 2021)

Detoriation of agriculture productivity

There is significant proof that air pollution has an effect on crop output. Pollutants may have a direct or indirect impact on agricultural output. Damage to leaves, grains or heavy metal absorption is examples of direct consequences. As an example; nitrogen oxide can harm plant tissue and create discoloration. SO_2 may cause acid rain, which has serious consequences for plants and soil, as well as plant death (Muhammad *et al.,* 2020). Plants exposed to particle pollution for an extended period of time may develop chlorosis or Necrosis (Ghosh *et al*., 2019). Indirect consequences include creating suitable circumstances for pests or diseases to thrive, for example, Elevated levels of SO_2 and NO_2 stimulate the proliferation of aphid pests. Some crops, such as wheat and soy, are seen to be very susceptible to ozone, while others, such as barley, have shown some resilience. Rice and maize were said to be considerably harmed (Sharma et al., 2019). As a result, stubble burning has a detrimental influence on agricultural productivity and must be addressed correctly in order to boost agricultural output (Muhammad *et al.,* 2020).

Effects of improper residue management

Keeping more quantity of residues may have some negative effect; even though it helps in reducing evaporation paralleled it accumulates high moisture content near surface region which encourages growth of feeder roots (Akash *et al.,* 2020). There are chances of pest, disease and weed infestation which shows antagonistic effect on main crop. There would be a problem in site specific management of seeds, fertilizers, and herbicide and pesticide application (Reddy, 2017). Depth of seed placement and tilth are very important for germination but by following conservation agriculture with zero tillage practices upon adding residues over plots would be a restricting factor for germination of the seed (Bharati and Kaushal, 2019). The most prominent cropping system of India is Rice Wheat Cropping system where the seed bed preparation of both the crops is totally different i.e., one is puddled and transplanted another is sown after deep ploughing which enables oxidation of organic carbon that is hazardous to environment (Sarkar *et al*., 2020).

Different methods of crop residue management

Mulching and *In-situ* Incorporation

In the crop residue mulching, the remnants of previous crop left on the soil surface at the time of crop emergence which covers about 30% of soil surface area (Premasis and Kaushal, 2020). The mulch used will subsequently incorporate or decomposed into the soil. The incorporation of remnant biomass into soil which improves tilth, reduces erosion process, prevention of nutrient losses by run-off & leaching, and improves microbial population. Incorporation of residues improves soils physical, biological and chemical properties of soil and also increases nitrogen mineralization or immobilization of available nitrogen. Due to high amount of organic matter supply erosion process decreases (Jorge *et al.,* 2015). The straw incorporation with starter dose nitrogen of 15-20 kg ha^{-1} enhances wheat and rice yield than burning it on field. Ploughing is one of the important methods of residue incorporation (Kamalijeet *et al*., 2019). Water is conserved by reducing evaporation losses from the soil which maintains optimum moisture levels as well as soil temperature (Singh, 2019). In areas of short duration and low intensity rainfall mulching reduces soil water recharge frequently (Leonard, 2015). Mulching also helps in reducing weed germination which improves crop yields by avoiding crop-weed competition. This remnant biomass is economical and easily available to the farmers and has a record of improving yields up to 50 %(Anandha and Dayana, 2021).

Livestock feed

Feeding plant residues after harvesting is an old practice from the time known. The stem of the rice straw is cut just above the ground which is good for cattle feed but due to high silica content it is not preferred. Stems are preferred than leaves because of less silica content. These leftovers are low-density fibrous material with varied quantities of lignin, which acts as a physical barrier to microbial decomposition and inhibits the process (Surendra *et al.,* 2012) Different physical, chemical, biological practices are followed to break the ligno-cellulose bond which increases the nutrition value. Wheat straw is used as a fodder feed to animals where the straw is cut into small pieces. To enrich these residues mixed with urea, molasses and green manuring crops which help in increasing nutritional content. From the analysis of (Biswas *et al*., 2006) stated that the paddy which is treated with urea and molasses mineral mixture have an increased protein content from 3.2% to 6.4% (Kamaljeet *et al.,* 2019)

Animal straw bed & Compost

The residues are used as bedding material for animals which comforts them and helps in yielding high milk production. 1Kg of straw absorbs nearly 2-3 liter of urine which increases the nitrogen content (Yadav *et al.,*2015).One hectare of land gives nearly 3 tons of nutrient enriched compost (kamaljit *et al.,* 2019). These crop residues are rich in primary nutrients like N, P, K, S which on recycling provides high value compost that helps in enhancing soil fertility and productivity (Anandha and Dayana, 2021). This decomposition process is accelerated by using microbial consortium (Surendra *et al.,* 2012)

Mushroom cultivation

Rice straw is an excellent substrate for production of white button mushroom and straw mushroom which is sustainable with high moisture and protein (Kamaljit *etal*., 2019).maize stalks are used for production of oyster mushroom which helps in increasing the yields in terms of fruiting body and fresh weight. Inedible crop residues are converted into edible one with high protein and amino acid content (Anandha and Dayana, 2021)

Bio char production

Production of bio char is obtained by slow pyrolysis of biomass in anaerobic conditions. It is finely grained charcoal plays an important role in carbon sequestration and easing of greenhouse gases (Surendra *et al*, 2012). It is identified that due to rice cultivation 38-49% of carbon foot prints are reduced by bio char production. The quality of bio char is determined by temperature of pyrolysis, rate of heating and type of feed stock (Anandha and Dayana, 2021). It should be made economically viable by collecting hydrogen and bio oils; which helps in bio char production without wasting the biomass (Surendra *et al.,* 2012).

Bio methane production

Bio methane is generated from biogas, which is obtained from organic matter like human waste/sewage, food waste, distillery waste, or agricultural waste. Biogas is dried and purified before being improved to pure bio methane. Peaking stations can also employ bio methane. Because bio methane is a renewable fuel, it may be used to balance intermittent renewable energy to provide a completely sustainable power source (Clarke energy). Biogas of excellent grade is extracted, and the manure produced is recycled. The yield per ton of dry rice straw is 300m^3 biogas with 55-60% methane. The remaining by-product slurry can be applied to the land as organic manure (Anandha and Dayana, 2021)

Gasification

It is a Thermochemical process where the remnant biomass undergoes partial combustion that result in production of Producer gas which contributes to the generation of electricity(Anandha and Dayana, 2021). Where one ton of biomass can generate 300kWh of power. The drawback of this process was production of impurities along with the production of impurities. Therefore, during adoption of this technique for generation of energy; bio filters should be used to protect the environment (Surndra *et al.,* 2012).

CONCLUSION

Thus to feed the growing population in India, the food production has to be increased through sustainably by conserving the available natural resources. Crop residues are prerequisite and have higher commercial value as a raw material for different industries, feed for livestock, fuel etc. So, crop residues must be properly utilized or managed. In order to achieve this proper knowledge and training must be given to stockholders, farmers and peoples so that crop residues can be utilized properly and it can improve the socio economic status of the people for sustainability and resilience of Indian agriculture.

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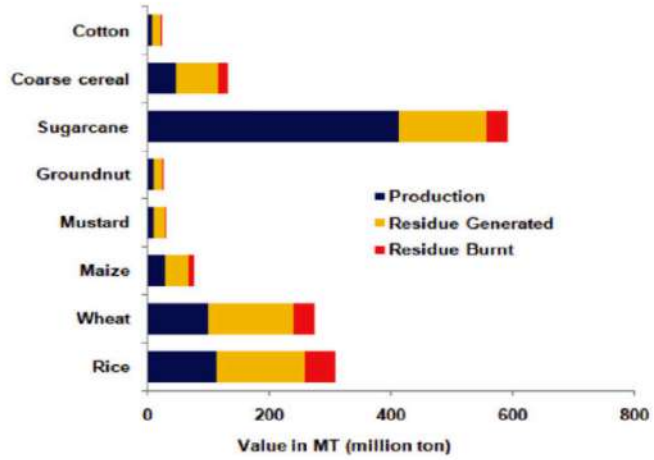

Fig.1 Graphical representation of crop wise data regarding crop production, residue generation and residue burning for the year of 2018 (Gaurav *et al.*, 2021).

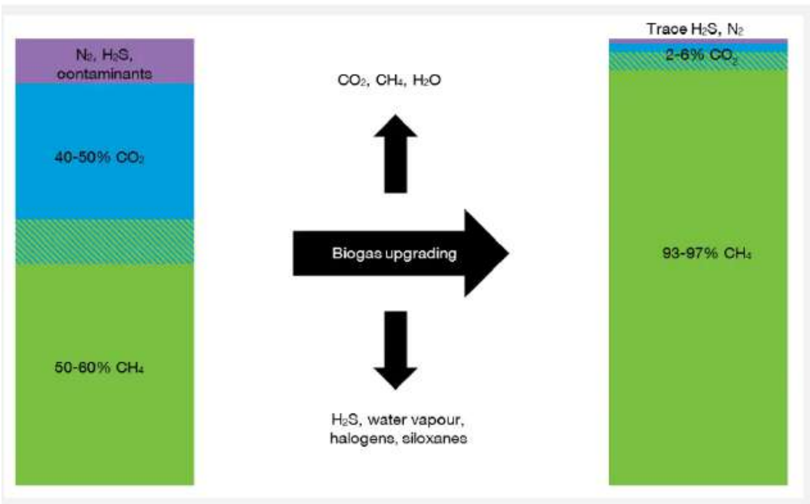

Fig 2: Representation of different biogas upgrading technologies producing bio-methane

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RESEARCH ARTICLE

Influence of Irrigation and Nitrogen Management on Growth and Root Characteristics of Aerobic Rice

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ABSTRACT

Rice (*Oryza sativa* L.) is an important staple cereal food crop for a large population of the world. Nitrogen and water are the two most important input for rice. Due to growing scarcity of fresh water, aerobic rice is now become an increasingly popular alternative than transplanted rice in India. A field experiment was carried out in Visva-Bharati, Birbhum, West Bengal during the pre-kharif season of 2016 on red and lateritic soil to find out the Influence of irrigation and nitrogen management on growth and root characteristics of aerobic rice (Sahbhagi dhan**)**. The experiment was carried out using split plot design with 3 replications with 12 treatment combinations. The treatment combinations are three irrigation management i.e., 75 percent CPE (Cumulative Pan Evaporation), 100 percent CPE, 125 percent CPE in the main plot, and four nitrogen management strategies i.e., 100 percent nitrogen was obtained by fertiliser, 75 percent through fertiliser + 2.5 t ha^{-1} vermicompost, 50 Percent through fertiliser + 5.0 t ha^{-1} vermicompost, and 25 percent through fertiliser +7.5 t ha^{-1} vermicompost in subplot. The growth parameters like plant height, above ground biomass production, LAI, numbers of tillers m^{-2} and root characteristics of aerobic rice were considerably affected by irrigation and nitrogen management. Maximum values for growth attributing characters were recorded with nitrogen at 100% N through fertilizer and 75 % N through fertilizer + 2.5 t ha^{-1} vermicompost which are significantly different from other nitrogen management whereas irrigation management at 100% of CPE and 125% CPE is better than the irrigation at 75% of CPE.

Keywords: Aerobic rice, irrigation, nitrogen, rice root study

INTRODUCTION

Rice is the source of staple food for half of the world's people and is farmed on half of the earth's cultivable land (Duary and Pramanik, 2019). To fulfil increasing rice demand with decreasing water resources, it will be necessary to increase rice yield with less water (Duary, 2020). Among the different water saving rice cultivation technologies, aerobic rice is a system of rice production that involves direct seeding of seed in unpuddled conditions without standing water and irrigation in the same way that other upland cereal crops. Aerobic rice provides the maximum yield by using less water. These systems of rice production can reduce water use up to 44% compare to traditional transplanted systems, by reducing water loss such as percolation, seepage and evaporative losses, while maintaining yield up to a certain level (Singh*et al*., 2017). Proper irrigation management is required in any crop for more efficient water use and greater shoot and root growth which resulted increased in output. Under aerobic conditions, rice plants cultivated with intermittent irrigation had higher root activity (Keerthi *et al*., 2018). Nitrogen fertilisation in rice crops should also be balanced between increasing output and reducing the danger of lodging (Shah *et al*., 2019). Nitrogen fertiliser at the right time is the most important agronomic activity that impacts rice growth and yield. Further, the study addresses some of the Sustainable Development Goals (SDG) such as SDG 1 (no poverty), SDG 2 (zero hunger), and SDG 15 (life on land)(UN, 2021).

MATERIALS AND METHODS

During the pre-kharif season of 2016, a field experiment was conducted at agricultural farm,Visva-Bharati, located in the western region of West Bengal, India. The experimental location is situated at 20.39'N latitude and 87.42'E longitude, with 58.9 m above mean sea level. The experiment was conducted with split plot design and replicated thrice. and test crop was aerobic rice “Sahbhagi dhan”. Variety Sahabhagi variety. The prevailing soil of the experimental site was sandy loam where soil pH, organic carbon and soil available N, P and K were 6.1, 0.49% and 136kg ha^{-1}, 11.5 kg ha^{-1} and 160.5 kg ha^{-1} respectively. Nitrogen was supplied through urea and Phosphorus and potassium were supplied through DAP and MOP, respectively. Nitrogen was applied as per treatments one P; K were applied uniformly in all the experimental plot. In the channel of the experimental field, irrigation water was measured using 90^0 V notch weirs and the rate of discharge calculated by the formula:
$Q = 0.0138 \times H^{5/2}$
Where, Q is the discharge in litre per second; H is the head of the crest (cm)

Treatments Details
Main plot treatment: Irrigation at 75% CPE (I_{75}); Irrigation at 100% CPE;(I_{100}); Irrigation at 125% CPE(I_{125})
Sub-plot treatment: 100% N through Fertilizer (N_1); 75 % N through Fertilizer + 2.5 t/ha vermicompost (N_2); 50 % N through Fertilizer + 5.0 t/ha vermicompost (N_3);25 % N through Fertilizer +7.5 t/ha vermicompost (N_4).
The ratio of area/weight of the leaves was used for determining leaf area index as described by Kemp (1960): $LAI = \frac{\text{Leaf area}}{\text{Ground area}}$

The chlorophyll content was calculated by using the formula of Arnon (1949) and expressed as mg/ g of fresh leaf. Arnon’s formulae to estimate chlorophyll content of leaf is as follows:

Chlorophyll a (mgg^{-1} of fresh weight of leaf) $= \frac{[12.7\ (D\ 663nm) - 2.69(D\ 645nm)\ ]}{1000xw} xv$

Chlorophyll b (mgg^{-1} of fresh weight of leaf) $= \frac{[2.29\ (D\ 645nm) - 8.02(D\ 663nm)\ ]}{1000xw} xv$

Total chlorophyll (mg g^{-1} of fresh weight of leaf)
$= [20.2\ (D\ 645\ nm) + 8.02(D\ 663\ nm)\ ] \times V/1000$

Here, D is the absorbance at wavelength 645 nm and 663 nm, V is the final Volume of DMSO (ml) and W is the weight of fresh leaf (g). Plants are gown in PVC tubes that are filled with soil for root study. 10 cm-wide and 30-cm-long tubes was used. At panicle initiation stage, PVC tubes with plant and soil dig out from plot then the soil block with plant was soaked in water for 24 hr. Roots were separated from soil particles carefully and root length, root volume, root diameter were measured by root analyser i.e., WinRHIZO. After separating the roots from the stem's base, the dry weight of the roots (g) was taken. The roots of three plants from each plot were weighed after oven drying, and an average was calculated. The F-test was used to determine the significance of treatment means (Gomez and Gomez, 1984).

RESULTS

Plant height

The results revealed that impact of irrigation management on plant height at harvesting stage of the "Sahbhagi dhan" variety of aerobic rice grown in pre-kharif conditions (Table 1). The observations showed that irrigation at I_{125} and I100 exhibited the highest plant height among different irrigation management treatments, while irrigation at I_{75} presented significantly lower plant height than I_{125} and I_{100}. Both I_{125} and I_{100} were at par in respect of plant height. The lower number of tillers under I_{75} might be due to non-availability of water (Duary and Pramanik, 2019; Pramanik and Mondal, 2020). The observation revealed that nitrogen management has a great impact on plant height. N_1, and N_2 treatments showed the highest plant height among different N management treatments, while N_3, and N_4 presented significantly lower plant height than N_1, and N_2. N_1 exhibited significantly higher plant height than N_2, while N_4 presented significantly lower plant height over N_1, N_2, and N_3 (Table 1).

Number of tillers m^{-2}

The data on the number of tillers m^{-2} revealed that the irrigation and nitrogen management influenced the tillers production in aerobic rice "Sahbhagi dhan" during pre-kharif (Table 1). The treatment I_{125} being statistically on par with I_{100} produced a significantly greater number of tillers than the I_{75}. The minimum number of tillers production under I_{75} might be due to less availability of moisture (Nayak, 2015 and Duary and Pramanik, 2019). Among the N management options, N_1 recorded significantly higher tillers m^{-2} than rest of the nitrogen managements, and lowest number of tillers m^{-2} produced by N_4 treatment.

Dry mater accumulation (g m^{-2})

The data on dry matter accumulation of shoot were recorded and analysed statistically and presented in Table1**.** In respect to irrigation management,I_{100} and I_{125} was at par but they were recorded significantly higher dry matter accumulation than the I_{75} treatment. I_{125} was significantly higherthan rest of the irrigation management in respect to dry matter accumulation m^{-2}. N_1 was at par with $N_2$and N_2 is significantly higher than N_3 and N_4 treatment on the aspect of dry mater accumulation. The lowest aerial dry matter accumulation was observed at I_{75} which may be due to lower production of tiller with irrigation at 75% of CPE (Mondal et al., 2020).

Leaf area index (LAI)

Irrigation and nitrogen management showed significant effect on LAI in Table 1. Data on leaf area index (LAI) revealed that I_{125} was statistically on par with I_{100}, registered significantly higher values of LAI at 90 DAS than I_{75}.

The higher in leaf area index under regime at I_{100} and at I_{125} could be due to enhancement in the uptake of nutrients under higher moisture condition resulting in a greater number of leaf and higher leaf area. The result is in conformity with the finding of Singh and Shivay (2019). Among different N management treatments, N_1 registered higher values in LAI during the experiment, and N_2 closely followed it; however, these two treatments were statistically on par. Treatment N_4 resulted in the least values of LAI of aerobic rice "Sahbhagi dhan" during pre-kharif at 90 DAS.

Chlorophyll a content: The maximum value of chlorophyll a was recorded in crop receiving I_{125} at 60 DAS which was at par with I_{100} in respect to chlorophyll a both I_{125} and I_{100} were recorded significant higher chlorophyll a content than I_{75} (Table 2). In respect to nitrogen management the highest chlorophyll a was recorded at N_1 nitrogen management which was at par with N_2 but significantly superior to rest of the treatment in regard to chlorophyll a content.

Chlorophyll b content: As regards to irrigation management, the results showed that irrigation management exerted significant effect on chlorophyll b content in leaf. I_{125} was at par with I_{100} in respect to chlorophyll b content and I_{100} was recorded significantly higher chlorophyll b than I_{75} (Table 2). In respect to nitrogen management, the results showed that chlorophyll b content in leaf was significantly influenced by different nitrogen management. The highest chlorophyll b was recorded at N_1 treatment. N_1 was recorded significantly higher chlorophyll b than the rest of the treatment whereas there was no significant difference between N_2 and N_3.

Total Chlorophyll content

The maximum value of total chlorophyll was recorded incrop receiving I_{125} significantly higher than other irrigation treatment in respect of total chlorophyll content in leaf (Fig.1). As regards to nitrogen management the highest total chlorophyll was recorded at N_1 nitrogen management and N_1 was recorded significantly higher total chlorophyll of leaf than the rest of the nitrogen treatment.

Results of the experiment showed that irrigation at I_{75} significantly reduced total chlorophyll content. From previous research it is clear that water scarcity increases the plant electrolyte leakage and ultimately reduce chlorophyll content in leaves (Petrov *et al.*, 2012). Chlorophyll contents increased significantly under application of 100 % N through fertilizer (N_1) and 75 % N through fertilizer + 2.5 t of vermicompost ha^{-1}(N_2)(Fig.2). This is may be due to the enhanced chlorophyll synthesis for nitrogen supply, which is a major component of chlorophyll (Hudson *et al.*, 2011).

Root study

Roots are essential for survival and play a crucial role in determining the crop yield. Irrigation at I_{100} and I_{125} recorded higher values of root parameters like root length, root volume, root diameter and root mass. The data on root length as affected by irrigation and nitrogen management during the experiment was statistically analyzed and presented in the Table 3. The results showed that root length of aerobic rice was maximum at I_{100} and there was no significance difference between I_{100} and I_{125} but I_{100} was recorded significantly higher root length than I_{75}.The root length was significantly influenced by different nitrogen managements during the experiment. The highest root length was recorded at N_1 (100% N through inorganic fertilizer) and it was significantly higher than rest of the nitrogen management i.e., N_2, N_3 and N_4.

As regards to irrigation management, the results showed that the surface area of root on aerobic rice was influenced by different irrigation management during the experiment. The results showed that the surface area of root of aerobic rice was maximum at I_{100} and it was significantly higher than I_{125} and I_{75}. The surface area of root was significantly influenced by different nitrogen managements during the experiment. The highest surface area of root was recorded at N_1 (100% N through inorganic fertilizer) and there was no significant difference between N_1 and N_2 but N_2 recorded significantly higher root volume than rest of the nitrogen management i.e., N_3 and N_4.

As regards to irrigation management, the results showed that root volume on aerobic rice was influenced by different irrigation intervals during the experiment. The results showed that root volume was maximum at I_{100} and there was no significance difference between I_{100} and I_{75} but I_{100} was recorded significantly higher root length than I_{125}. The root volume was significantly influenced by different nitrogen managements during the experiment. The highest root volume was recorded at N_1 (100% N through inorganic fertilizer) and there was no significant difference between N_1 and N_2 but N_2 recorded significantly higher root volume than rest of the nitrogen management i.e., N_3 and N_4.

The results showed that root volume was maximum at I_{75} and there was no significance difference between the treatments. In respect to nitrogen managements, the results revealed that nitrogen management played an important role for increasing average diameter of root in aerobic rice. The average diameter of root was significantly influenced by different nitrogen managements during the experiment. The highest average diameter of root was recorded at $N_2$and but N_2 recorded significantly higher root volume than the nitrogen management onN_1 and N_3 and there was no significant difference between N_3 and N_4

As regards to irrigation management, the results showed that dry weight of root on was influenced by different irrigation intervals during the experiment. The results showed that dry weight of root was maximum at I_{100} and there it was no significantly higher than rest of the treatment. The growth of roots is inhibited during water deficit and this is similar with the findings of Smith *et al*., 2012.

CONCLUSION

In water-scarce areas aerobic rice can be a viable option for rice cultivation with proper irrigation and nitrogen management. On red and lateritic soils of West Bengal, aerobic rice needs to be irrigated for optimum growth and root growth at 100 percent CPE with the application of 100 percent N through inorganic fertiliser produced optimum growth, yield, and root growth.

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Table 1: Effect of irrigation and nitrogen management on growth characteristics of aerobic rice

Treatments	Plant height (cm)	Number of tiller m^{-2} 90 DAS	Dry matter accumulation (g m^{-2}) 90 DAS	LAI
Irrigation management				
I_{75}	75.5	370	628	2.21
I_{100}	78.60	330	855	2.70
I_{125}	79.7	378	920	2.75
SEm (±)	0.76	5.72	20.7	0.04
CD at 5%	2.98	22.45	81.2	0.15
Nitrogen management				
N_1	82.8	396	886	2.82
N_2	79.5	369	853	2.69
N_3	75.8	351	797	2.49
N_4	73.50	322	667	2.21
SEm (±)	0.84	5.35	17.3	0.04
CD at 5%	2.51	15.89	51.3	0.13

Table 2: Effect of irrigation and nitrogen management on chlorophyll content of aerobic rice

Treatments	Chlorophyll a (mg g^{-1} of fresh leaf)	Chlorophyll b (mg g^{-1} of fresh leaf)
Irrigation management		
I_{75}	1.89	0.92
I_{100}	2.28	1.41
I_{125}	2.41	1.51
SEm (±)	0.10	0.04
CD at 5%	0.39	0.18
Nitrogen management		
N_1	2.63	1.56
N_2	2.38	1.32
N_3	2.04	1.22
N_4	1.74	1.02
SEm (±)	0.10	0.05
CD at 5%	0.30	0.16

Irrigation at 75% CPE (I75); Irrigation at 100% CPE; (I100); Irrigation at 125% CPE (I125); 100% N through Fertilizer (N1); 75 % N through Fertilizer + 2.5 t ha-1 vermicompost (N2); 50 % N through Fertilizer + 5.0 t ha-1 vermicompost (N3); 25 % N through Fertilizer +7.5 t ha-1 vermicompost (N4).

Table 3: Effect of irrigation and nitrogen management on root study of aerobic rice

Treatments	Length(cm)	Surface area (cm²)/78.57cm²	Volume (cm³)/2394.85cm³	Average diameter of root (cm)	Dry weight (g)
Irrigation management					
I_{75}	1033.8	223.2	3.8	0.69	2.71
I_{100}	1298.4	267.5	4.3	0.67	6.64
I_{125}	1154.9	230.8	3.7	0.64	5.92
SEm (±)	42.8	8.1	0.1	0.02	0.14
CD at 5%	168.2	32.0	0.5	0.06	0.56
Nitrogen management					
N_1	1386.6	276.9	4.6	0.63	5.34
N_2	1174.4	266.5	4.5	0.75	5.54
N_3	1195.7	235.5	3.7	0.63	3.87
N_4	892.7	183.1	3.0	0.66	5.61
SEm (±)	30.8	5.9	0.1	0.01	0.10
CD at 5%	91.6	17.6	0.2	0.02	0.30

Irrigation at 75% CPE (I75); Irrigation at 100% CPE; (I100); Irrigation at 125% CPE (I125); 100% N through Fertilizer (N1); 75 % N through Fertilizer + 2.5 t ha-1 vermicompost (N2); 50 % N through Fertilizer + 5.0 t ha-1 vermicompost (N3); 25 % N through Fertilizer +7.5 t ha-1 vermicompost (N4).

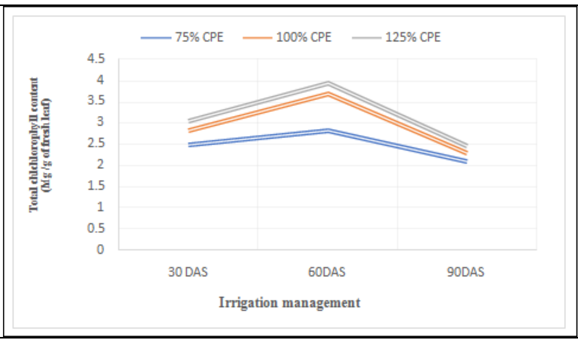

Fig.1: Total chlorophyll content as influenced by irrigation management

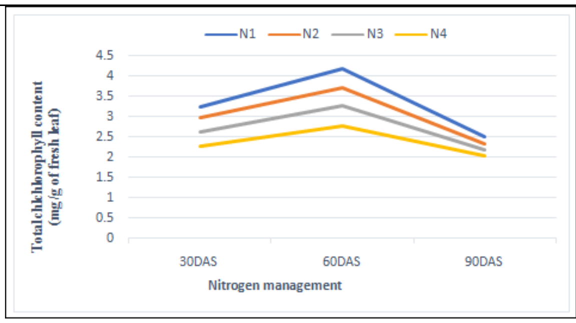

Fig.2: Total chlorophyll content as influenced by nitrogen management

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REVIEW ARTICLE

Drip Fertigation for High Productivity and Sustainable Production of Banana: A Review

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ABSTRACT

Banana is a highly nutrient demanding crop which needs huge quantity of nutrients for quick growth and development, therefore banana shows significant response to the applied nutrients. Manual application of fertilizers in banana leading in to low nutrient efficiency and sometimes contributed as a pollutant to natural water resources. To increase the input use efficiency nutrients can be applied through drip fertigation to reduce the losses and increases the efficiency. Drip fertigation facilitates precise quantity of water and nutrient application. Therefore an attempt made to review the advantages of fertigation in banana and analyzing the response of banana under fertigation. The review also augmented the information on fertigation doses and fertigation intervals for different varieties of banana.

Keywords: Soil nutrients, fertigation dose, fertigation interval, drip irrigation

INTRODUCTION

Banana consumes a huge amount of fertilizer (Thangaselvibai et al., 2009) throughout its cropping period, hence emphasizing the importance of fertilizer management for getting a greater yield. Banana is a high soil nutrient exhausting crop. Therefore it is essential to retain the higher fertility of the soil for harvesting sustainable yield for a longer period. A large quantity of macronutrients, especially nitrogen and potassium is essential for higher growth and yield, higher quality and greater economic feasibility of banana cultivation (Badgujar et al., 2004). Therefore, well-managed application of nutrients at shorter intervals with small quantities is used full compare to heavy applications sporadically. On this background, the effect of different doses of fertigation and fertigation interval for the banana crop has been reviewed under the following topics for high productivity and sustainable production of banana.

Nutrient responses on banana

Banana, consider being a heavy feeder and requires an enormous quantity of major nutrients (Noor et al., 2010). Banana significantly influenced by the doses of applied nitrogen and potassium. However, the types of fertilizers, quantity of nutrients, time and application methods, etc. vary depending upon the agro-climatic regions and cultivars. Many studies reported that banana needs a large amount of potassium followed by nitrogen and phosphorus. Santos et al., (2009) reported that potassium and nitrogen are required for the banana in large quantity in comparison to other nutrients. Studies also opined that reducing the application of NPK may reduce the yield and yield attributing characters considerably. Nalina et al. (2003) reported the corresponding reduction in banana fruit quality parameters such as total soluble solids (TSS), ascorbic acid, total, reducing, and non-reducing sugars by reducing the application of NPK. A field study conducted by Rivera (2004) concluded that a 20 kg banana bunch removes 44g N, 5g P, and 143.47g K.The plant response to nutrients was high when a combination of N:P:K are applied as compared to nutrients applied separately. The uptake of major nutrients through the fruits is in the order of K>N>P>Mg>Ca=S, which indicates that the utilization of nutrients in the same order for growth and yield. However, accumulation of nutrients in the main plants presents in the following descending order K > N >Ca> Mg > P > S > Fe >Zn > B > Cu. Various researchers reported improved yield and yield parameters by applying different doses of fertilizers for the banana crop is presented in Table 1.

Fertigation for banana

Application irrigation water and water-soluble fertilizers (WSF) via a drip irrigation system are called fertigation. Fertigation system allows to irrigate and fertigate more uniformly and for a larger area in comparison to the conventional method of fertilizer application (Santosh and Maitra, 2022). It is more useful in agro-climatic conditions of India where most of the horticultural crops are grown on sloppy land (Naira et al., 2012). Fertigation system results in higher fertilizer use efficiency as well as a reduction of nutrient leaching below the plant root zone. This also prevents fertilizer losses from runoff and leaching which may pollute both surface and groundwater. Mohammad (2004) reported minimizing the risk of nutrients leaching under fertigation. A study conducted by him also concluded that fertilizer use efficiency (FUE) increased with the use of water soluble fertilizers (WSF) through drip in comparison to solid fertilizer applied manually to sandy loamy soil for squash. Nanda (2010) found 60 to 70 percent higher yield through drip fertigation with WSF in banana in comparison to conventional fertilizer application. In addition to increased yield, reduces the water and fertilizer requirement, it also reduces weeding cost. Mustaffa and Kumar (2012) reported saving of 20 to 30 percent of fertilizers, including increasing of yield and quality of produce in comparison to the conventional methods of fertilizer application. Teixeira et al. (2011) study concluded that fertigation system increased nutrient use efficiency by 36 percent in comparison to conventional fertilization, for both nitrogen and potassium.

Banana is a heavy feeder of water and nutrients. It is highly suitable to fertigation technique. The yield of the banana crop increased by 60 to 70 percent by adopting the practice of fertigation in comparison to conventional fertilizer application system (Nanda, 2010). Suresh and Hasan (2002) reported 40 percent fertilizer saved without the reduction in banana yield by adopting the fertigation system. A study conducted by Kumar et al. (2007) concluded that maximum fertilizer use efficiency and yield was obtained by water at 60 percent and fertilizers through a drip. Higher yield and a maximum number of hands per branch obtained through fertigation. Many researchers from India reported higher yield with improved quality of banana through fertigation (Srinivas et al., 2001; Mahalakshmi et al., 2001). Drip fertigation in combination with plastic mulch can be used to enhance water and nutrient use efficiency (Bowen and Frey, 2002). Reduced nutrient leaching and increased soil temperature are few of the benefits of plastic mulch. Gutal et al. (1992) reported higher moisture conservation, yield, nutrient use efficiency, and weed control by applying black plastic mulch in chili crop. Black plastic mulch increases the soil temperatures rapidly and increases the growth of plants which results in earlier and higher yields compared to open field condition.

Fertigation scheduling

The success of the fertigation system can be achieved by proper scheduling of fertigation as it influences the growth and development of crops. By using fertigation system fertilizer can be applied more frequently as per the crop nutrient requirements. Fertigation interval depends on soil type, weather conditions, nature of fertilizers, etc. Sandy soils in heavy rainfall regions nutrients need to be applied frequently. Rigorous leaching areas require the immediate application of nutrients at short intervals. Application of fertilizers in shorter intervals will improve the nutrient uptake capacity of plants by continuous replenishment of nutrients at the vicinity of the plant roots interface (Sathya et al., 2008). For banana crop, it is necessary to schedule fertigation according to soil conditions and different developmental stages of the banana crop. Mahalakshmi et al. (2001) advocated in favor of the regular frequency of the fertigation. They recorded a higher yield of Robusta cultivar banana crop with weekly fertigation interval. Santosh and Tiwari (2017) reported the advantage of weekly fertigation in most of the crop growth parameters. They also reported an increase in bunch weight and yield by 0.7 kg and 2.2 t ha^{-1}, respectively in comparison to the frequent application. The various intervals of fertigation as suggested by different researchers for a banana crop presented in Table 2.

CONCLUSION

Banana shows significant response for nutrient application using drip fertigation. The biometric characteristics of banana, yield and yield parameters were better with fertigation in comparison to the conventional techniques. The review also gathers the information of fertigation doses and fertigation intervals for different varieties banana as reported by different researchers.

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Table 1. Fertilizer doses recommended for the banana crop by different researchers

Reference	Variety	N:P:K(g/plant/year)
Hegde and Srinivas (1991)	Robusta	200:47:187
Ray et al. (1993)	Basara	200:100:300
Shelke and Nahate (1996)	Dwarf Cavendish	200:40:200
Agrawal et al. (1997)	Robusta	450:200:450
Nalina et al. (2003)	Robusta	300:90:450
Thippesha et al. (2008)	Robusta	180:108:225
Hazarika and Mohan (2009)	Jahaji	160:17:260
Bhalerao et al. (2009)	Grand Naine	200:40:200
Hazarika and Ansari (2010)	Jahaji	110:33:330
Pandit et al. (2011)	Harichal	300:50:300

Table 2. Reported fertigation intervals for the banana crop by different researchers

Reference	Variety	Frequency of application
Lahav and Kumar (1995)	Williams	Weekly application
Shahar and Achila (1997)	-	Weekly intervals
Srinivas (1997)	Robusta	Daily application of Urea up to 180 days
Berad et al. (1998)	Basrai	15 days interval
Srinivas et al. (2001)	Robusta	On alternate days from 45 days after planting till 320 days
Mahalakshmi et al. (2001)	Robusta	At weekly interval
Badgujar et al. (2004)	Grand Naine	Monthly fertigation
Pinto et al. (2005)	-	N and K nutrients applied three times a week and P nutrient applied twice a year.
Bhalerao et al. (2009)	Grand Naine	Bi-weekly fertigation
Pawar and Dingre. (2013)	Grand Naine	Bi-weekly fertigation
Senthilkumar et al. (2016)	Robusta	Weekly fertigation

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REVIEW ARTICLE

A Review on Green Manuring Technique in Rice

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ABSTRACT

In 1931, the government advised green manure, developed green manure crop seed production farms, and subsidized the supply of seed and root nodule bacteria to combat the agricultural depression. Green manure is an alternative to inorganic N sources. There are many types of research that show the beneficial effects of green manuring. The utility of green manuring for increasing soil productivity has been recognized in rice-based cropping systems, they are particularly acquiescent to green manuring. Various green manure plants are employed, and they differ by region. By increasing the solubility of lime, green manuring speeds up the restoration of alkali soils. Green manure crops can provide phosphorus and nitrogen while also improving soil organic matter levels.At the same time, soil fertility and long-term soil productivity maintenance must be taken into account. Green manure crops improve yields by a large amount. The cost of green manure seed varies by area. Green manure application efficiently adds a lot of new organic matter and soil nutrients. Green manure decomposition increased the proliferation and activity of soil microbes while also altering the structure and content of dissolved organic matter.As a result, the study's goals were to assess the impacts of green manure and analyze its structure and composition in paddy fields.Low or no fertilizer application, as well as high weed infestation, are the key restrictions limiting rice output in diverse locales.According to the findings, green manure technology is a potential low-cost solution for increasing rice yield and profitability in an ecosystem. The majority of soils are lacking in nitrogen and organic matter. Green manure technology management in rice adds to the long-term sustainability of the system while also raising farm income above subsistence levels.Rice farming intensifies, resulting in a drop in groundwater levels and deterioration of soil quality. Chemical fertilizer prices are rising, and there is a need for an alternative. Periodic application of organic matter is required to repair humus loss, improve nitrogen delivery, and promote microorganism growth. Green manuring can be the best alternative to improve soil health and the nutritional need of succeeding crops.

Keywords: Green manuring, green leaf manuring, organic matter, rice-based cropping system, productivity, profitability, sustainability

INTRODUCTION

Food grain production is the most important activity in India. Rice (*Oryza sativa*) is an essential food grain crop since it provides staple food for more than two-thirds of Indians. Despite the fact that many other kinds of cereal are grown, rice's importance is unavoidable because it contributes greatly to the national economy and offers global nutrition security. Rice bridges the gap between supply and demand for dietary grains. Rice provides 20 percent of the world's nutritional energy source (Tao and Li, 2018). Rice is a major grain crop, and the majority of the population relies on it. According to the third advance projections for 2020-2021, rice is cultivated in 43.77 million hectares in India, accounting for 20% of total rice production worldwide with 121.46 million tonnes produced and a yield of 2576 kilograms per hectare. Green manuring, according to Vrikshayurveda, is an ancient notion that was used in ancient times (Beniwal *et al.*, 2020). Green manuring was first implemented in China in 1134 BC. Green manure crops help to boost fertility and nourish soils (Swarup, 1987). Green manure only covers 1.23 million hectares in India (Indoria *et al*., 2018; FAI 2015). There are various green manure crops around the world that can help restore soil health and boost soil fertility while also controlling or managing pests (Kumar *et al*., 2014). Because of the widespread availability of low-cost chemical fertilizers, interest in green manuring has waned in recent decades. Due to the rising cost of chemical fertilizers, public concern about the high risk of environmental pollution, energy conservation, and the necessity for a sustainable cropping system, low-input farmers are once again turning to green manuring (Pimentel and Burgess, 2014).

Fertilizers are now the mainstay of modern agriculture. The indiscriminate use of fertilizers will pollute the environment, and contaminate resources (Bhunia *et al.,* 2021). Chemical fertilizer application, whether excessive or injudicious, has an impact on soil microflora (bacteria, fungi, protozoa, algae), soil health, soil quality deterioration, and structural degradation (physiochemical and biological properties of the soil). Chemical fertilizers have the following disadvantages as they eliminate soil-dwelling organisms that promote soil fertility; they are expensive; they disrupt soil qualities; and they emit nitrate, which is toxic to humans and animals (Pahalvi *et al*., 2021). The major goal or objective is to produce high-quality food grains in sufficient quantities to meet or feed the growing world population without compromising the soil's fertility (Timsina, 2018). With increased food production pressure on the world's agricultural land Farmers have been cultivating rice with compatible yields with modest amounts or no chemical fertilizers for generations because rice cropping facilitates for biological nitrogen fixation (Papademetriou, 2000). Out of the 17 SDGs recommended by UNDP, green manuring with rice has enough potential to fulfil SDG 2 and 3 (FAO, 2021).

Green manuring procedures

Green Manuring: The process of cultivating green manure crops and integrating them in situ to improve soil fertility is known as green manuring (Das *et al.* 2020). Crops are cultivated to increase organic matter in the soil, integrating green plants into the soil, either in situ or from other locations, when they are still green and before flowering (Egodawatta *et al.* 2012).Crops that produce green manure include the following: (legumes) dhaincha, sesbaniarostrata,sun hemp, cowpea, pillipesara, berseem, lucern, alfaalfa, lupins, vetches, Azolla, green gram, field bean, (non-legumes) sunflower, rye mustard and buckwheat (Maitra *et al*., 2018).

Desirable characteristics of green manure crops

- Quick-growing, short-duration crops.
- Multipurpose uses (green manure cover crop, N fixation, fodder) (Florentín *et al*., 2010)
- Tolerance to pests and diseases.
- Ability to grow in poor soils, wastelands.
- Ability to produce high seed.
- Early establishment and high seed viability.
- Easy to incorporate.
- Low C: N ratio (in legumes allows quick decomposition and makes the nitrogen available to other plants).

- Rapid decomposition supplies a high amount of nutrients (Jama, 2000).
- Highly tolerant to adverse climatic conditions (temperature).
- High water use efficiency (less water requirement).
- Biological nitrogen fixation (legume in nature).
- Ability to fix atmospheric nitrogen to improve fertility.
- High nutrient accumulation.
- More foliage and the ability to accumulate high biomass.
- Resistance to drought stress, floods, and high temperature.
- High nitrogen sink in underground parts (roots).
- Insensitive to photoperiod.
- Well-developed root system.
- Early-onset of biological nitrogen fixation.
- Good yield of high viable seeds.

Green manure crops used in Japan

Leguminous crops should be used as green manure because rhizobium symbiosis contributes a lot of nitrogen to the soil. Leguminous crops produce 8 to 25 tonnes of green matter per hectare and add 60 to 90 kg of nitrogen to the soil (Singh *et al*., 2013). On the basis of organic matter, it is equivalent to applying 3 to 10 tonnes of FYM. In the presence of leguminous plants, rhizobium has the ability to fix nitrogen. rhizobium can fix 50-300 kg N/ha (Choudary *et al*., 2018). Commonly used leguminous crops for green manuring were given below (Kaul *et al.,* 2015) (table 1,2& 3).

Green leaf manuringis the application of green matter brought in from outside, such as chopping down and incorporating leaves, twigs, herbs, branches, trees, and bushes growing on wastelands, field bunds, and abandoned sites and enriching the soil (Panda ,2013). Some examples of green leaf manure crops are Legumes-gliricidia, Pongamia, Gulmohar, peltophorum, cassia, Non-legumes- subabul, neem, calotropis, adathoda, weed species-parthenium, Eichhornia, trianthema, ipomea (table 3).

Characteristics of green leaf manure crops

- Nitrogen fixation (Legume nature.)
- Easy incorporation.
- Quick decomposition.
- Tolerant to adverse conditions (drought, stress).
- Fast-growing crops.
- High biomass and heavy foliage
- Ability to possess insecticidal properties
- Ability to grow in all agro-climatic zones

Benefits of green manure/Greenleaf manure crops

- Control of root-not nematodes by green manuring (root-knot nematode).
- Helps in the reclamation of alkaline soil
- Improves soil microbial activity and biomass(Selvi *et al*.,2009)
- Helps to suppress weeds and provides supplementary animal forage
- Well-developed root system helps in the uptake of nutrients to the top layer and makes it available to plants(Kaul *et al*., 2015)
- Improves the soil physical, chemical, biological properties of soil
- Improves the soil fertility by raising leguminous green manure crops (biological nitrogen fixation) (Becker *et al*.,1995).
- Addition of undecomposed plant material as mulch material (soil cover)
- Helps in reducing soil and water erosion
- Uses in a multipurpose manner such as feed, food, fuel, organic matter addition.

- Low input requirement
- Green manure crops are N sources with relatively high efficiency (Sharma *et al.*,2009)
- Offers ecological sustainability in the long run
- Green manure crops supply nutrients (40-60% of nitrogen) to subsequent crops (Aulakh *et al.*, 2000)
- Reduce losses through leaching, soil erosion and improves nutrient concentration
- Improves water holding capacity, water infiltration aeration
- Improvement of yield in rice due to the raising of green manure found to be 0.1 to 0.3 t/ha.

Disadvantages of green manuring

- If there is insufficient soil moisture under rainfed conditions It's possible that proper breakdown of green plant material and satisfactory germination of the subsequent crop won't be possible (Tripathy, 2021).
- If sufficient rainfall is not available a proper stand and growth of green manure crops cannot be achieved
- Green manuring may not be cost-effective, particularly in areas where irrigation and fertilizer are readily available. Because it is more cost-effective to add the amount of N that the crop is expected to fix from the atmosphere in the form of fertilizer.
- Green manure crops may also harbour some of the insects, pests, and nematodes which could harm the succeeding crop
- A green manure crop can compete for time, labour, and water, but the expense of inorganic fertilizer must be balanced.
- Certain green manure species' seeds might be expensive and difficult to acquire by.
- Incorporation of green manure crops can be costly and difficult
- Pests and diseases that are harmful to green manure or rice crops may be attracted to a green manure species.
- An intercropped green manure may compete with the primary crop for space, water, and nutrients (Miyazawa *et al.*, 2010).
- Control of the quantity and timing of nutrients is more complex than with inorganic fertilizer currently it is unpredictable.

Green manure technology in rice

Leguminous green manures develop quickly and adapt to a variety of rice-based cropping systems. To suppress weeds in many crops, green manuring must be found (Cheer *et al.*, 2006). However, due to a lack of irrigation water, growing a green manure crop is not possible. However, cultivating a green manure leguminous crop alongside rice and uprooting and depositing weeds on the soil surface in intra row space during weeding may provide a significant advantage over incorporating before rice planting. Green manuring is practiced according to the suitability of climatic and soil conditions. Green manuring had a substantial impact on rice growth and yield variables such as tillers, ears row, grain weight, plant height, and test weight, as well as improved soil nutritional status and soil organic carbon (Kumar *et al.*, 2011; Mangaraj *et al.*, 2022). Organic matter releases nutrients slowly and keeps them available for a long time. Decomposition of organic matter also improves mineralization conditions, resulting in improved nutrient availability in soil. Green manure crop integration in soil exhibited a considerable and positive effect on subsequent and succeeding crop output in terms of nitrogen contribution.

Green manure crops in the rice-based farming system: It is mainly done on rice fields that are irrigated. In rice, green manuring increased crop yield and productivity. In India, rice yield response to green manuring ranged from 0.65 to 3.1ha in high-yielding types (Singh and Kumar, 2017). The highest yield was from sesbania aculeate. Raising green manures boosted water-holding, water absorption, and water retention in long-term trials. Rice production in Asia is mostly influenced by the careful application of chemical fertilizers, improved varieties, and excessive irrigation (Singh *et al.*, 2021). Many different forms of leguminous green manure crops are employed as nitrogen sources. When compared to inorganic fertilizers, rice yields are higher when the crop is included at 45-65 days.

Potential green manure crops

Azolla in rice production:It is a symbiotic nitrogen-fixing blue-green alga (*Anabaena azollae*), as it is an aquatic fern used as an organic source of N in rice under low land conditions. Availability of nitrogen to rice based on the application time and method of application.50% of nitrogen is absorbed by the rice plant from incorporated Azolla by 42 days after transplanting.it is grown as green manure as well as intercrop in rice.it is incorporated before transplanting in rice and inoculated after transplanting and incorporated after 28 days in rice as intercrop (Rosegrant *et al*.,1988). for inoculation of Azolla 1.5 -2.5 t, Azolla /ha is required.it is assumed that 2kgN /t biomass is fixed by Azolla. Azolla contributes 80kg/ha N from green manure and40kg/ha of nitrogen from intercropping (table 4).

Gliricidia as green manure: it is native to Mexico it I woody species used for green manure in tropical areas.it produces high foliage yields and it is resistant to weathering. gliciridia is not only provided as green manure in rice but also in maize, sugarcane, yam, and taro (Glover,1988). addition of gliricidia as green leaf manure in combination with inorganic fertilizers increased rice yields by 60%.one tons of gliricidia providing 29-43 kg nitrogen,2.9kg phosphorous,16-26 kg potassium

Leucaenaleucocephala: Leucaena is used as green manure in upland crops, not with irrigated rice. Leucaena foliage was incorporated before rice. The yields of 459-551kgN/ha for normal harvest. Leucaena herbage yields 40 to 80 t fresh weight/ha. The nutrient content in leaves of Leucaena is 30-35kg nitrogen, 2.7kg phosphorous,14.0 kg potassium.

Sesbaniabispinosa: Sesbania is grown widely in India as a green manure crop.it is a shrubby annual or perennial also known as sesbaniaaculeata and a common name by dhaincha.it is of multipurpose use used as fiber fodder and green manure (Glover,1988).it is incorporated before transplanting rice.it is estimated that N accumulation of 80kg/ha in 30 days and 23kg in 60days.it is reported that sesbania yield averages of 26 t fresh foliage/ha and after incorporation of leaflets release of 50% N is recorded.

Green manuring rice with milk vetch (*Astragalussinicus*): Chinese milk vetch is cultivated during the Edo era (1603-18670 as green manure. milk vetch yields a fresh weight of about 45t/ha. nitrogen accumulation of milk vetch is about 0.4%N and carbohydrates is 2%. The efficiency of nitrogen in milk vetch is equal to ammonium sulfate. milk vetch increased the rice yields and increases the organic content in the soil(Wang *et al*., 2021). Before blooming N content was 4.5% of dry matter and decreased to 3.2% at full bloom.it is estimated that the maximum rice yield obtained with milk vetch was 33.8 t milk vetch/ha(135kg N/ha).

***Sesbaniarostrata*:**It is used as green manure to improve the fertility of the soil and supply nutrients to crops.it improves soil properties physical, chemical, and microbial properties of the soil, *Sesbaniarostrata* fixes nitrogen in the form of nodules and supplies after plowing *Sesbaniarostrata*fix high rates of N in the soil about 200kg N/ha (Arunnin *et al*.,1998). it produced 12-17t green matter/ha. Dakar Senegal used s. rostrata as green manure doubled rice yields.it bears nodules both on the stem and roots of the crop (Panda, 2013). two types of strains have been identified from *s. rostrata*both stem nodulating and root nodulating strains.

Winter green manure(*AstragalusSinica*): Originated in China,, it is the primary green manure in China. astragalus biomass reached 40-75 t/ha. The amount of nitrogen fixed in the field varies from 81-128 kg/ha. With 22.5-30t/ha biomass. while with 75t/ha, fresh biomass nitrogen-fixing reaches 270 kg /. Low lignin and C;N ratio helps in nitrogen utilization by rice and makes residual nitrogen available for the late cropping season. because of low lignin content astragalus decomposes quickly.1 kg of fresh biomass of astragalus increases rice grain yield by 12-16 kg.it increases organic content in the soil. The seeding rate is 22.5 to 37.5 kg/ha. the recommended dose of basal manure is 22t/ha. astragalus has to be incorporated at the flowering stage of pod bearing stage.

Green manure cropping sequences and fresh matter content

Agricultural crops and green manuring crops fight for time and space. As a result, by putting green manure in the cropping system, they can be coordinated. Mixed cultivation yielded better outcomes in several circumstances than single cropping. When intercropping, it's critical to choose the right row spacing. Here are some examples of green manure crops (table 5).

Biomass production and Nitrogen fixed: Green manure incorporated into the soil as fresh biomass can be an important source of dissolved organic content in the soil (GAO et al.,2018). the addition of organic matter into the soil may accelerate mineralization and enhance the organic matter in the soil. Sunhemp and dhaincha, when compared to legumes, have higher major and micronutrient accumulation due to higher biomass output and superior nutritional composition.

Future line of work

Crop land is scarce and grass used just as manure is not economically viable, the space for green manure crops has shrunk.it is critical to increase the economic value of green manure (Fig.1). it has numerous applications. Green manure can be used for fodder or seeds in addition to being used as manure its economic benefits could be boosted. There are numerous cultivation methods green manure can be sown on uncultivated land, forest land, orchards, hills in addition to agriculture. Appropriate crops should be chosen so that the amount of land planted to them can be increased. Green manure produced on 1 hectare could be applied to 2-3 hectares if better production techniques for higher productivity are used. Conduct a survey of available green manure species for various cropping patterns. Divide green manure species into use categories like forage green manure, leafy green manure. Determine the most effective methods for establishing green manure crops on your farm. Land preparation costs must be kept to a bare minimum for example combining a cash crop with non-cash crop Identify the various environments in which green manure could be produced. Collect and test various types of blending equipment currently in use by farmers. Investigate farm level methods for producing and storing green manure seed. Identify cultivars that are pest and disease resistant or tolerant genetically. To speed up the decomposition of green manure use cellulolytic microbial cultures. Identify legume species-specific rhizobialgermplasm and maintain it. Determine fast-growing high leaf yielding tree species for various agro-climatic conditions and examine the cropping behavior of tree legumes in different situations. Compile a list of labor requirements and costs for the production of green manure define various place that have different labor constraints (Doggliotti *et al*., 2005). Continue to track the economics of green manure production in various locations. Establish a link between research and extension programs in priority areas having the potential to profit financially from the usage of green manure. On-farm planting pattern trials enlist the help of the local social service organization.

CONCLUSION

In many aspects, green manure requires attention that is necessary to continue research on green manure species used in the rice-based farming system. The emphasis should be on improving process understanding, which is a requirement for better green manure management. The economic feasibility of green manure is hampered by high labour costs, high land opportunity costs, and poor water management. Designing a research program should be given substantial support to overcome the limits. Green manure technological advancements increase soil fertility production and insect resistance. Farmers should be informed of the repercussions and alternatives and take appropriate action. Only rice crops provide acceptable yields in rain-fed locations with a rice-based cropping system. The value of a green manure crop is determined by the amount of green matter present, the amount of nitrogen accumulated, and the ability to gather maximal nutrients. It is estimated that biological nitrogen-fixing accounts for 50% of the nitrogen accumulated in legumes. Lack of proper nutrient application and weed management strategies are the main constraints in achieving the potential yield of rice crops. As a result, it is an environmentally sustainable, low-cost solution for resource conservation even while maintaining ecological integrity in a long stretch.

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Table 1.Leguminous crop for green manure

Sl.No	Common name	Scientific name	References
1	Alfaalfa	*Medicago sativa L.*	(Kaul*et al*.,2015)
2	Green soybean	*Glycine max Merr.*	(Kaul*et al*.,2015)
3	Chinese milkvetch	*AstragalussinicusL.*	(Dubey*et al*.,2015)
4	Pea	*Pisumsativum L.*	(Dubey*et al*.,2015)
5	Common vetch	*Vicia sativa L.*	(Kaul*et al*.,2015)
6	Broad bean	*Viciafaba*	(Kaul*et al*.,2015)
7	White clover	*Trifoliumrepens L.*	(Dubey*et al*.,2015)
8	Sun hemp	*Crotalaria juncea*	(Dubey*et al*.,2015)

9	Dhaincha	*Sesbaniaaculeata*	(Kaul*et al*.,2015)
10	Pillipesera	*Phaseolustrilobus*	(Kaul*et al*.,2015)
11	Mungbean	*Phaseolusaureus*	(Kaul*et al*.,2015)
12	Berseem	*Trifoliumalexandrinum*	(Dubey*et al*.,2015)
13	Cowpea	*Vignasinensis*	(Kaul*et al*.,2015)
14	Khesari	*Lathyrussativus*	(Kaul*et al*.,2015)
15	Guar	*Cyanopsistetragonoloba*	(Dubey*et al*.,2015)
16	Senji	*Melilotus alba*	(Dubey*et al*.,2015)

Table 2. Non leguminous crop for green manure

Sl.No	Common name	Scientific name	References
1	Buckwheat	*Fagopyrumesculenturnmaench*	(Ishikawa,1988)
2	Rape	*Brassica napus L*	(Ishikawa,1988)
3	Green maize	*Zea mays L.*	(Ishikawa,1988)
4	Green rye	*Secalecereale L.*	(Ishikawa,1988)

Table 3. Plant species used as green leaf manuring

Sl.No	Common name	Scientific name	References
1	Glyricidia	*Glyricidia maculate*	(Dubey*et al*.,2015)
2	Karanj	*Pongamiapinnata*	(Kaul*et al*.,2015)
3	Subabul	*Leucaenaleucocephala*	(Dubey*et al*.,2015)
4	Neem	*Azadiractaindica*	(Kaul*et al*.,2015)
5	Mahua	*Madhucaindica*	(Dubey*et al*.,2015)
6	Wild dhaincha	*Sesbaniaspeciosa*	(Kaul*et al*.,2015)
7	Ipomoea	*Ipomeasps.*	(Dubey*et al*.,2015)
8	Madar	*Calotropis gigantean*	(Dubey*et al*.,2015)
9	Tarwar	*Cassia auriculata*	(Dubey*et al*.,2015)
10	Water hyacinth	*Eicchornea spp.*	(Dubey*et al*.,2015)

Table 4. Seed rate and Biological nitrogen fixation of green manure crops (Yadav*et al*., 2019)

Sl. No.	Common name of crop	Scientific name	Seed rate for sowing	Green biomass yield	Nitrogen fixed	References
1	Dhaincha Green manure	*Sesbania aculeata*	40-50kg seed ha^{-1}	20-30t ha^{-1}	96-135 kg N ha^{-1}	(Yadav *et al*.,2019)
2	Sesbania Root and stem nodule	*Sesbania rostrata*	30-40kg ha^{-1}	15-20ha^{-1}	80-100 kg N ha^{-1}	(Yadav *et al*.,2019)
3	Sunhemp Green manure	*Crotalaria juncea*	35kg ha^{-1}	13-15t ha^{-1}	95-100 kg N ha^{-1}	(Yadav *et al*.,2019)
4	Rice bean Legume green manure	*Vigna umbellata*	35kg ha^{-1}		3.15% N	(Yadav *et al*.,2019)
5	Subabul Multipurpose tree	*Leucaena leucocephala*	10kg ha^{-1}	40 ha^{-1}	260-320 kg N ha^{-1}	(Yadav *et al*.,2019)

Table 5. Effect of green manure on fresh matter of different cropping sequences

Sl.No	Cropping system	Fresh matter t/ha	References

1	Wintergreen manure and double-cropped rice	30-45 t fresh matter/ha	(Lizhi,1988)
2	Intercropping sesbania with early rice	0.4-0.8 t fresh matter/ha	(Lizhi,1988)
3	Azolla cultivated as green manure for rice	Winter-75 t fresh matter/ha Spring -30-45t / ha	(Lizhi,1988)
a)	In Early rice fields in spring	15-25t fresh matter/ha	(Lizhi,1988)
b)	In Early rice fields in summer	20-30 t fresh matter/ha	(Lizhi,1988)
c)	In Seedbeds for late rice	20-30 t fresh matter/ ha	(Lizhi,1988)
d)	Rice-Azolla-fish systems	100-150 t fresh matter/ha	(Lizhi,1988)
4	Single rice crop with green manure	15-30t fresh matter/ha	(Lizhi,1988)
5	Double cropped rice and oil rape with green manure	15t fresh matter/ha	(Lizhi,1988)
6	Wheat, rice, and green manure	15t fresh matter/ha	(Lizhi,1988)
7 a)	Rice and dryland crop with green manure Interplanting with single crop maize	25-3- t fresh matter/ ha	(Lizhi,1988)

Table 6.Representing the biomass production and nitrogen content in green manure crops

Sl.no	Crop species	Biomass in roots	Biomass in tops	Nitrogen content	References
1	Clovers (sweet and crimson)	24-26%	2.4-2.9 q	2.0- 2.3%	(Westcott *etal.*,1988)
2	vetch	17-19%	3.3%	2.2% in roots	(Westcott *etal.*,1988)
3	Vetch green manure crop (about 1 t / ha)	9 kg N/ha	66.8 kgN/ha	54 kg fixed nitrogen/ha	(Westcott *etal.*,1988)
4	cowpea	4.9 kg N/ha	54 kg N/ha	39.3 kg nitrogen fixed/ha	(Westcott *etal.*,1988)
5	Azolla	2.7 kg/ha/day		40-93 kg nitrogen/ha	(Westcott *etal.*,1988)

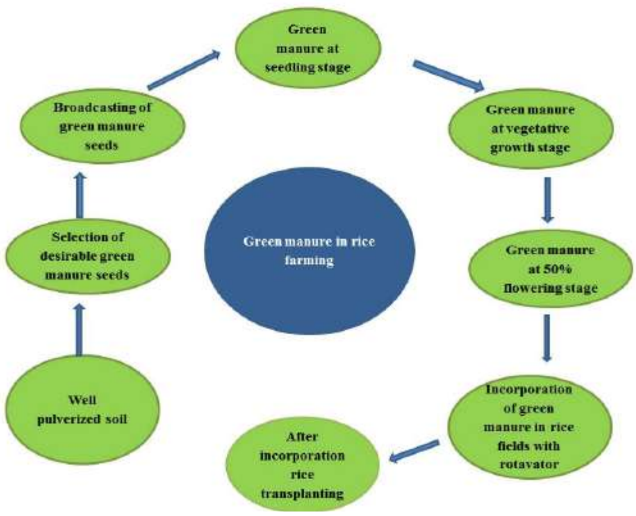

Figure 1 Green manuring in rice

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RESEARCH ARTICLE

Face Recognition using Raspberry Pi and Open CV

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ABSTRACT

Human face acknowledgment assumes a significant job in video observation, human-PC interface, customizing various applications. In this paper, the methodological way is dealt, which distinguish and recognize a face from the continuous stream that tracks a face and contrasts it and put away information of known people .Our approach completely ignores the background effect while recognizing a face of an individual. This approach also works on various conditions with different lighting effects which allow to execute results in large aspects of environmental conditions without getting any mismatches. Here a Raspberry Pi and different open source python libraries like open CV, NumPy are used. This framework utilizes Haar Course classifier for face detection in a picture and for facial recognition Local Binary Pattern Histogram (LBPH) is used.

Keywords: Face detection, Face Recognition, OpenCV (Open Source Computer Vision Library), Raspberry Pi,Local Binary Pattern Histogram, NumPy

INTRODUCTION

The process of Human identification is to spot a person based on their unique features. There are various types of human verification procedure are present on this commercial world, in which Password Verification Number(PIN) is mostly preferred .But this method is most likely to be theft or forgery because most of the people keep the pin with their date of birth or any special dates. So, the focus on Biometric has been increased due to its unique features [1]. The feature such as face detection, fingerprint, iris, palm etc. Human movement is a significant worry in a wide assortment of exercises, for example, human observation, human-machine interface, [2], [3], and face recognition based database management [4].But in recent years, Artificial Intelligence and other sophisticated development had lot of applications which made recognition easier and economical.. So face recognition is recognizable proof for its business and law implementation applications. The meaning of facial recognition alludes to a subset of PC innovation that recognizes human faces in computerized pictures. The algorithm of face detection values on human face in the image , which may also contains various other objects like landscapes etc .OpenCV is most preferred algorithms for identifying .And some other algorithms using OpenCV are LBPH, Eigenface, Fisherface.Now, the application of face recognition is increased in our lives. One of the practical applications where it can be implemented is in ATMs where the transactions can be made safe by using face recognition. The face capturing assessment with Exceptional Occlusion Handling (EOH). Is achievable on practical conditions [5]. And when it is used in security system, such as CCTV surveillance there is no need to see the whole video of the theft, but with the help of the face recognition, will show the parts of video where the crime took place. And face recognition is also very useful to include the quantity of individuals in a spot with the help of edge contrast and chromatic components to find people's face[6].If face recognition is used in educational institutes for attendance, it becomes more efficient and easy to record the student's attendance which is called as Personal Component Analysis (PCA).It also helpful for the faculty to maintain a record of students in-out information[7].Face recognition has lot of potential in hospitals and medical emergency, where we can track the movement of unauthorized access of patient[8].

System Architecture

In this system we used Raspberry Pi and Python is used for coding. And OpenCV and Numpy are the open source libraries of python are applied to process face recognition algorithm. The Haar Cascade classifiers are used to detect face from an image and the Local Binary Pattern Histogram (LBPH) are used to recognize a face from the given database. The whole process is categorized as:
Detection and Data Gathering
Training
Recognizing

Detection and Gathering

As of late face detection is widely used due to its interaction and application in the world of computers. Face detection is also used to detect multi face irrespective of the background noise. The first step is to detect a face by using Haar Cascade classifier and then the captured information is stored in a dataset. Using Haar based cascade classifier for object detection is mostly used and implemented by OpenCV

Training

In this part, the trainer takes the information from the data set and able to specify persons. In the trainer system the input images are converted to grayscale format. Although the system does not need colour images but, it becomes difficult to identify the edges in colour images and considered as noise to the system. So, gray scaling is important, because it makes the image processing algorithm faster and efficient [9]. At the point when a RGB picture is changed over into a grayscale design the 3D pixel qualities are changed over into 1D value. Therefore, we should manage less information if gray scaling is utilized.

Recognisation

The camera takes the input through a video stream and imported to python code of the raspberry Pi as a 2D matrix. Numpy is used to processes this 2D matrix [10]. At first, the face of the person/image is taken avoiding the background and compared with sample photos stored in the trainer. If any match found, the name is displayed along with the square mark tracking the image.

System Performance

Face Detection:

The main objective of the work is to identify/detect the face using Haar Cascade Classifier algorithm. The detected image is shown in blue square mark as in the following Figure.

Data Gathering:

A database of different images is maintained and an authorized system is run to get the nearest identify of personalities in quick time. A few samples were gathered as shown in the following Figure.

Trainer

In this phase, all the user data is taken from dataset by using a specific OpenCV function. The result will be a .yml file that will be saves on a trainer “trainer/”directory. In this segment the images are converted into grayscale image to make the system fast and efficient. The 3D values are converted into 1D value.

Face Recognisation

In this segment, the image is taken as a input and checked with the samples present in the dataset which was stored, if the match found ,it will be tracked with a square along with the name and confidence level of matching, according to the python code written as the following Figure.

ACKNOWLEDGEMENTS

The facial images used in this research article have been used with the permission of the person concerned. We would like to thank that person on behalf of our research team.

CONCLUSION

Security is the most concerned problem and this system can give wide impact on the lives of the general public. It has found a lot of applications in the present era of communication, where the numbers of users are increasing day by day. So an automated face detection classifier will be a proper solution .And it has a lot of applications in security, educational, health sectors.

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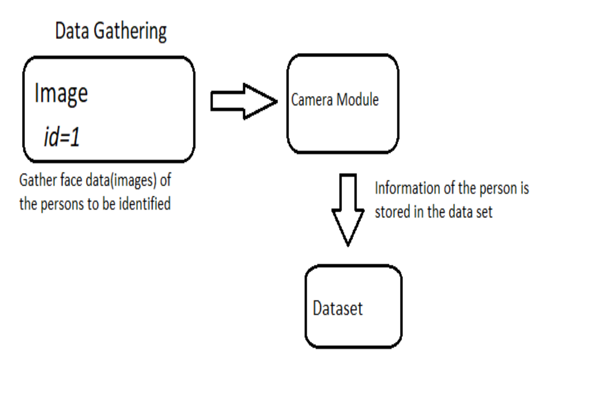

Figure 1. Detection and Data Gathering

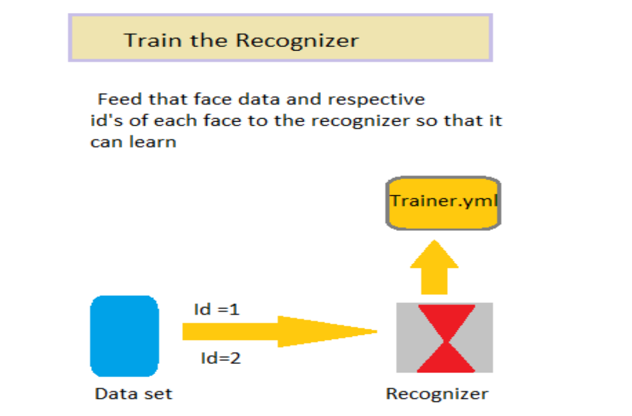

Figure 2: Training the Recognizer

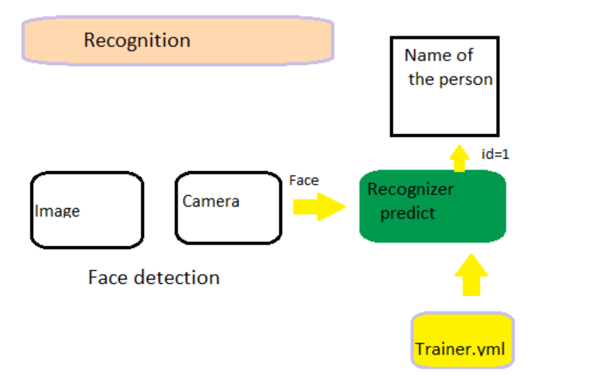

Figure 3:Recognition

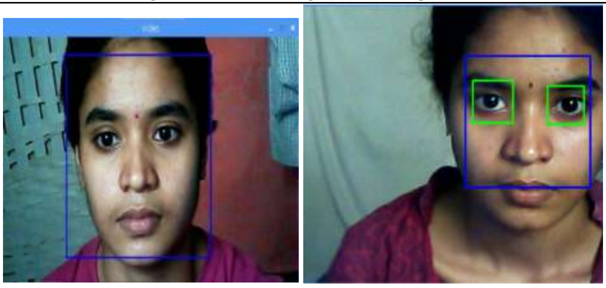

Figure 4: Detecting Human Face.

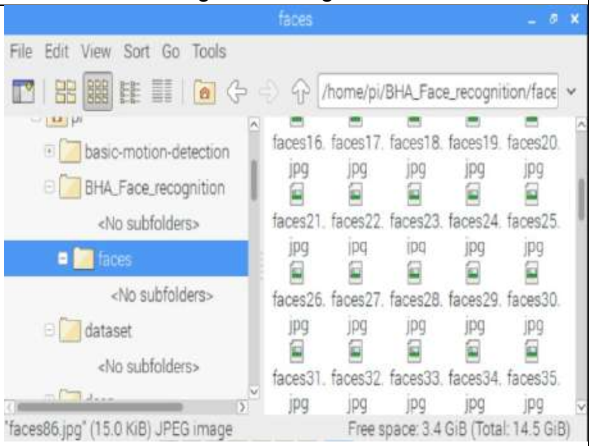

Figure 5: Gathering the Samples

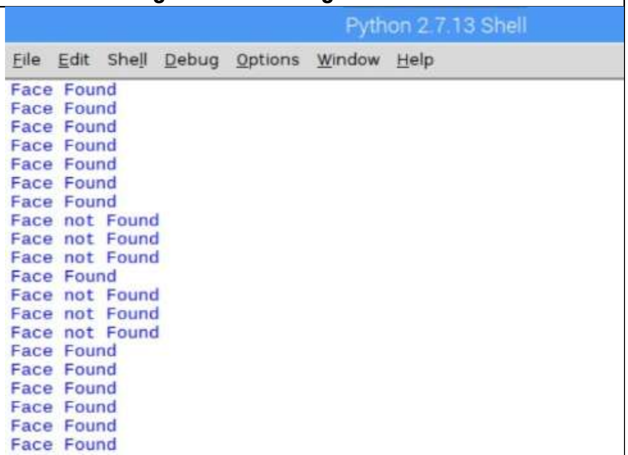

Figure 6: Detecting a Face

Figure 7: Converting from Colour Images to Grayscale

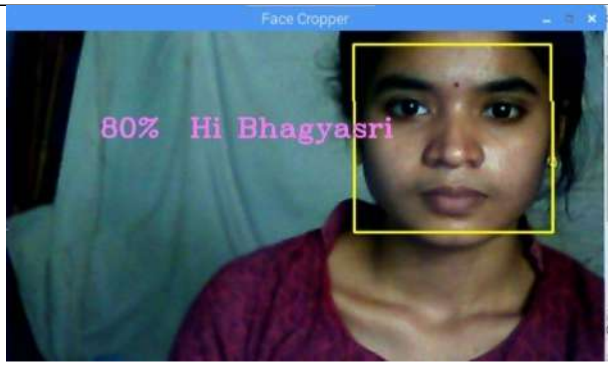

Figure 8: Recognized Face