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INDEX

INDEX

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SPEED BREEDING : ADVANCE BREEDING STRATEGY

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Abstract
In order to meet the world's food needs, current crop improvement methods appear to be moving too slowly. However, rapid breeding might shorten the time needed for cultivar development release and commercialization. Faster than traditional breeding methods, speed breeding technology is a recent invention from NASA's experiment. Speed breeding depends on factors such as temperature regulation, soil moisture, carbon dioxide concentration, photoperiod extension, and plant population density. Speed breeding is a promising method that shortens the breeding cycle to achieve nutritional security and sustainable agriculture, therefore accelerating the aims of food and industrial crop improvement.

Keywords : Speed breed, photoperiod, sustainable agriculture

Introduction

By 2050, there will likely be close to 9.8 billion people on the planet, up from the present projected 8.1 billion. Climate changes that include increasing temperatures, more frequent floods, and droughts are expected to cause new diseases and pest outbreaks more often, necessitating a quick reaction from plant breeders (Lin et al). emphasized the urgent need to protect global food security by accelerating the existing rate of genetic crop growth. To enable the quick supply of enhanced crop varieties, increasing the pace of genetic gain will rely on expedited crop breeding pipelines. The development of a speed-breeding program by scientists at the Universities of Queensland and Sydney in Australia was prompted by NASA's extraterrestrial trials to grow crop seeds in space. Speed breeding intensifies the breeding cycles of photo insensitive crops by creating a longer daylight routine in an artificial environment with increased light duration.

The main things preventing scientists from creating new types are longer generation times and seasonal restrictions. Using Rapid Generation Technology (RGA), a technique known as speed breeding can produce a quicker varietal development. Up to 6 generations of wheat, chickpeas, and barley and 4 generations of canola may be produced annually using speed breeding. NASA and Utah State University collaborated on a research project in the 1980s to develop wheat on the space station quickly. This marked the beginning of a new era for crop breeding and the search for ways to grow food in space to meet the needs of the station's astronauts.

The first dwarf wheat variety created through "speed breeding" was USU-Apogee. Light emitting diode (LED) technology was discovered in the 1990s, and the University of Wisconsin in the USA assessed how it affected plant growth and development. This led to an acceleration of more advanced research and the use of speed breeding in agricultural improvement. The University of Queensland's study, which was influenced by NASA's work, coined the phrase "speed breeding" in 2003 to describe the quick generational development in wheat breeding.

The main things preventing scientists from creating new types are longer generation times and seasonal restrictions. Using Rapid Generation Technology (RGA), a technique known as speed breeding can produce a quicker varietal development. Up to 6 generations of wheat, chickpeas, and barley and 4 generations of canola may be produced annually using speed breeding. NASA and Utah State University launched a cooperative research program in the 1980s to accelerate the generation of wheat on the space station. This initiative ushered in a new era of crop breeding and the search for ways to grow food in space to meet the needs of the station's astronauts. The first dwarf wheat variety created through "speed breeding" was USU-Apogee.

In order to swiftly generate superior varieties, breeders made few adjustments to the standard techniques - shuttle breeding, single-seed descent method, and haploid methodology—that had been employed in past crop improvement projects. The term "speed breeding" describes the modernization and fusion of these with other state-of-the-art technologies. In the speed breeding protocol, scientists adopted novel techniques like marker-aided selection, in vitro culture, next-generation sequencing, selection of genomics, and gene editing to achieve rapid generation advancement, despite the fact that field selection processes take an entire season and that the slow rate of advancement of each generation during conventional breeding is due to the inherent nature of the crop cycles. The duration of each crop breeding cycle might be reduced with the use of speed breeding technologies.

Opportunities and challenges of speed breeding

1. Various crops are subjected to speed breeding procedures, which quickly create homozygous lines following first crossings of chosen parents with complementary features. The method relies on adjusting photoperiod, temperature, light intensity, soil moisture, soil nutrition, and high-density planting. By inducing early blooming and seed set, these techniques have shortened the time needed to produce a breeding generation. 3 to 9 breeding generations may be produced annually using this process.
2. Modification of photoperiod regime: To promote quick growth, development, blooming, and seed set, plants are exposed to prescribed light and dark regimes for a certain amount of time each day. This period is known as their photoperiod. Plant growth, net photosynthetic rate, stomatal conductance, intercellular CO2, and transpiration rate are all directly impacted by light quality, which is defined as the instantaneous and cumulative amount received each day (Yang et al., 2017). Additionally, blooming pace and maturity are influenced by the daily light to dark hours. For prolonged photosynthesis, light sources that generate PAR (photosynthetic active radiation) in the 400–700 nm range are advantageous.
3. Temperature regime regulation: Changes in soil and air temperatures influence germination and growth responses, which result in quick development, blossoming, seed set, and maturity.
4. Control of soil moisture content: Stress from flooding or drought can cause early blooming and maturity, which can be utilized for rapid breeding. In cowpea, plants cultivated in drought stress bloomed around 12 days ahead of their well-irrigated counterparts. A number of crops, including wheat, barley, canola, and chickpea, have been bred quickly by reducing the frequency of watering from daily to twice weekly, starting four to six weeks after

flowering, and then ceasing irrigation during the week leading up to harvest. (2018) Watson et al.

5. Plant population density: High-density planting means that plant populations are grown at densities higher than those necessary to provide maximum yields. Because of light competition, tall plants grow quickly from the vegetative to the reproductive growth phases when plant densities are high. By using this strategy, you may increase the number of generation cycles each year and achieve early blooming and maturity.
6. Carbon dioxide concentration: According to Jagadish et al. (2016), some plants may develop more quickly and transition from the vegetative to the reproductive phases more quickly when exposed to greater levels of carbon dioxide (CO2).

   The administration of nutrients and plant growth regulators has been used to accelerate flowering and seed set, as well as to promote the germination of immature seeds in vitro.

(https://prod-static.irri.org/public/styles/slideshow/public/news/speedbreed-a-crop-breeding-center-built-for-speed-banner.jpg?itok=1i5jwOcT&c=62815d1e1e7d1ccd36731be441897b6b)

SPEED BREED: A speed breeding center built for speed

Conventional techniques for developing new varieties take longer time to develop as a result it can't meet the rising global demand of food crop in world like rice, wheat. A new variety of rice may take 8 to 9 years to produce using conventional breeding methods and a few more years for the variety to be available to farmers.

In December 2001 India's Prime Minister Narendra Modi officially opened the state of the art speed breed facility of IRRI at IRRI South Asia Regional Centre (ISARC) in Varanasi in December 2001.

Six optimization chambers and two multiplication chambers with completely controlled environmental conditions, including temperature (18°C to 42°C), relative humidity (60% to 90%), and CO2 levels, are included in the Speed Breed facility. 39,200 rice plants can be advanced at once using speed breeding. The walk-in chambers' stainless steel inside finish regulates humidity and temperature precisely, and the epoxy flooring provides antimicrobial qualities. Hydroponic fertigation systems with automated water and fertilizer supply control are installed in each chamber to induce physiological stress and quicken the development cycle.

Walk-in chambers have stainless steel interiors with precise temperature and humidity while the epoxy flooring provides antibacterial property. Hydroponic fertigation systems with automated

water and nutrients supply control are installed in each chamber for inducing physiological stress to hasten the growth cycle.

MULTIPLICATION CHAMBER

OPTIMIZATION CHAMBER

Fig 1 & 2: (source :https://www.irri.org/news-and-events/news/speedbreed-crop-breeding-center-built-speed)

Advantages of speed breeding

- Speed breeding is promising breeding technology that can drastically shorten breeding cycle and increase selection efficiency, regardless of the seasonal change in day length ,temperature and precipitation.
- Speed breeding substantially outruns the efficacy of conventional breeding, expediting the process multifold while being less labour intensive.
- Speed breeding is 2 to 3 times faster than conventional breeding method. Not labour intensive.
- Many germplasm could be densely grown in small space, which is especially useful for large scale population screening.
- Speed breeding could be carried out at any period of year regardless of external environment and climate change.
- Speed breeding can be done in smaller areas also researchers who don't have access for larger areas can have smaller set up for speed breeding unit

Limitations in speed breeding

- Due to sensitivity to photoperiod the response of short day plant under speed breeding is not as successful as long day plants. Therefor alternate approaches have to be followed speed up breeding cycle in such plants. The Institute of Soyabean Research(ICAR-IISR), Indore is extremely taking up off season generation advancement of segregating material at University of Agriculture Science Bangalore, in addition ICAR-ISSR has green house and poly house facility which is being used for advancement ofF1 and F2 generation and important individual plant selection during off season.
- Prolonged photoperiod may cause adverse effect on plant growth and development ,such as wilting , chlorosis and decrease biomass.
- Completely enclosed environment leads to pest outbreak.
- Diseases and disorder under speed breeding:

Disease/disorder	Species	Reference
Stripe rust (Puccinia striiformis f. sp. tritici)	Spring wheat (T. aestivum)	Pretorius et al Hickey et al
Leaf rust (Puccinia recondita f. sp. tritici, 'brown rust') (Puccinia triticina, 'black rust')	Spring wheat (T. aestivum)	Pretorius et al. Riaz et al.
Yellow spot/tan spot (Pyrenophora tritici-repentis)	Spring wheat (T. aestivum)	Dinglasan et al.12
Preharvest sprouting	Spring wheat (T. aestivum)	Hickey et al
Pod shattering	Canola (B. napus)	Watson et al

Conclusion

Burgeoning population ,ever changing lifestyle and advance climate change has made it mandatory to revamp currently available crop cultivars so as to secure food and nutritional security worldwide and accomplish other market driven trait .Many of crop enhancement breeding procedures utilized in current agriculture such as genetic engineering, mutation breeding, cross breeding and so on are lengthy and time demanding such time consuming , difficult and unfocused breeding programmes cannot fulfil the world's expanding food demand. The idea of speed breeding act as a savior hereby decreasing time needed for cultivar development, release and commercialization to nearby half. Speed breeding allows researchers to rabidly mobilize the genetic variation found in wild relatives of crops and introduce it into elite varieties that can be grown by farmers generation time in most plant species represent a drawback in applied research programmes and breeding Tackling this bottleneck means scientists can respond quicker to emerging diseases, changing climate and increased demand for certain traits.

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COMPUTER VISION SYNDROME OR DIGITAL EYE STRAIN

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Abstract
Computer Vision Syndrome (CVS), or digital eye strain, impacts around 60 million people worldwide due to extensive screen use. Symptoms such as eyestrain, headaches, blurred vision, dry eyes, and neck pain arise from factors like poor lighting, screen glare, incorrect viewing distances, and uncorrected vision issues. Blue light from screens causes retinal oxidative stress and reduces blinking, leading to dry eyes. Diagnosis requires a thorough eye exam. Treatments include routine eye care, specialized glasses for screen use, and vision therapy. Preventative strategies involve proper lighting, ergonomics, and taking regular breaks. Addressing these aspects can ease symptoms and enhance comfort and productivity.

1. An Overview:

Computer vision syndrome (CVS) is also termed as digital eye strain that happens due to continuous or prolonged use of digital screens in the form of computer, laptops, mobile, electronic gadget or tablets etc. It causes an eye discomfort and the level of discomfort appears to increase with the time of digital screen usage.

Fig 1: Pictorial presentation of CVS

Nearly 60 million people suffer from CVS globally, resulting in reduced work efficiency and deteriorating the quality of life. With the widespread use of digital devices such as computers, tablets, and smartphones, concerns about the impact of computer screens on our eyes have increased considerably. The human eye is not naturally designed to stare at screens for prolonged periods. The high energy visible (HEV) light, also known as blue light, emitted by these screens can cause ocular problems or vision dysfunctions resulting in dryness, irritation, blurred vision, and headaches. Over time, prolonged exposure to irritating blue light can also contribute to risk of developing serious conditions such as age-related macular degeneration.

The mechanism behind these effects involves the way our eyes process light. Light is essential for our vision, but our eyes are more susceptible to blue light due to its shorter wavelength and higher energy. When we focus on digital screens for an extended period, excessive exposure to blue light may cause oxidative stress on the retina. This is because the human eye is not very efficient at blocking blue light, and most of it reaches the light-sensitive retina, potentially leading to long-term damage. Furthermore, focusing on digital screens can disrupt the natural blink reflex, leading to dry, irritated eyes. When we stare at screens, we blink less, causing less natural lubrication and resulting in also dry eye syndrome and uncorrected vision problems can increase the severity of computer vision syndrome (CVS) or digital eyestrain symptoms. Viewing a computer or digital screen is different than reading a printed page. Often the letters on the computer or handheld device are not as precise or sharply defined, the level of contrast of the letters to the background is reduced, and the presence of glare and reflections on the screen may make viewing difficult.

Fig 2: Image representing the eye strain/stress while using screen for prolonged hours

2. Highlights:

- Viewing distances and angles used for this type of work are also often different from those commonly used for other reading or writing tasks. As a result, the eye focusing and eye movement requirements for digital screen viewing can place additional demands on the visual system.
- In addition, the presence of even minor vision problems can often significantly affect comfort and performance at a computer or while using other digital screen devices.
- Uncorrected or under corrected vision problems can be major contributing factors to computer-related eyestrain. Even people who have an eyeglass or contact lens

prescription may find it's not suitable for the specific viewing distances of their computer screen.

- Some people tilt their heads at odd angles because their glasses aren't designed for looking at a computer or they bend toward the screen in order to see it clearly. Their postures can result in muscle spasms or pain in the neck, shoulder or back.
- In most cases, symptoms of CVS occur because the visual demands of the task exceed the visual abilities of the individual to comfortably perform them. At greatest risk for developing CVS are those persons who spend two or more continuous hours at a computer or using a digital screen device every day.

3. Causes of developing CVS:

- Poor lighting
- Glare on a digital screen
- Improper viewing distances
- Poor seating posture
- Uncorrected vision problems
- Low intake of nutritious food
- Consumption of junk food

4. Symptoms associated with CVS:

- Eyestrain
- Headaches
- Blurred vision
- Dry eyes
- Neck and shoulder pain
- Shoulder pain
- Backache
- Double vision
- Redness in eyes

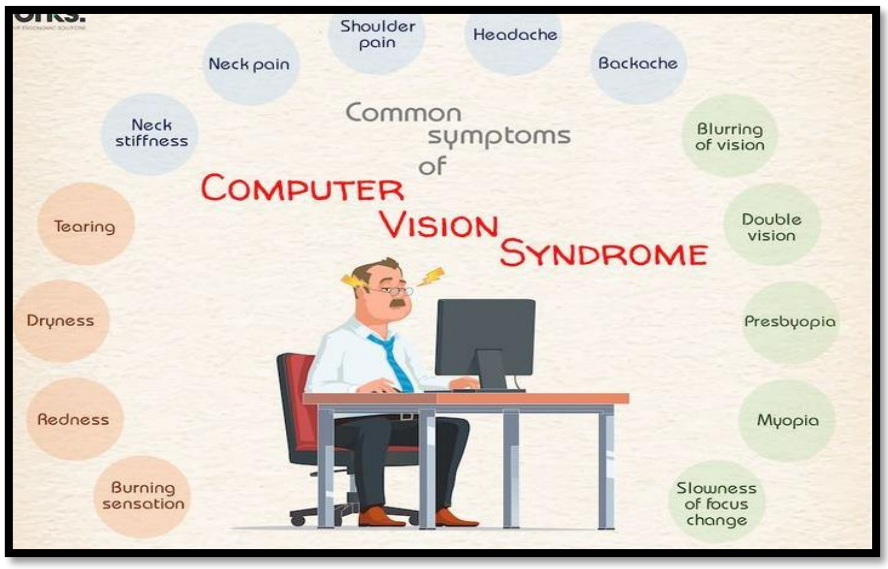


Fig 3: Representing the different types of symptoms caused by CVS

Many of the visual symptoms experienced by users are only temporary and will decline after stopping computer work or use of the digital device. However, some individuals may experience continued reduced visual abilities, such as blurred distance vision, even after stopping work at a computer. If nothing is done to address the cause of the problem, the symptoms will continue to recur and perhaps worsen with future digital screen use.

5. Diagnose of CVS

CVS, or digital eyestrain, can be diagnosed through a **comprehensive eye examination** Testing, with special emphasis on visual requirements at the computer or digital device working distance, may include:

- Patient history to determine any symptoms the patient is experiencing and the presence of any general health problems, medications taken or environmental factors that may be contributing to the symptoms related to computer use.
- Visual acuity measurements to assess the extent to which vision may be affected.
- A refraction to determine the appropriate lens power needed to compensate for any refractive errors (near sightedness, farsightedness or astigmatism).
- Testing how the eyes focus, move and work together. In order to obtain a clear, single image of what is being viewed, the eyes must effectively change focus, move and work in unison. This testing will look for problems that keep the eyes from focusing effectively or make it difficult to use both eyes together.

This testing may be done without the use of eye drops to determine how the eyes respond under normal seeing conditions. In some cases, such as when some of the eyes' focusing power may be hidden, eye drops may be used. They temporarily keep the eyes from changing focus while testing is done. Using the information obtained from these tests, along with the results of other tests, a doctor of optometry can determine the presence of CVS or digital eyestrain and advise treatment options.

6.Treatment for CVS

Solutions to digital screen-related vision problems are varied. However, they can usually be alleviated by obtaining regular eye care and making changes in how the screen is viewed.

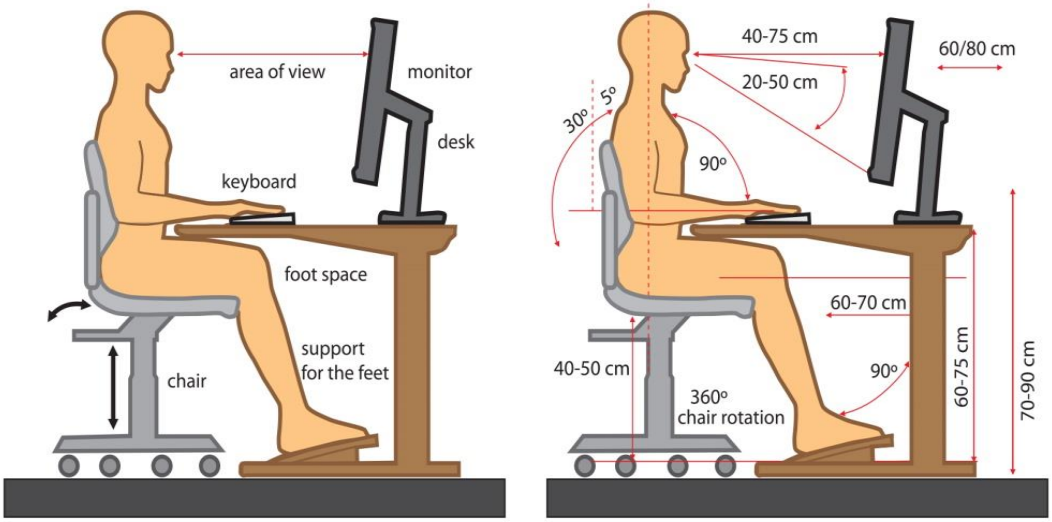
In some cases, individuals who do not require the use of eyeglasses for other daily activities may benefit from glasses prescribed specifically for computer use. In addition, persons already wearing glasses may find their current prescription does not provide optimal vision for viewing a computer.

- Eyeglasses or contact lenses prescribed for general use may not be adequate for computer work. Lenses prescribed to meet the unique visual demands of computer viewing may be needed. Special lens designs, lens powers or lens tints or coatings may help to maximize visual abilities and comfort.

Some computer users experience problems with eye focusing or eye coordination that can't be adequately corrected with eyeglasses or contact lenses. A program of vision therapy may be needed to treat these specific problems. Vision therapy, also called visual training, is a structured program of visual activities prescribed to improve visual abilities. It trains the eyes

and brain to work together more effectively. These eye exercises help remediate deficiencies in eye movement, eye focusing, and eye teaming and reinforce the eye-brain connection. Treatment may include office-based as well as home training procedures. Proper body positioning for computer use. Some important factors in preventing or reducing the symptoms of CVS have to do with the computer and how it is used. This includes lighting conditions, chair comfort, location of reference materials, the position of the monitor, and the use of rest breaks.

Viewing the computer



Proper body positioning for computer use. Some important factors in preventing or reducing the symptoms of CVS have to do with the computer and how it is used. This includes lighting conditions, chair comfort, location of reference materials, the position of the monitor, and the use of rest breaks.

7. Measures to follow to combat CVS:

- **Location of the computer screen.** Most people find it more comfortable to view a computer when the eyes are looking downward. Optimally, the computer screen should be 15 to 20 degrees below eye level (about 4 or 5 inches) as measured from the center of the screen and 20 to 28 inches from the eyes.
- **Reference materials.** These materials should be located above the keyboard and below the monitor. If this is not possible, a document holder can be used beside the monitor. The goal is to position the documents, so the head does not need to be repositioned from the document to the screen.
- **Lighting.** Position the computer screen to avoid glare, particularly from overhead lighting or windows. Use blinds or drapes on windows and replace the light bulbs in desk lamps with bulbs of lower wattage.
- **Anti-glare screens.** If there is no way to minimize glare from light sources, consider using a screen glare filter. These filters decrease the amount of light reflected from the screen.

- **Seating position.** Chairs should be comfortably padded and conform to the body. Chair height should be adjusted so the feet rest flat on the floor. Arms should be adjusted to provide support while typing and wrists shouldn't rest on the keyboard when typing.
- **Rest breaks.** To prevent eyestrain, try to rest eyes when using the computer for long periods. Resting the eyes for 15 minutes after two hours of continuous computer use. Also, for every 20 minutes of computer viewing, look into the distance for 20 seconds to allow the eyes a chance to refocus.
- **Blinking.** To minimize the chances of developing dry eye when using a computer, try to blink frequently. Blinking keeps the front surface of the& eye moist.

Regular eye examinations and proper viewing habits can help to prevent or reduce the development of the symptoms associated with CVS.

8. Suggestions for computer vision syndrome sufferers

- **Don't take a vision problem to work.** Even if glasses are not needed for driving, reading or other activities, they still may offer benefits for a minor vision problem that is aggravated by computer use. A mild glasses prescription may be needed to reduce vision stress on the job. It's a good idea for computer users to get a thorough eye exam every year.
- **Glasses should meet the demand of the job.** If glasses are worn for distant vision, reading or both, they may not provide the most efficient vision for viewing a computer screen, which is about 20 to 30 inches from the eyes. Tell the doctor about job tasks and measure on-the-job sight distances. Accurate information will help get the best vision improvement. Patients may benefit from one of the new lens designs made specifically for computer work.
- **Minimize discomfort from blue light and glare.** Blue light from LED and fluorescent lighting, as well as monitors, tablets and mobile devices, can negatively affect vision over the long term. Special lens tints and coatings can reduce the harmful impact of blue light. Minimize glare on the computer screen by using a glare reduction filter, repositioning the screen or using drapes, shades or blinds. Also, keeping screens clean; dirt-free and removing fingerprints can decrease glare and improve clarity.
- **Adjust work area and computer for comfort.** When using computers, most people prefer a work surface height of about 26 inches. Desks and tables are usually 29 inches high. Place the computer screen 16 to 30 inches away. The top of the screen should be slightly below horizontal eye level. Tilt the top of the screen away at a 10- to 20-degree angle.
- **Use an adjustable copyholder.** Place reference material at the same distance from eyes as the computer screen and as close to the screen as possible. That way the eyes won't have to change focus when looking from one to the other.
- **Take alternative task breaks throughout the day.** Make phone calls or photocopies. Consult with co-workers. After working on the computer for an extended period, do anything in which the eyes don't have to focus on something up close.

9. Key Points:

- **20-20-20 Rule:** For every 20 minutes spent looking at a screen, one should look at something 20 feet away for at least 20 seconds. This simple technique can reduce fatigue.
- **Adjusting Screen Settings:** Ensuring that the brightness of the screen matches the surrounding illumination can help. Screens should not be too bright or too dark.
- **Proper Positioning:** Screens should be just below eye level and about an arm's length away. This position helps reduce the strain on your neck and eyes.
- **Regular Eye Exams:** Regular eye check-ups can ensure that your prescription, if you have one, is up to date. An outdated prescription can increase screen-related eye strain.

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NANOFERTILIZERS FOR SUSTAINABLE FOOD, NUTRITION AND ENVIRONMENT SECURITY: RECENT DEVELOPMENTS, CHALLENGES, AND PERSPECTIVES

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Abstract
Environmental crises, food, and nutritional insecurities are the global issues that need immediate scientific and policy interventions for sustainable agriculture. New age smart fertilizers nano-fertilizers may have greater role in improving nutrients use efficiency (NUE), enhancing the crop yield, reducing the environmental pollution hazard and the fertilization cost for crop production. This paper aims to highlight the role of Nanofertilizers for sustainable food, nutrition and environment security with major focus on recent developments, challenges, and perspectives.

Introduction
In the last six decades, the consumption of fertilizer in India has been growing rapidly, whilst the nutrient use efficiency (NUE) of fertilizers in the cropping systems has been decreasing. These trends have led to increasing environmental losses of N, threatening the quality of air, soils, and fresh waters, and thereby endangering climate-stability, ecosystems, and human-health. Needless to emphasize that use of chemical fertilizers in balanced and optimum quantity is desirable to get achievable potential of high yielding cultivars but overuse of this costly input increase the environmental pollution including soil quality deterioration, eutrophication, and ground water and air pollution (Chhipa, 2017; Ye *et al*., 2020). Additionally, the indiscriminate use of chemical fertilizers raises the production cost and reduces farmer's profit. On the other hand, it is also true that to feed the burgeoning population in future, the food as well as the fertilizer demand will increase. One-third of the growth in cereal production around the world and half of the growth in grain production in India between the 1970s and 1980s can be attributed to more fertilizer use. The futuristic food demand can only be achieved by arresting indiscriminate use of fertilizers and increasing resource utilization efficiency without compromising agricultural production through adaptation of best management practices. In this context, it is important to mention that chemicalfertilizersaccountedfor∼50–55%cropyield increment in developing countries like India (Adhikari and Ramana,2019). However, the use efficiency of applied nutrients through fertilizers remains very low (nitrogen (N) 30–40%, phosphorus (P):15–20%, potassium (K): 50–55%, and micronutrients : 2–5%(Adhikari and Ramana, 2019 and Tiwari et al. 2023**).** So, the improvement of NUE would be essential and inevitable to supporting the sustainable agricultural production systems and increasing soil quality components (Mahanta et al., 2019).

Food sustainability is the main concern in agricultural production as research is undertaken in order to adapt plants to changing climates without affecting existing ecosystems. Controlling soil and plant quality and health are a plus for sustainable agriculture and conservation of climate. Fertilizer application plays a crucial role in increasing the agricultural production; however, excessive fertilization limits the available area for crop production. Sustainable agriculture requires a minimal use of agrochemicals that can protect the ecosystem and spare biodiversity from extinction.

Current Status of Fertilizer Use in Agriculture in India

The projections of the Food and Agriculture Organizations of United Nations (FAO, 2018) suggests that India may double its fertilizer input by 2050. In India, total fertilizer nutrient consumption ($N+P_2O5+K_2O$) was estimated at 29.84 million tonnes (MT) as against 29.80 MT in the previous year registering a marginal growth of 0.2%. The consumption of N and P2O5 at 20.21 MT and 7.92 MT during 2022-23 registered increase of 4% and 1.2%, respectively, over 2021-22. However, consumption of K_2O at 1.72 MT witnessed a sharp decline of 32.2% during the period. In terms of product, All-India estimated consumption (based on DBT sale) of urea at 35.73 MT, DAP at 10.53 MT during 2022- 23 recorded increase of 4.5% and 13.6%, respectively, over 2021-22. However, consumption of NP/NPK complex fertilizers at 10.07 MT, MOP at 1.63 MT and SSP at 5.02 MT witnessed decline of 12.2%, 33.6% and 11.7%, respectively, during the period. Total consumption of all fertilizer products at 63.92 MT during 2022-23 showed a decline of 0.03% over 2021-22. All-India NPK use ratio widened from 7.7:3.1:1 during 2021-22 to 11.8:4.6:1 during 2022-23. Per hectare use of total nutrients ($N+P_2O_5+K_2O$) improved marginally from 141.0 kg in 2021-22 to 141.2 kg in 2022-23 (FAI, 2023). Apparently, fertilizer nutrient use in India is imbalanced resulting poor nutrient use efficiency.

Although the use of fertilisers has increased several folds, yet the overall consumption continues to be low in most parts of the country. Several studies have shown that in most of the regions there is a net negative balance of nutrients and a gradual depletion of the organic matter content of soil. Soil nutrient deficiencies cause great economic losses for farmers and significant decreases in nutritional quality and quantity of grain for humans and livestock. It is estimated that every year 24.29 MT of the three major nutrients – nitrogen, phosphorus, and potassium are removed by growing crops but the corresponding addition through chemical fertilisers and organic manures falls short of this figure. It was determined that only 23% of the applied fertilisers is consumed by plants; the remaining 77% is mainly leached out beyond the root zone, lost by volatilisation, fixed and gets transformed into unavailable forms etc. The annual loss in production of eleven major crops in India due to depletion of nutrients as a result of unsuitable agricultural practices amounts to 0.5 to 1.3 MT (Vision 2050). The problem of maintaining the nutrient balance and hence preventing the consequent nutrient deficiencies will also be a major concern in most cultivated areas of the country. Apart from this, climate change coupled with consequent biotic and abiotic stresses are posing a serious threat to the agricultural production system of the country.

Fertilizers and Environment

Fertilizer application is believed to have been responsible for at least 50% increase in crop yield in the 20th century. However, due to the inappropriate use of mineral fertilizers (i.e., when used in both excess or deficiency), mostly concerning nitrogenous and phosphate, many productive soils

have been thwarted in their ability to function, as shown not only by chemical indicators but also by physical and biological ones. Thus, improper fertilizing technology might have a negative effect on soil health and soil-related ecosystem services. Imbalanced use of chemical fertilizers can alter soil pH, and increase pests attack, acidification, and soil crust, which results in a decrease in soil organic carbon and useful organisms, stunting plant growth and yield, and even leading to the emission of greenhouse gases. Nitrogen is an extremely important element in food production. Many chemical fertilizers contain nitrogen, which is an essential ingredient for supporting food production to meet the needs of a growing population. Meanwhile, there is also concern that chemical fertilizers place a burden on the environment. The challenges are decarbonization in chemical fertilizers production and optimization in nitrogen cycling. In terms of decarbonization, for example, the full process for nitrogen fertilizer (from production to use) accounts for 2.1% of total GHG (greenhouse gas) emissions. The largest share of these emissions arises during production and use, with approximately 39% occurring during the production process and about 59% during use, while the remainder occurs during transportation (Nozaki, 2022).

Need for the Development of Nanofertilizers

The traditional method of fertilizer usage involves the use of much more fertilizer than is necessary, whereas the nanotechnological approach emphasizes the use of less quantity of fertilizer. To address the significant concerns of sustainable food production and development, several great technological advances have occurred in recent years in the field of farming. Nanofertilizers are useful in raising the production of crops by increasing the quality of agri-inputs. In the last two decades, a lot of research on nanotechnology has been performed in agriculture sectors. The growth in nanotechnology in herbicides and fertilizers has improved crop yields. Nanotechnology is a revolutionary agriculture method that can enable the efficient production of agricultural fields. Nanotechnology may as well save human capital and wastage. Agro-nano-technologies provide short-term solutions to the difficulties of modern industrial agriculture.

Researchers experimented with foliar applications of IFFCO Nano Urea Plus, Nano DAP, Nano Zn and Nano Cu which helped correcting deficiencies of these micronutrients with minimal quantity and mitigated these problems. Based on the results of the on-farm and on-station trials, these fertilizers have been included in the Fertilizer Control Order. The specifications of IFFCO Nano Urea Plus and Nano DAP are mentioned in **Table 1** and of IFFCO Nano Zn and Nano Cu in Table **2.**

Table 1. FCO Specifications for IFFCO Nano Fertilizers

S. No	Parameters	Specifications	
	NANO DAP AND NANO UREA PLUS		
		NANO DAP	**Nano Urea Plus**
1	Total Nitrogen (N), per cent by weight	7-9	16
2	Total Phosphorus (as P2O5) per cent by weight	15-17	-
3	pH	3-6	4-8.5
4	Viscosity	5-30 cps	5-30 cps
5	Particle size in nano metre (nm) in one dimension		
	(a) Physical particle size as per TEM ANALYSIS (minim um 50 per cent of the material	20-70 nm	20-50 nm

S. No	Parameters	Specifications	
	NANO DAP AND NANO UREA PLUS		
		NANO DAP	**Nano Urea Plus**
	shall be in range of 20-70 nm)		
	(b) Hydrodynamic Particle size (as per DLS Analysis)	<100 nm	20-80 nm
6	Surface charge /Zeta potential mV (+/- scale)	>5	>15
7	Date on which it comes in FCO	02-03-2023	15-04-2024

Picture 1. IFFCO's Nano Urea Plus and Nano DAP.

Table 2 FCO Specifications for IFFCO Nano Zinc and Nano Copper

S. No	Parameters	Specifications
	NANO ZINC	
1	Total Zinc (Zn), per cent by weight	1
2	pH	3.5-6
3	Viscosity	5-30 cps
4	Particle size in nano metre (nm) in one dimension	
	(a) Physical particle size as per TEM ANALYSIS (minim um 50 per cent of the material	10-80 nm
	shall be in range of 20-70 nm)	
	(b) Hydrodynamic Particle size (as per DLS Analysis)	10-90 nm
5	Surface charge /Zeta potential mV (+/- scale)	>15
6	Date on which it comes in FCO	22-04-2024
	NANO COPPER	
1	Total copper (Cu), per cent by weight	0.8
2	pH	3-6.5

S. No	Parameters	Specifications
3	Viscosity	5-30 cps
4	Particle size in nano metre (nm) in one dimension	
	(a) Physical particle size as per TEM ANALYSIS (minim um 50 per cent of the material	10-80 nm
	shall be in range of 20-70 nm)	
	(b) Hydrodynamic Particle size (as per DLS Analysis)	10-90 nm
5	Surface charge /Zeta potential mV (+/- scale)	>15
6	Date on which it comes in FCO	22-04-2024

In this context it is important to mention that IFFCO launched the world's first 'Nano liquid urea' fertiliser in June 2021. Thereafter, it came up with 'Nano DAP' fertiliser in April 2023. The government has notified specifications of above mentioned four Nanofertilizers in which 'Nano Urea Plus', Nano Zn and Nano Cu are new fertiliser products to be manufactured by IFFCO in the country. IFFCO's Nano Urea Plus is an advanced formulation of Nano Urea in which nutrition is redefined to meet crop nitrogen requirements at critical growth phases. It is used in place of conventional urea and other nitrogenous fertilisers for promoting soil health, farmer's profitability and sustainable environment. It also enhances the availability and efficiency of micronutrients. It is a chlorophyll charger, yields booster and helps in climate-smart farming. IFFCO has already started its commercial production and making available to the farmers from June 2024.

Former Chemicals and Fertilisers Minister Mr. Mansukh Mandaviya had said that by the end of 2025 India would stop importing urea as a massive push for domestic manufacturing has helped bridge the gap between supply and demand. The government is making efforts to promote alternate fertilisers like nano liquid urea and nano liquid di-ammonium phosphate (DAP). In an interaction with PTI, Mr. Mandaviya had said, "Use of alternate fertilisers is good for crops and soil health. We are promoting it," he said.

Benefits of Nanofertilizers

Nanofertilizer is a kind of smart fertilizers, which has the same benefits of smart fertilizers in delivering nutrients as a tailoring agent or an agro-nanotechnology. Many published articles confirmed the role of agro-nanotechnologies, which have been proposed and substantially examined over the last two decades, with tens of reviews published from various perspectives (Shao et al. 2022). These studies included smart fertilizers as a strategy for sustainable agriculture (Calabi-Floody et al. 2018), smart nanomaterials and nanocomposites for advanced agrochemical activities (Tiwari et al. 2022, 2023), nanotechnology-based controlled release of sustainable fertilizers (Beig et al. 2022), using of bio-nanoparticles as fertilizers in smart farming (Ndaba et al. 2022), functional nanomaterials (NMs) for sustainable and smart agricultural chemical technologies (Shao et al. 2022), and smart nano-biosensors for sustainable agriculture and environmental applications (Ramachandran et al. 2022). NFs have the potential to reduce soil chemical load, improve nutrient use efficiency (NUE), reduces negative effect of traditional bulky fertilizers, and reduce application frequency thus protects environment by arresting air pollution, soil degradation, water eutrophication, and ground water pollution. NFs boost health in a variety of ways, including lowering chemical loads in the soil, increasing enzyme activity, improving

microbial activity, and improving native nutrient mobilization in the rhizosphere (Raliyaet al., 2017).

A general comparison between smart fertilizer and nanofertilizer can be noticed in **Fig. 1.**

Fig. 2. A general comparison between smart fertilizer and nanofertilizer
Source: Zulfiqar et al. (2022)

- The unique physico-chemical properties make NFs more advantageous than conventional fertilizers. Small particle dimensions (<100 nm) enable NFs to enter plant systems when used as foliar spray or basal. (Seleiman et al., 2021).

- NFs owing to ultra-small size, have a high surface area and surface area to volume ratio which increase the absorption and retention capacity of NFs as compared to conventional bulky chemical fertilizers (Hussain et al., 2022).
- NFs have a more surface area than conventional chemical fertilizers thereby, contains morenutrientsandreleasesthemgraduallyasperthecropneedswithoutany negative consequences while low plant uptake efficiency of commonly used chemical fertilizers, and wastage of nutrients through leaching, volatilization and gaseous emissions, etc. are major causes for environmental destruction.

Nanomaterial-coated fertilizers releases nutrients slowly and uniformly for long period up to 45 days, whereas the traditional bulk fertilizer losses only for very short period with uneven release that reduce the nutrient use efficiency of the plants with relatively poor crop growth performance.

NFs increase nutrients and water absorption potential of seeds and plants that in turn helps to enhance the vigor of root systems and biomass production.

NFs increase enzymatic activity, positively affect growth physiology, increase chlorophyll content, improve photosynthesis and metabolites, increase anatomical properties of plants, nutrient uptake, grain yield and produce quality.

NPs stimulate root nodulation, soil bacterial diversity and significantly influence soil microbial activity.

NFs accelerate plant adaptation to progressive climate change factors (such as temperatures, water deficiency, cold, salinity, alkalinity and environmental pollution with toxic metals, thus increase tolerance to abiotic and biotic stresses and also mitigate Cd toxicity and improve growth by stimulating antioxidant potential and inhibiting Cd translocation.

- The slow and gradual release of nutrients from NFs reduces the negative environmental outcomes. Strong ionizing power, improved chemical stability, increased absorbability, more surface tension, increased pH lenience, and mobility are the imperative characteristics of NFs (Seleiman et al., 2021).
- Foliar application of NFs reportedly increases 10–25% yield of cereals, 20–30% in oilseeds, and 13–15% in pulses as compared to the conventional fertilizers in different agro-climatic and management conditions (Delfani et al., 2014; Rathore et al., 2019).
- The application of P-based NFs has the potential to increase the seed yield of soybean by ∼20% over conventional synthetic fertilizers (Liu and Lal, 2014).

Hence, NFs hold great potential for attaining sustainable agriculture, particularly in under developed and developing nations (Liu and Lal, 2014). However, the overuse of NFs may have a harmful effect on crop growth and the environment that must be also taken into account.

In the light of aforesaid benefits, hopefully, IFFCO Nano Urea Plus, Nano DAP, Nano Zn and Nano Cu will be a game changer tool for sustainable agriculture.

Nano-fertilizers are considered as slow-release fertilizer to overcome the fluctuations i.e., soil acidity, moisture and temperature to enhance plant growth (Vega-V asquez et al., 2020). Nanofertilizers encourage to development of plant growth parameters, such as the height of

plants, number of leaves per plant, leaf area, the difference in fresh and dry matter content, chlorophyll content, roots, and rate of photosynthesis. This results in keen consideration of an increase in the yield due to a higher translocation rate of photosynthesis to various parts of the plant as compared to chemical fertilizers. Yomso and Menon (2021) reported that nano-fertilizer as compared with chemical fertilizers significantly improved the plants growth i.e., plant height, leaf area, number of leaves and biomass by increasing the photosynthetic pigments and translocation photosynthetic products to different parts of the plant. According to Chhipa and Joshi (2016) nanofertilizerhas great potential to improve nutrients use efficiency, minimize the cost and reduce environmental deterioration.

The Road Ahead

Conventional fertilizers have nutrient usage efficiency of just 30-35%, 18-20%, and 35-40% for N, P, and K, respectively. For the previous few decades, the data has remained steady, and study efforts have not yielded productive outcomes. Nano-fertilizers are nutrient transporters made from substrates with nanoscale dimensions ranging from 1 to 100 nm. Nanoparticles have a large surface area and can contain a lot of nutrients and release them slowly and gradually, making it easier for crops to get the nutrients they need without the negative side effects of tailored fertilizer applications.

The agriculture field are facing the challenges of nutrient deficiency, crop yield reduction, weakening the soil organic matter, low water availability as the result of poor nutrients use efficiencies. The application of different nano-fertilizers has greater role in improving nutrients use efficiency (NUE), enhancing the crop yield, reducing the environmental pollution hazard and the fertilization cost for crop production. However, Nano fertilizer technology has limited insights, and there is a shortage of published research in scholarly publications.

The delivery of nanofertilizers as next-generation fertilizers for agricultural applications faces difficulties even though they are both economically and environmentally sustainable. Along with scaling up the procedure for large-scale distribution, it is necessary to guarantee the availability of raw materials for the synthesis of NFs on an industrial scale. Once these issues are resolved, it will be simple to produce commercially viable NFs using the appropriate processes, which will pave the way for a day when even a minimal amount of use of these fertilizers will result in the desired higher agricultural yield.

Researchers are focusing on improving the nutrient efficiency of plants depending on nanotechnology (nanofertilizers) (<100 nm). The studies related to growth parameters need firm acceptability of the nanofertilizers followed by thorough field experiments. Thus, assisting the researchers and policymakers in the recommendation of the application of specific dosages in the actual fields on a bulk level without causing a significant hazardous effect on the environment would be required. Thus, it is strongly recommended that future research should be focused on defining the dosage for field application of nanofertilizers on a commercial level.

The technological development should primarily focus on the farmer-centric recommendations of nanofertilizers. Furthermore, it is expected that the development and validation of Nanofertilizers will contrast the production of chemical fertilizers, promoting the nanofertilizer industry. This will help policymakers to decide the dosage and time for nanofertilizer application.

Conclusion

The application of chemical fertilizers enhances food production but at the same time, excessive and imbalanced use of these chemicals pollute the soil and arial environment, leading to ecosystem disruption. Hence, an alternative mechanism is to be developed to enhance farm production and environmental sustainability. Innovative solutions which help increasing efficiencies of water, nutrients and other input sresult increase in the yield and product quality, protect the environment including natural resources and enhance the economic viability of farmers and rural livelihood are the need of the hour. Adoption of conservation agriculture, micro-irrigation and use of smart fertilizers like IFFCO Nanofertilizers (Nano Urea Plus, Nano DAP, Nano Zn and Nano Cu) on each and every farm holding will change the game leading to more efficient use of fertilizers, water and land, while lowering reliance on hazardous chemicals that can harm our ecosystem over time. Nanofertilizers may really have a phenomenal impact not only on our environment but also on energy consumption levels and economic growth with sustained support from both public institutions and private corporations, universities, farmer groups, and so on. Nevertheless, accelerated information and technology flow to farmers and other stakeholders through efficient extension approaches would be essentially needed.

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AQUAPONICS: AN EXCITING TOOL FOR SUSTAINABLE AGRICULTURE

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Abstract

Aquaponics is a cutting-edge agricultural technique that blends hydroponics and aquaculture to produce food effectively and sustainably. Traditional farming techniques are insufficient and detrimental to the environment as the world's population rises. By establishing a symbiotic ecosystem in which fish and plants grow together in a closed-loop system, aquaponics provides a solution. In this method, fish waste supplies vital nutrients for plant growth, and the plants, imitating natural biological processes, clean the fish's water. This technique is an environmentally friendly substitute for conventional farming since it not only uses less hazardous chemicals but also conserves water.

Aquaponics systems come in three main varieties: raft, substrate, and channel. The basic ideas of nutrient cycling and water conservation are the foundation of all systems, even though each system has a different design and is appropriate for a particular crop. Fish waste is transformed into types of nitrogen that plants can absorb by bacteria, which is how the nitrogen cycle keeps the system healthy. All things considered, aquaponics is a technology that effectively produces both fish and plants with the least amount of resources, making it a viable way to tackling environmental sustainability and food security.

Introduction

The world's population is expanding quickly, and there just isn't enough food to feed everyone! The task facing scientists is crucial: they need to figure out how to increase food production without endangering the ecosystem. There are numerous ways in which traditional farming methods harm the environment. They endanger wildlife and human health, in addition to damaging natural resources. An approach known as aquaponics may be able to help with this issue. The aquaculture industry, which involves cultivating fish, prawns, algae, and other shellfish, is where the word "aqua" gets its name. The word "ponics" refers to hydroponics, which is the practice of growing plants in water without the use of soil. Hydroponics and aquaculture can coexist independently, but when they do, we get aquaponics.

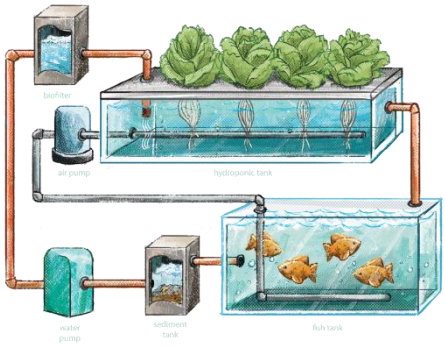

Fig.1

An ecology in miniature is what aquaponics is. It operates in every aquatic environment in the same manner as Mother Nature does! In aquaponics, the fish are employed first. We define working as eating and defecating. This produces nutrient-rich water—yes, fish excrement! Bacteria then become involved. Fish excrement is transformed by bacteria into an ideal fertiliser for plant growth. By using their roots to absorb this fertilizer, the plants purify the water as a result. Fish farms repurpose clean water for fish farming. The cycle begins again.

Fish excrement is transformed into nutrients that benefit plants by bacteria. By absorbing these nutrients, the roots of the plants purify the water. Fish farming uses the cleaned water again. By doing this, we can create a closed water cycle in which the same volume of water flows nonstop. Water moves in a cycle, going from the fish to the plants and back again.

Fish, plants, and microorganisms collaborate in an aquaponics system. By working together, farmers are able to produce two food products—vegetables and fish—with the same amount of water that would typically only be needed to produce one. Water is not wasted in this closed cycle because there is essentially no effluent released into the environment.

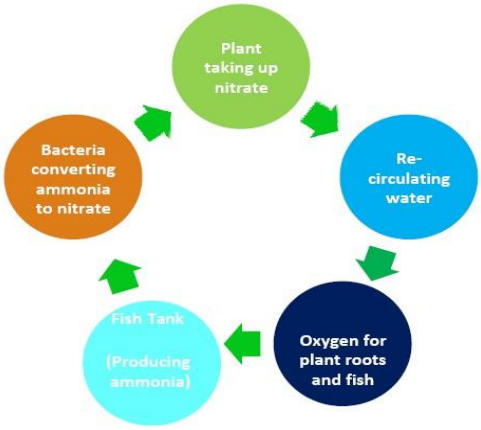

Fig: 2

Types of Aquaponics

There are three main aquaponics systems in use today:

1. Raft Aquaponics
2. Substrate Aquaponics
3. Channel Aquaponics

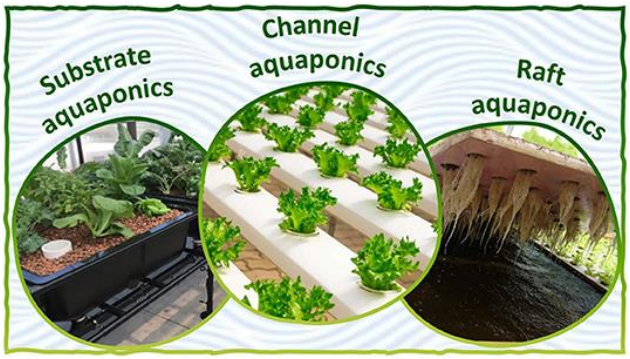

Fig: 3

1. **Raft Aquaponics**

With raft aquaponics, plants are inserted into raft-drilled holes. Within aquariums full of fish excrement, the rafts float. Plants are raised on floating rafts, and their roots dip into the water to obtain nourishment. The fish culture wastewater is contained in tanks where the rafts are floating. In order to receive the nutrients from the fish excrement, the plant roots dip into the water. Small plants like salad greens, basil, spinach, chard, and others are most suited for this technique.

2. **Substrate Aquaponics**

Under the substrate aquaponics system wherein plants are planted in holes bored into pipes that carry fish wastewater water continually. The plants grow on a substrate that resembles dirt, and their roots dip into the water stream where they may absorb the nutrients. In addition to supporting plant roots, this substrate aids in water filtration by bacteria. While any sort of plant can be grown with this kind of system, tomatoes, peppers, cucumbers, beans, peas, squash, melons, and carrots are the most common crops that are grown with it.

3. **Channel Aquaponics**

Channel aquaponics system wherein plants are grown on a substrate that resembles dirt. Additionally, the bacteria in this substrate aid in the plant's intake of nutrients from the fish wastewater, which passes through tiny pipes with holes into which the plants are inserted. In order to absorb the nutrients from the fish excrement, the roots dip into the water stream inside the pipe. Plants that require little support, like herbs, leafy greens, and strawberries, do well grown this way. To save room, the pipes can alternatively be arranged vertically. The substrate used in substrate aquaponics resembles dirt and aids with plant development. The plants in channel aquaponics are grown in pipes that are filled with nutrient-rich water. Raft aquaponics involves growing plants on floating rafts with roots that reach into the water to get nutrients.

Nitrogen cycle

There are three stages of the nitrogen cycle in Aquaponics.

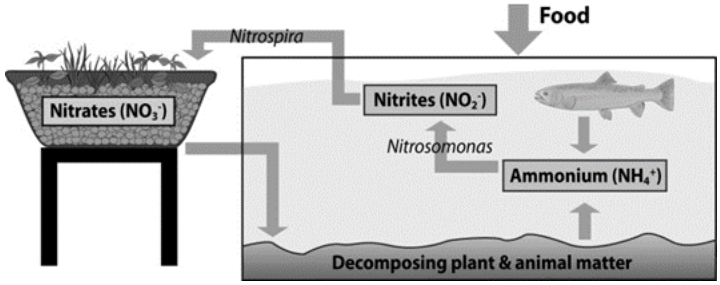

Fig:4

- **Initial stage**:

When fish are added to the aquarium, the cycle starts. They rapidly convert any uneaten food, urine, and excrement into unionized or ionized ammonia. If the pH is less than 7, ammonium (NH4), the ionized form, is present and is not harmful to fish. When the pH is 7 or higher, ammonia (NH3), the unionized form, is present and extremely harmful to fish. When the concentration of unionized ammonia (NH3) reaches 2 parts per million (ppm), the fish will perish. Usually, the third day after adding fish to the system, ammonia starts to rise.

- **Second stage:**

In this phase, ammonia is oxidized by Nitrosomonas bacteria to nitrite, which is likewise extremely hazardous to fish. For certain fish, nitrate levels as low as 1 mg/l can be fatal. By the end of the first week following the addition of fish to the system, nitrite normally starts to rise.

- **Third stages:**

The bacteria Nitrobacter transforms the nitrites into nitrates at the cycle's final stage. At low to moderate concentrations, nitrates do not pose a significant hazard to fish. Every few months, established tanks should have their nitrate levels checked to make sure they aren't getting too high.

Plants will absorb nitrates once the nitrogen process is initiated, supplying the system with clean water. Fish and plant growth environments need to be balanced for this dynamic system to continue. The system's pH, temperature, and chemical components must all be watched to make sure this happens. Nitrifying bacteria will be negatively impacted by excessively acidic pH values. On the other hand, if the water gets too basic, the plants won't be able to absorb as many micronutrients. For fish, plants, and nitrifying bacteria to develop in the right conditions, the pH should ideally be at 7. In addition, frequent feeding of the fish and possible pest monitoring of the plants are required.

Conclusion:

Considering the constantly expanding global population and the environmental damage brought on by conventional agricultural practices, aquaponics offers a novel and sustainable answer to the problems facing modern agriculture. Aquaponics is a self-sustaining ecosystem that efficiently produces both fish and plants with low resource inputs and environmental effects. It is achieved by merging hydroponics and aquaculture. Through the recycling of nutrients within a closed-loop system, this technique decreases waste, saves water, and does away with the need for chemical fertilizers. Raft, substrate, and channel aquaponics systems provide crop production versatility, allowing it to adapt to a variety of agricultural needs and situations. Understanding and preserving the delicate nitrogen cycle balance is essential to the effective application of aquaponics, as it ensures ideal circumstances for fish, plants, and beneficial microorganisms. In addition to addressing food security, this integrated strategy encourages sustainable agriculture methods and environmental stewardship. In summary, aquaponics is a distinct and exciting alternative to conventional farming that can increase food production while safeguarding ecosystems and natural resources. Aquaponics has the potential to significantly influence how the world's food systems develop in the future as science and technology develop.

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BENEFITS OF FLAXSEED IN LAYING HENS : A REVIEW

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Abstract
Flaxseed has gained recognition in poultry nutrition for its nutritional richness and benefits to layer birds. Research underscores its positive influence on egg production, facilitated by omega-3 fatty acids and phytoestrogens that enhance hormonal levels and feed conversion ratios. Flaxseed's antioxidants contribute to hen health and productivity. Studies reveal varied outcomes regarding feed consumption and conversion ratios, underscoring the necessity for further investigation. Flaxseed also enhances egg quality, including weight and yolk color, although its effects on the Haugh unit and yolk index exhibit inconsistency across studies. Overall, flaxseed proves advantageous for egg production and quality, prompting ongoing research efforts.

Key words : Flaxseed, layers, egg production, poultry nutrition.

Introduction

Flaxseed, known for its rich nutrient content, has become a focal point in poultry nutrition due to its numerous benefits for layer birds. Research spanning several decades has extensively explored the incorporation of flaxseed into the diets of laying hens, uncovering a range of advantages from improved egg production to better overall health. This article examines these benefits, drawing on a substantial body of scientific evidence to understand flaxseed's impact on various aspects of poultry production. A primary benefit of flaxseed is its positive effect on egg production. The omega-3 polyunsaturated fatty acids (PUFA) and phytoestrogens in flaxseed have been shown to enhance egg production rates by modulating hormonal levels and optimizing feed conversion ratios. Additionally, the antioxidants and anti-inflammatory properties of flaxseed play a crucial role in maintaining hen health and productivity, which in turn supports higher egg production. The influence of flaxseed on live body weight, feed consumption, and feed conversion ratios (FCR) has been widely studied, although results vary. Some studies report significant improvements in FCR and slight changes in body weight, while others show no significant differences, indicating the need for further research to determine the optimal levels of flaxseed inclusion in poultry diets. In terms of egg quality, flaxseed has shown promising results in improving parameters such as egg weight, yolk index, and yolk color score. However, the effects on the Haugh unit and yolk index have been inconsistent, suggesting that flaxseed's benefits may be influenced by other dietary and environmental factors. Overall, incorporating flaxseed into the diets of layer birds offers several advantages, particularly in enhancing egg production and improving certain egg quality metrics. This article synthesizes findings from various studies to provide a comprehensive overview of flaxseed's role in poultry nutrition, emphasizing the need for ongoing research to fully understand its long-term effects on poultry health and productivity.

1. **Enhancement of Egg Production:** One of the primary benefits of flaxseed in layer birds is its positive impact on egg production. Scheideler *et al.* (1998) found that flaxseed, rich in omega-3 polyunsaturated fatty acids (PUFA), enhances egg production. Additionally, Elkomy *et al.* (2008) discovered that flaxseed's phytoestrogens, particularly lignans, act as estrogenic compounds. These compounds structurally resemble 17-β-estradiol, stimulating estrogen receptors and significantly increasing blood estrogen levels. This hormonal boost results in higher egg production rates and better feed conversion ratios. Further studies by Martinchik *et al.* (2012) emphasized the role of flaxseed's antioxidants and phytoestrogens, such as secoisolariciresinol and secoisolariciresinoldiglycoside, in enhancing egg production. These compounds possess potent antioxidant and anti-inflammatory properties, contributing to the overall health and productivity of hens. Dai *et al.* (2021) highlighted that flavonoids in flaxseeds enhance reproductive performance by regulating liver lipid metabolism, improving ovarian function, and maintaining the number of primordial follicles in aged breeder hens. Saadany *et al.* (2022) also reported elevated blood total antioxidant capacity (TAC) and increased blood estradiol 17β hormone secretion in flax-fed hens, leading to a significant rise in egg production. Stanhiser *et al.* (2022) noted that omega-3 supplements, including flaxseed, are associated with an increased likelihood of conception, further supporting reproductive health and productivity in poultry.
2. **Feed Consumption and Feed Conversion Ratios:** The influence of flaxseed on average feed consumption has been widely studied. Most studies, including those by Amini *et al.* (2007), Chen *et al.* (2014), Omri *et al.* (2017), Saleh *et al.* (2019), and Panaite *et al.* (2021), reported non-significant differences in feed consumption among treatment groups. In terms of feed conversion ratios (FCR), studies have shown mixed results. Saleh *et al.* (2019), Panaite *et al*. (2021), and Chen *et al.* (2014) reported significant improvements in FCR on an egg mass basis, indicating better efficiency in converting feed into egg mass. Conversely, Saadany *et al*. (2022) noted a decrease in FCR, while Mattioli *et al.* (2017) found no significant impact on FCR.
3. **Egg Production Metrics:** Several studies have documented the positive effects of flaxseed on egg production metrics. Saadany *et al.* (2022), Aziza *et al*. (2013), and Chen *et al.* (2014) reported significant increases in egg production in hens fed flaxseed-enriched diets. These findings highlight the potential of flaxseed to enhance egg production rates, making it a valuable dietary supplement for layer birds.
4. **Egg Quality Parameters:** The quality of eggs, including egg weight, shape index, yolk index, and yolk color score, has also been a focus of research. Studies such as those by Saadany *et al*. (2022), Omri *et al.* (2017), Aziza *et al*. (2013) reported significant improvements in egg weight and yolk color scores with flaxseed supplementation. However, other studies, including those by Al-Nasser *et al*. (2011), and Mattioli *et al.* (2017), found no significant differences in these parameters. The impact of flaxseed on the Haugh unit and yolk index has shown varied results. While Aziza *et al*. (2013) reported non-significant changes in the Haugh unit. Similarly, the yolk index results were mostly non-significant across various studies, as reported by Ghosh *et al.* (2023).

Conclusion

The incorporation of flaxseed in the diets of layer birds offers several benefits, particularly in enhancing egg production and improving certain egg quality parameters. While the effects on

body weight and feed consumption are mixed, the overall positive impact on reproductive performance and egg production metrics makes flaxseed a valuable dietary component for layer birds. Continued research is essential to optimize flaxseed inclusion levels and fully understand its long-term effects on poultry health and productivity.

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GIS, GPS AND REMOTE SENSING FOR CROP MANAGEMENT IN AGRICULTURE

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Abstract
Agriculture is a multifaceted system made up of several ideas and connections. Computing background-created geographic information systems (GIS) enable the generation of sophisticated field views and the making of sound agricultural technology decisions. Farmers now have the opportunity to consider geographical variability thanks to the Global Positioning System (GPS), which is based on satellite technology. While GIS software may combine data from GPS and many other sources, GPS is a satellite system. Through the identification of possible impact areas and areas susceptible to both GPS and GIS technologies can help farms mitigate and prepare for biosecurity threats, both intentional and unintentional. Initiatives include management, risk and route analysis, survey data gathering, data visualization, and querying.

Introduction
These days, the rapidly expanding fields of remote sensing and GIS provide a plethora of exciting and lucrative career opportunities. Numerous organizations invest a significant amount of money in these disciplines. This brings up the reason behind these fields' rapid rise to prominence. Two This is mostly due to several factors. These days, a deeper comprehension of our surroundings is something that scientists, researchers, students, and even everyday people are quite interested in. We define environment as I refer to their study area's actual location as well as the activities that take place there. That's the location. Stated differently, we have realized that the actual location and the data that highlights how they are a part of our everyday lives and how almost every decision we make is affected or dictated by a geographical truth. The development of more sophisticated space technology, which can produce enormous volumes of spatial data, and the decline in the price of computer hardware and software, which can handle these data, have made G.I.S. and remote sensing affordable for complex environmental and spatial situations and available to a wider audience.

GIS, GPS & Remote sensing in crop management

Production of crops
Remote sensing is an essential technique for determining crop production and yield estimates across a certain region and the amount of crop that will be harvested under specific conditions. These data can be used by researchers to predict the amount of agricultural output that will be produced in a given area during a certain period of time.

Assessment of crop damage and crop progress
Assessment of crop growth and damage Remote sensing technology can be used to scan the field and determine the exact amount of a crop when damage or progress occurs. That has suffered damage in addition to the condition of the remaining crop.

Crop identification

Furthermore, the identification of crops has been greatly aided by remote sensing, especially in cases where the crop being observed has distinctive or confusing characteristics. Data on the crop is collected and brought to the labs to be studied for many crop-related subjects, like crop cultivation.

Identification of pests

The application of remote sensing technologies is essential for the regular tracking and measurement of agricultural stress brought on by various biotic and abiotic factors. These techniques should be sufficient in identifying insect breeding grounds so that preventative steps can be taken to prevent the insects from proliferating. It also plays a significant role in identifying agricultural pests and giving advice on the most effective pest control techniques to apply in order to get rid of diseases and pests from the farm.

Soil moisture estimation

It might be difficult to measure soil moisture without the use of remote sensing equipment. Using data from remote sensing, one can determine the type of crop to plant in a field according to the moisture content of the soil.

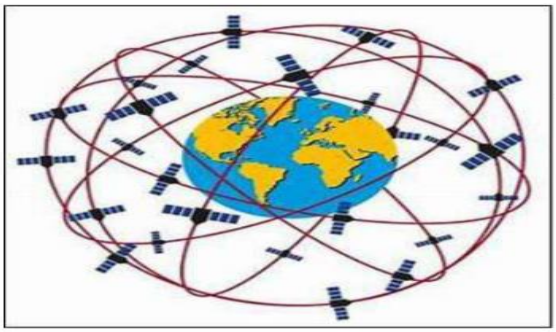
Flood mapping and monitoring

Using remote sensing technologies, farmers and agricultural specialists may map out areas that have poor drainage and those that are prone to flooding. This knowledge can then be applied to avert flood catastrophes in the future.

Climate change monitoring

Since these variables are critical in deciding which crops may be produced, remote sensing technology is essential for tracking climate conditions and monitoring climate change.

GPS in agriculture



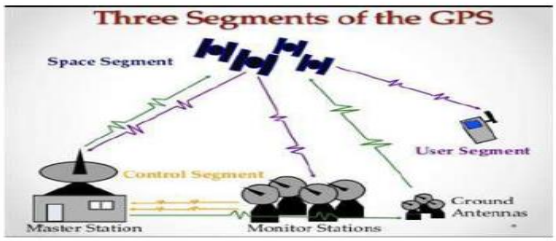


Fig 1 : Satellite constellation and orbital plane Fig 2 : Segments of GPS

The 24 satellites that make up the GPS are divided into six orbital planes, each including four satellites (Fig. 1), as well as associated ground stations [9]. The planet is orbited by satellites. These satellites are positioned specifically to ensure coverage of the entire world. Farmers can `use GPS to pinpoint certain fields year after year in order to collect soil samples or monitor farm conditions [10]. Collectively referred to as NAVSTAR, these satellites are launched and maintained by the Department of Defense (DOD). (Navigation by Satellite Timing and Ranging) in order to

provide comprehensive meteorological information around-the-clock, wherever on Earth [11]. Each orbit has a height of 20,200 km (12,500 mi). The four atomic clocks are each outfitted with These satellites are positioned specifically to ensure worldwide coverage. Farmers can consistently find specific fields with GPS in order to collect soil samples or monitor farm conditions [10]. The Department of Defense (DOD) launched and is responsible for maintaining these satellites. They are intended to provide all-weather information around-the-clock, wherever on Earth, under the moniker NAVSTAR (Navigation by Satellite Timing and Ranging) [11]. Every orbit is finished at a height of 20,200 kilometers (12,500 miles). These satellites are organized in an odd way, with four atomic clocks fitted with each to ensure that the entire world is covered. Each year, farmers can use GPS to go precisely to pre-arranged locations in the field in order to collect soil samples or monitor agricultural conditions.

GIS in agriculture

A computer application called GIS (Geographical Information System) is used to collect, evaluate, store, and make accessible data that has been sent by a GPS-type navigation system. The GPS data is connected to other georeferenced information sources through GIS. Layers of spatial data can be combined using GIS, and it can reveal potential Registration is the process of changing one spatial information layer to match another layer.

The potential to share data and do innovative spatial relationship analysis rises substantially when a large set of data is registered from the same coordinate system. The field of GIS applications for agriculture is expanding quickly. These applications include more specialized programs made from commercial packages like ArcView (ESRI, Redlands, CA) and MapInfo Desktop (MapInfo Corp., Troy, NY), as well as more general programs like Site-Specific Technology Development Group, Inc., Stillwater, and Red Hen Systems (MapInfo, Fort Collins, CO). AGRIS Corporation, Agri-Logic, Farm Works TM, John Deere Precision Farming Group, Case Corporation, RDI Technologies, and Rockwell International have created and introduced a few other software programs. Similar to other computer software categories, incompatibility between competing systems can be an issue; however, to address this issue, generic data formats and data transfer protocols have been developed.

The elements that make up remote sensing:

Remote sensing is the study of collecting information about the Earth's surface without physically touching it. Sensing and recording energy that is reflected or radiated, as well as collecting, analyzing, and using such data, are necessary to do this." The interaction between the targets of interest and incident radiation is a common feature of remote sensing techniques.

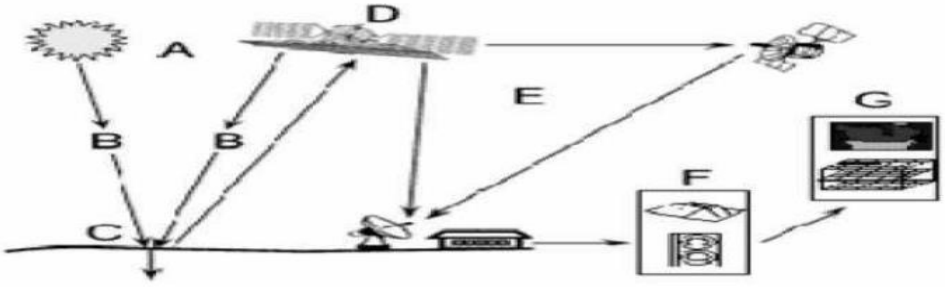


Fig 3 : Components of remote sensing

(A): The main requirement for remote sensing is an energy source that provides electromagnetic energy to the target of interest or illuminates it.

(B): As energy travels from its source to its destination, it comes into contact with and interacts with the atmosphere. This contact may reoccur as the energy travels from the target to the sensor.

(C): The energy interacts with the target after it has passed through the atmosphere, depending on the properties of the radiation and the target.

(D): After the energy has been released, we require a remote sensor that is not in direct touch with the target in order to collect and record electromagnetic radiation dispersed throughout or released from it.

(E): The sensor's energy must be transferred, usually electronically, to a receiving and processing device in order for the A picture can be created from information, either digitally or physically.

(F): The processed image is used to extract information about the lighted target by electronic, digital, interpretation.

(G): Applying the information we were able to learn about the target from the pictures is the final phase in the remote sensing process, which helps us understand it better. discover fresh data or assist in resolving a particular issue.

Conclusion

Crop management in agriculture has been completely transformed by the fusion of GIS, GPS, and remote sensing technology. By offering accurate and thorough data on crop output, damage assessment, pest identification, soil moisture calculation, and climate monitoring, these cutting-edge instruments help farmers and agricultural researchers make better decisions. Crop yields may be optimized, pest and environmental change risks can be reduced, and overall agricultural efficiency can be increased by utilizing the spatial and temporal data these technologies provide. Future farming will be sustainable and fruitful thanks to the ongoing developments in these domains, which promise even more innovations in agricultural methods.

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ARTIFICIAL INTELLIGENCE IN AGRICULTURE : A VIABLE PROSPECT OR A DISTANT DREAM?

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Abstract
The advent of Artificial Intelligence (AI) in agriculture represents a transformative approach to addressing critical issues in the sector. This article examines the deployment of AI technologies, including Machine Learning, Neural Networks, and Expert Systems, in the automation and optimization of various agricultural practices in India. AI's applications in soil analysis, crop monitoring, pest management, and irrigation are highlighted, demonstrating significant improvements in efficiency and productivity. Despite challenges such as climatic variability and financial limitations of smallholder farmers, AI's potential to enhance agricultural sustainability and yield is substantial. The study underscores AI's role in advancing agricultural practices and mitigating environmental impacts in the Indian context.

Keywords : Agriculture, Artificial Intelligence, Automation, Machine Learning, Optimization

Introduction

Agriculture is an important sector that serves as the foundation of India's economy and is the main source of income for more than 58% of rural households with around 80% of the overall Indian population directly involved in agriculture-related work on 159.7 million hectares of agricultural land (Saxena *et al*., 2020). Despite its popularity, agriculture and its related businesses are facing numerous challenges due to insufficient optimization in breeding, production, and protection technologies, as well as nutrient, water, and agrochemical management. Artificial Intelligence (AI) is one of the pivotal branches of computer science, and can significantly help to address these issues. Branches of AI, such as Machine Learning (ML), Deep Learning (DL), Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), Expert Systems (ES), and Fuzzy Logic Systems (FLS) can assist in training and establishing one or more technically accurate Internet of Things (IoT). These IoTs are comprised of automated embedded machinery, which can relieve the farmers of their drudgery and the environment from entailing carbon footprints of conventional practices (Jha *et al*., 2019; Mor *et al*., 2021), described in this study.

Implementation of AI in Agriculture

The following farm operations can benefit from the application of AI technology to increase efficiency:

- **IoT-driven development:** IoT-based "Smart Farming" has assisted farmers in applying fertilizer with precision, minimizing waste and enhancing yield through optimal nutrient absorption.
- **Soil analysis:** AI models such as feedforward backpropagation ANN use sensors, infrared radiation, and image recognition are used to understand seed responses to soil types, providing precise data for weather change analysis (Irimia *et al.,* 2016). AI systems utilize

temperature, soil moisture, and evaporation information to identify potential soil flaws and nutrient shortages through different techniques like Management-oriented modelling (MOM) and Fuzzy Logic -SRC DSS.

- **Sowing**: AI-enabled technology such as a Fuzzy-based prototype expert system named "PRITHVI" optimizes crop timing, sowing depths, and climate variables to increase crop yield as well as reduce input costs for farmers.
- **Fertilizer, weed and pest control**: AI models such as KISAN, and AGPEST supplement the naturally occurring nitrogen, phosphorus, and potassium in the soil to improve soil fertility and produce quality. These also address paying-related losses in agricultural produce through drones and deep learning techniques. AI-guided robots reduce input costs for herbicides and agrochemicals and mitigate environmental problems by improving weed detection, discrimination, and destruction. (Dhaliwal *et al.*, 2015)
- **Irrigation:** AI-enabled thermal imaging cameras can monitor crop water requirements, increase yield, eliminate diseases, and reduce manual intervention. They also aid in weather estimation, evapotranspiration, evaporation, and daily dew point temperature prediction using models like AGREX.
- **Crop harvesting**: AI-coupled technologies like CALEX, ROBOTICS Demeter improve crop harvesting by sorting crops based on grades, saving time and labour, and achieving significant workforce savings of approximately four labourers per acre of land (Panpatte *et al*., 2018).
- **Farm produce aggregation:** AI technologies help farmers to reduce the manual labour in the sorting, grading, and assembling of farm produce through the use of robots, driverless tractors or vehicles, and blockchain technologies.
- **Crop monitoring:** Artificial intelligence (AI) models such as IBPNL, and CFS utilize sensors, drones, and artificial lighting to reduce the carbon content of crops, protect them from wild animals, and provide warnings for locust swarms, weather changes, droughts, and floods.
- **Predictive agricultural analytics:** AI-enabled satellites and drones use predictive agricultural analytics to analyse pest and disease threats, forecast weather, and enhance plant nutrition using data on solar radiation, temperature, wind speed and rainfall. These are facilitated through three models such as ANN, Random Forest Partial dependence plots (RF) and SVM (Bisen *et al.,* 2019).

Potential Setbacks of Implementing Ai in Indian Agriculture

The implementation of AI in the Agrarian Sector of India may face significant challenges, including the complexities of soil and agro-climatic conditions as well as the diverse knowledge, beliefs, and customs of the diverse practitioners of the sector. The elaboration is articulated hereunder,

- **Diverse and Unpredictable Climate:** The primary challenge confronting by Indian Agriculture is the climatic conditions of the regions where arable lands are located. India is divided into 15agro-climatic zones, which are variable due to climate change. Existing sluggish systems and practices are unable to adequately adapt to these changes, necessitating consistent training of IoTs and expert systems with updated datasets of

current variables to generate accurate outcomes within specified timelines (Jha *et al*., 2019).

- **Inaccurate Articulation:** The failure of the domain experts to accurately articulate their diagnosis and deduction methodologies in important fields such as crop protection prevents the systems from receiving with necessary programming and training, resulting in unreliable outcomes (Dutta *et al*., 2020).
- **Financial Constraints of Farmers:** The average land ownership of Indian farmers has declined to around 1.16 ha, pushing more of them into the categories of small and marginal farmers and landless labourers over time. Introducing AI in such circumstances necessitates numerous cost-effective purchase plans, policies and insurance schemes to effectively mitigate the risks as agriculture gradually transitions into the notion of "Smart Agriculture" in this challenging economy. (Mor *et al*., 2021)
- **Inadequate Dissemination:** The nationwide shortage of extension agents poses a serious hurdle to the introduction of AI in Indian Agriculture, significantly limiting opportunities for the upcoming generations of farmers to learn and invest more in AI, which will boost the National Economy in the long run. (Jha *et al*., 2019)
- **Employment Issues:** The rationalized automation offered by AI technologies will inevitably recalibrate the labour demand and reduce conventional jobs in the sector within a span of a few months. Faced with financial obstacles, the freshly laid-off labourers may struggle to find new opportunities in automated agriculture alongside intelligent machines. The perception of such scenarios accompanied by inadequate research and extension efforts in both agricultural and computer sciences, discourages the farmers from adopting AI and replacing their conventional practices.
- **Sluggish Reforms:** The necessary systematic changes required within the economy are significantly hindered by the concerned regulatory bodies due to numerous legal, ethical and social challenges faced by them at the onset of AI introduction. These challenges have created complicated ethical, legal and moral scenarios from which the former needs to create revised mitigation strategies in a relatively accelerated pace (Saxena *et al*., 2020).

Prospects of AI in Indian Agriculture

The ability of AI-enabled tools and technologies to achieve sustainable optimization has secured their role in Agriculture. Farm analytics has emerged as a high-potential driver for productivity and research, propelled by neural networks' cognitive capacity to process massive datasets. Developing AI algorithms specific to the agricultural industry can be challenging, yet domain-specific ML techniques and subsequent big data can boost crop production.

The global population is projected to reach 9 billion by 2050, necessitating a 70% increase in agricultural yield, a milestone only reachable through technologies like AI-mediated automation. Computational Networks like ANN, CNN, RNN etc., AI techniques are rapidly advancing in domains like identification, diagnosis and management of crop pests and diseases, employing diverse approaches including ML, AI, deep learning, neural networks, and fuzzy logic, to carry out optimized automation (Ferentinos *et al.,*2018).

The reduction of human intervention and effort can be achieved by utilizing any of these extended methods. Any unwelcome natural situation may be controlled and managed using AI technology.

AI-powered methods could enable prompt and intelligent responses to detect plant illness or climate change (Jha *et al*., 2019). Training the upcoming generation with accurate information and effective dissemination methods, coupled with an increase research and development in the concerned domains, can help Indians exploit the Global AI race and earn from a budding market.

Conclusion

The AI market is estimated to reach US $266.92 billion by 2027 and would attract numerous startups focusing on AI technology solutions to improve agricultural production efficiency. This article proposes substituting traditional agricultural operations with an automated system that integrates sensors, IOT and machine learning.

It is paramount to develop an efficient plan that will make AI tools accessible to even the smallest farms and implement AI solutions in a timely and practical manner, thereby providing the necessary support for farming input deployment. Artificial intelligence can significantly enhance Indian agriculture by improving decision-making, enabling more crop yields and advancing scenario analysis, risk prediction, and action against hunger. As food is a fundamental human need, this cutting-edge technology plays a crucial role in the nation's development.

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BANANA FIBRE : EXTRACTION AND BY PRODUCTS

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Abstract
Banana fibre, from the stem of the banana tree, is known for its resilience and biodegradability, primarily composed of cellulose, hemicelluloses, and lignin. Unlike bamboo fibre, it boasts superior tensile strength, fineness, and spin ability. Extraction methods—manual or mechanical—affect its qualities, ranging from soft and silky to robust, depending on the stem part used. Processes like peroxide bleaching prepare it for textiles, paper, and handicrafts. Its sustainable attributes and types—outer peel, inner peel, silk, and cotton—make it versatile in eco-friendly industries. By-products like banana sap and scutcher waste also find agricultural and composting uses, enhancing its value chain. As banana fibrere-emerges in textile and non-textile sectors, its potential for sustainable product development grows.

Introduction

Banana is one of the important fruit crops grown in most of the states of India. After harvesting, almost 5 lakh tones of banana trunk are thrown away as garbage in India annually. With proper use of the pseudostem, leaves, suckers, and other parts of the banana crop, there is a strong chance of earning extra money from the crop. Fabrics of varying weights and thicknesses can be crafted from banana pseudostem fibre which is extracted from outer sheaths yielding softer fibres, while inner sheaths provide thicker, more robust ones. There are attempts to use the pseudostem, leaves, and suckers to make goods on a very small scale that are reasonably priced, such as papers, handicrafts, ropes, and edible items. Banana fibre is a great substitute for synthetic fibre and offers a sustainable option to silk.

Method of Extraction of Fibre:

Banana fibres are extracted from the sheath by the following methods:

Manual extraction

A stainless-steel scraper is used to manually extract fibers from banana sheaths. The scraping process begins inside the sheath and progresses outward. The sheaths are typically cut to 30 cm length and 8-10 cm width or as needed. Fibres obtained through scraping are smooth, silky, white, and somewhat stiffer compared to mechanically extracted fibres.

Mechanical extraction by fibre responder machine:

Fibre is mechanically extracted using commercial responder equipment. Banana sheaths are fed directly into the machine after being cut from the stem, or they can first pass through two roll crushers to eliminate excess moisture. The mechanically extracted fibres are smooth, homogeneous, and white in colour. The responder machine specifications include an extraction capacity of 2 kg/hour, a 1 HP motor, rolls measuring 18-20 inches in length, and 8 knives.

Treatment of fibres:
Fibres that are removed manually or mechanically typically have a white hue. Nevertheless, there is occasionally a chance that the fibres would seem crimson. In such instance, whitish fibre is obtained by mildly bleaching the material. When the fibre is treated with hydrogen peroxide, some undesirable substances like gum, tannin, lignin, etc. are removed, leaving the fibre completely white.

Peroxide bleaching:
Banana fibre is bleached with hydrogen peroxide in an alkaline medium while keeping a 10% consistency. To bleach the fibre, 5-7% hydrogen peroxide (30% W/V) is applied on an OD basis. The temperature is kept between 40 and 60 degrees Celsius, with a pH of 8 to 10, and the duration is roughly 30 to 45 minutes, or less, depending on when the light brown tint in the fibre completely disappears.

Softening of the fibre:
In order to soften the fibre, 50 grams of commercial detergent powder, such as 'Surf Excel' or 'Tide' is applied to the fibres in two to three litres of water for thirty minutes. The fibres are then washed with cold, fresh water. Depending on the colour and stiffness of the fibre, hot water is also occasionally utilized.

Dyeing of Fibres:
The bleached fibres can be dyed using direct dyes. First, prepare a hot water solution with 1-1.5% dried dye based on the fibre weight, filtering if needed. Dip the fibres into the dye solution, then boil them for thirty minutes. Remove the fibres from the dye bath and immerse them in a 1.5% aluminium sulphate solution at room temperature, stirring thoroughly. After 15 minutes, remove the fibres, pass them through two rollers, and hang them to air dry.

Drying of the fibre:
The wet fibres are dried in the sunlight by hanging the fibre in rows fabricated locally using galvanized pipes. When the fibres are totally dried in sunlight these can be used for making products.

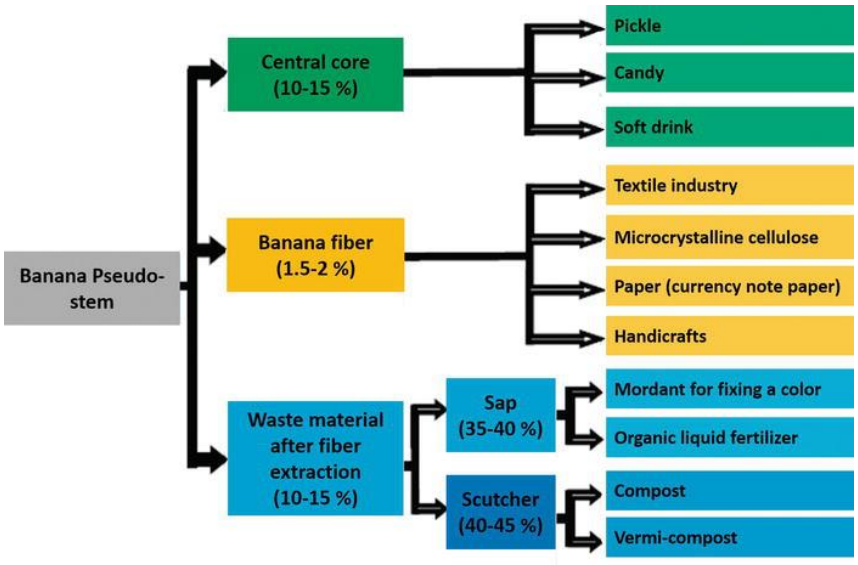

Fig 1- Potential applications of components from the banana pseudo-stem.

Banana pseudo stem by-products:

1. **Products made by sap**: The liquid division's a good source of plant nutrients like N, P, K, and micronutrients as well as growth-promoting hormones like cytokinin and gibberellic acid (GA3), in the sap that is extracted from the pseudo-stem of banana tree along with the scutcher during the fibre extraction process. It can save 20–40% of the dosage of chemical fertilizer when applied as liquid fertilizer by a drip system or drenching of crops, with a yield gain of 10-15%.
2. **Scutcher:** Similar to fibre, the waste produced during the extraction of fibre was also examined as a potential pulping raw material. According to the findings, scutcher waste has a very low unbleached pulp yield (24.4%) and a higher-Kappa no. of 20.8, indicating a larger need for cooking chemicals (22%). Thus, it can be said that scutcher waste is unsuitable for use in the production of paper.
3. **scutching waste based vermicompost** :Scutcher waste, a by-product of the raspador machine used to extract fibre from the banana pseudostem, decomposes quickly and is ideal for high-quality vermin compost. It requires 30% less dung compared to other agricultural wastes, which typically need 50% for vermin compost preparation. Testing on bananas, sugarcane, and papaya has shown that it performs similarly to commonly used organics like FYM and bio-compost from sugar industry press mud. Farmers can produce scutcher waste vermin compost on their own fields, offering a valuable alternative organic manure source.
4. **Central core candies/drinks :** A section of the banana pseudostem that can be eaten is its centre core. It being colourless and tasteless can be blended with any fruit with improvement in nutritional quality as added advantage. The method for making candies with centre core has been standardized. The candy obtained in this manner has a significant amount of vitamins B and B content, as well as rich sources of K and Fe. The national committee of NAIP also placed this technology in the "ready for commercialization category." RTS drinks in a variety of flavours can be made from the syrup (70 brix) that is left over after making candies.
5. **Making Cushion:** Banana fibre and stem products are known for their smooth texture and fine finish. The banana pseudo stem is chopped, juiced, and flattened for weaving, sometimes sun-dried for flexibility over 2-3 days. Weaving typically occurs on the inner side of the outer layer. Products like cushions use only banana stems and 'Kora grass' twines, while bags combine fibres from sisal, banana, and kora grass for diverse patterns. These items are popular in Delhi, Chennai, and Bangalore.
6. **Yarn**: Banana fibre yarn, used for making rope, transforms fibres into a strong, braided or twisted material essential for pulling and connecting. The banana tree's bark has three layers: the outer is tough and used in weaving, the inner yields silky fibres for fine clothing like t-shirts and sarees, while the middle layer produces robust ropes and textiles.
7. **Clothes and Fabrics**: While clothing refers to the various types of apparel made from cloth, fabric refers to materials made from rope or yarn. The process for making fabric and apparel from banana fibre is the same as that for making cotton material. Additionally, by combining particular ratios of various fibres, such cotton or jute, it is possible to make laminated and synthetic fabrics.
8. **Paper** : Making paper from banana fibre involves harvesting, soaking, and pulping the fibres. A key step involves a 3-5 day microbial bleaching process using fungi like Pythium and

Trichoderma to enhance fibre softness and paper brightness by breaking down cellulose and lignin. After thorough washing to remove impurities, the fibres are chemically beaten into pulp. This pulp is then used to produce various types of paper, similar to industrial methods using bamboo or wood pulp for writing paper.

9. **Solid board:** Production of solid board Banana fibre is combined with scutcher, cotton rags, waste paper, and paddy straw in varied amounts to produce hard paper and boards. This sort of board is replacing older boards on the market in a variety of applications.
10. **Handicrafts:** Banana fibre is used to make a variety of crafts. It consists of numerous dolls, key chains, bags, coasters, table mats, pillows, and other ornamental wall hangings. Participating in this industry can help women, in particular improve their economic and social situations.
11. **Eco-friendly handbag** : An eco-bag made of banana fibre can be made, and it breaks down organically. This eco-bag composed of banana fibre is more durable, resistant to wrinkles, and less absorbent than a cotton-only bag. A number of patterns and colour schemes are required in order to improve the eco-bag's quality.
12. **Sanitary napkins**: The International Institute for Environment and Development (TIIED) has created a program to teach African women how to make affordable, eco-friendly sanitary pads from banana fibres. To develop and manufacture a biodegradable home product, numerous scientists are working.

Conclusion

Banana plant pseudo-stems as a rich source of dietary fibre often overlooked after fruit harvesting. Its high cellulose and low lignin content make it ideal for eco-friendly alternatives in industries like pulp and paper, reducing environmental impact. Potential applications include N95 masks, bags, clothing, and medical research, suggesting broad avenues for sustainable innovation.

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BIOCONTROL STRATEGY IN INCREASING THE SHELF LIFE OF FRUITS AND VEGETABLES

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ABSTRACT

Fruits and vegetables are essential components of human diets and offer numerous health benefits. Extending the shelf-life of these products requires preserving their quality and safety. The quality of fresh or fresh-cut fruits and vegetables depends on various factors and can be assessed using analytical or sensory evaluation methods. "Biological control is a promising approach among the several technologies used to maintain the quality and increase the shelf life of fresh and minimally processed fruits and vegetables". The application of biocontrol agents in the field may help protect fruit surfaces from infections by aiding early colonization. Additionally, applying biocontrol agents before harvest can be an effective strategy for protecting fruits and vegetables from damage during postharvest handling. For preharvest applications to be successful, putative biocontrol agents must be able to withstand low-nutrient availability, UV radiation, high temperatures, and dry conditions. This article offers a brief introduction to the strategy of biocontrol to extend the shelf life of fruits and vegetables.

Keywords : shelf life, biocontrol, postharvest applications

Introduction

During the preharvest stage, pest management involves using tailored agricultural practices. In the postharvest stage, contaminations are addressed using specific (bio)technological methods such as physical, chemical, and biological. Some problems are interconnected between the preharvest and postharvest stages, and they can be addressed using parallel solutions. For instance, the presence of unwanted microorganisms during the preharvest stage can impact the quality of the postharvest stage, and affect crop production, yield, and storage.

Postharvest practices can increase contamination and promote the spread of microbes, leading to product damage supporting microbial growth. In this context, microbial biocontrol is gaining interest as a sustainable innovation. Biological control involves using microbial cultures to control postharvest pathogens. When this approach is used to extend the shelf-life of food, it is also known as bio-preservation, although the method is equivalent. The complex microbial ecosystems encompass the diversity of naturally associated bacteria, yeasts, and filamentous fungi (Klape *et al.,* 2022).

During harvest, the wide diversity of microorganisms can have a noteworthy impact on the quality and safety of the postharvest products (Sellitto *et al.,* 2021). This collection of microorganisms may be allied to harmful pathogens, toxin-producing bacteria, bacteria that carry genes for antibiotic resistance, and/or activities that could potentially spoil the food. At the same time, these unwanted microorganisms can originate from postharvest processes, workers, and

surroundings. These spoilage microbes can be managed using a variety of strategies often united within the framework of hurdle technology applications (Simone *et al.,* 2020). Among other methods, biocontrol is the primary solution in the realm of biological treatments

Using specific microbes as control agents, biocontrol is measured as a sustainable postharvest method to extend the shelf life of fruits and vegetables (Capozzi *et al.,* 2021). Bio-protection involves applying selected microbes to prevent the growth of undesirable microorganisms. Considering the microbiome of fruits or vegetables as a target provides a valuable outlook to understand the factors involved in biocontrol solutions. This includes the evolving interest in products designed for preharvest use that also determine promise for postharvest biological control (Sellitto *et al.,* 2021).

Currently Marketed Biocontrol-Based Products for Postharvest Applications

- Bio-fungicide named as Bio save with an active ingredient *Pseudomonas syringae*was applied on crops such as pome fruit, citrus, strawberry, cherry and potato as postharvest application in USA to target *Penicillium, Botrytis* and *Mucor*
- Boni Protect, Blossom Protect and Botector bio-fungicides were applied on pome fruits and grapes as a postharvest application which has *Aureobasisium pullulans* (2 strains) as an active ingredient to target *Penicillium, Botrytis* and *Monilinia*
- Bio-fungicide named as Noli with an active ingredient *Metschnikowia fructicola* was applied on crops such as table grape, pome fruit, strawberry, stone fruit and sweet potato as postharvest application in Netherlands to target *Botrytis, Penicillium, Rhizopus* and *Aspergillus.*
- To target *Penicillium, Botrytis* and *Monilinia,* Nexy was applied on pome fruits as a postharvest application which has *Candida oleophila* in Belgium
- Bio-fungicide Amylo-x which has an active ingredient *Bacillus amyloliquefaciens,* was developed for preharvest applications but also recommended for postharvest application on grape, apple, pear and kiwifruit to target *Botrytis* and *Pseudomonas syringae.*
- To target *Botrytis* and Silver scarf, bio-fungicides Serenade and Opti with an active ingredient *Bacillus subtilis* were applied on grapes, berry fruits and potato in Bayer as preharvest applications but also recommended for postharvest application.
- Bio-protection agent Gaia which has an active ingredient *Metschnikowia fructicola* was developed for food processing, also recommended for postharvest application on harvested grape, withering grapes and grape musts in France to target *Botrytis,* non-*Saccharomyces*spoiling yeasts
- To target *Botrytis,* non-*Saccharomyces*spoiling yeasts, bio-protection agent Nymphea was developed for food processing, also recommended for postharvest application with an active ingredient *Torulaspora delbrueckii* was applied on harvested grapes and grape musts in Lallemand and France

The successful use of yeast in postharvest biocontrol is due to their natural ability to physically colonize surfaces (especially in response to released exopolysaccharides), effectively compete for nutrients to outperform frequently used pesticides, release lytic enzymes, and induce host resistance (Hernandez *et al.,* 2021). The dual aptitude for creating antagonism justifies the amount of interest in yeasts for postharvest control actions on a wide range of fresh fruit and vegetables.

Conclusion

Numerous microbial antagonists (fungi, yeasts and bacteria) can be used on fruits in pre- and postharvest, as demonstrated in laboratory, pilot and industrial-scale studies proven to increase the shelf life of fruits and vegetables. Many of these bio-tools have reached advanced levels of development, although their application is mainly targeted toward deteriorating microorganisms (primarily fungal pathogens) during field ripening seasons (preharvest). The situation after harvest is quite different because of the postharvest process itself. This process involves the technological aspects of the supply chain, forming a complex system where microbial biocontrol can be crucial. This paper summarized the current development of strategies based on microbial antagonism considering both pre- and postharvest applications and has also highlighted the prospects for optimization in both areas. Even though each particular fruit or vegetable harbors its microbial ecosystem, which is linked to its cultivation history and physicochemical characteristics, common feature scan be exploited to develop widely applicable biological-based strategies. Understanding the mechanisms of action of biocontrol or bio-preservative agents is the corner stone for developing rational combinations of selected microbial cultures or technologies.

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BIOFORTIFICATION STRATEGIES: ENHANCING CROP NUTRITION TO COMBAT GLOBAL MALNUTRITION

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Abstract
Biofortification represents a pivotal strategy in agricultural science aims at enhancing the nutritional quality of crops through modern biotechnological, conventional breeding, and agronomic approaches. This methodological diversity targets the enrichment of essential vitamins and minerals in staple foods, addressing widespread micronutrient deficiencies prevalent in populations reliant on limited dietary diversity. By prioritizing nutrient content alongside yield, biofortification offers a sustainable solution to combat "hidden hunger" and improve public health outcomes globally. This review explores the methodologies of agronomic biofortification, conventional plant breeding, and genetic engineering, highlighting their respective advantages, challenges, and contributions to agricultural sustainability and food security. Successful biofortification initiatives across major crops such as cereals, fruits, and vegetables underscore the transformative potential of enhancing crop nutrient profiles to alleviate malnutrition. Through continued research and strategic implementation, biofortification emerges as a promising pathway to enhance global nutrition and advance sustainable development goals.

Keywords : Biofortification, crop nutrition, genetic engineering, sustainable agriculture, public health.

Introduction

The method of biofortification uses modern biotechnology, conventional plant breeding, or agronomic techniques to increase the nutritional content of crops. By increasing the concentration of vital vitamins and minerals in crops, this technique aims to make them more rich in nutrients for human consumption. It is a long-term solution to the world's micronutrient inadequacies, especially in areas with restricted access to a variety of foods. Our agricultural system has traditionally prioritized grain production over promoting human health. This has led to significant increases in micronutrient deficiencies in food grains, resulting in widespread micronutrient malnutrition. Agriculture now focuses on growing food crops rich in essential nutrients rather than just increasing production volume. In poorer and developing countries, where diets consist mainly of staple crops with insufficient micronutrients, this change is crucial to address "hidden hunger" or micronutrient malnutrition (Khush *et al.,* 2012). Biofortifying diverse crop varieties ensures sustainable, long-term delivery of micronutrient-rich produce to the population. Through established agricultural and food trade practices, biofortified crops with high micronutrient contents can be easily consumed by the general population. Through this biofortification approach, which targets undernourished and low-income families with limited access to diverse diets, it can help combat hidden hunger (Nestel *et al.,* 2006). Biofortified crops

efficiently provide micronutrients to nutrient-deficient populations. Despite growing interest in transgenic research, conventional breeding remains effective and widely used. Biofortified crops, despite facing various challenges, remain a promising solution to addressing malnutrition. Horticultural crops including bananas, cassava, beans, potatoes, orange sweet potatoes (OSP), cowpeas, and pumpkins have undergone biofortification. Numerous conventional and transgenic varieties have been introduced, and additional varieties are currently under development.

Methods of biofortification

1. Agronomic biofortification
2. Conventional plant breeding
3. Genetic engineering

Agronomic biofortification

Agronomic biofortification employs micronutrient-enriched fertilizers to efficiently improve crops' nutritional value. Consuming such biofortified crops enhances human nutrition. The effectiveness of applying fertilizers to enhance micronutrients in edible plant parts depends on mobility of mineral elements within both the soil and the plant (White and Broadley, 2003). The most effective micronutrients for agronomic biofortification are Zinc (via foliar applications of ZnSO4), Iodine (applied to soil as iodide or iodate), and Selenium (as selenate). Foliar applications can effectively boost Iron (Fe), Zinc (Zn), and Copper (Cu) levels in plants (Prasad *et al.,* 2015). Mycorrhizal associations have been proven to increase Fe, Se, Zn, and Cu levels in crops. Arbuscular mycorrhizal fungi enhance micronutrient absorption in plants, particularly for Zn, Cu, and Fe (Cavagnaro *et al.,* 2008). Agronomic biofortification has a considerable advantage over biofortification by genetic engineering, since fertilizer forms and application methods are not crop-specific. Because of this versatility, fertilizer application rates and methods may be easily adapted from one crop to the other. It takes a lot of time and resources to add new crops to the biofortified category since genetic and transgenic biofortification techniques are crop-specific (Bhardwaj *et al.,* 2022).

Conventional plant breeding

Recent advancement of Conventional plant breeding efforts to fortify the vitamin, antioxidant, and micronutrient content in crops. β-carotene, functional carotenoids, iron, zinc, and other minerals' concentrations in staple foods can be enhanced via conventional breeding, depending on available genetic variation among cultivars. Genetic diversity enables the creation of nutritionally superior crop varieties through selective breeding (Prasad *et al.,* 2015). Crops with high nutrient density are crossed with those with favorable agronomic characteristics for biofortification using conventional breeding methods. The objective is to develop new varieties of crops with improved nutritional and agronomic characteristics (Garg *et al.,* 2018). Plant breeding is a sustainable and cost-effective biofortification strategy that requires financial investments during the research and development stages. Unlike agronomic biofortification, this approach has minimal environmental impact. Crops biofortified through conventional plant breeding are generally well accepted by consumers and face fewer regulatory approvals than genetically modified foods. However, this method is labor-intensive and time-consuming because it takes longer to develop varieties that combine desirable traits, such as nutrient density and agronomic qualities. Additionally, limited genetic variation among crops can pose challenges for

biofortification through plant breeding, making it difficult to enhance the diversity of nutrients in each crop (Ofori *et al.,* 2022).

Steps in Biofortification through Conventional Plant Breeding

1. Discovery:

- **Identify Target Populations:** Determine the specific populations that will benefit from biofortified crops, focusing on those with high rates of micronutrient deficiencies.
- **Set Nutrient Target Levels:** Establish the desired nutrient levels that biofortified crops should achieve to meet the nutritional needs of the target populations.
- **Screen Germplasm and Genes:** Evaluate existing germplasm and identify genes associated with high nutrient density to use in breeding programs.

2. Development:

- **Breed Biofortified Crops:** Crossbreed selected high-nutrient varieties with other cultivars to develop new biofortified crop varieties.
- **Test Performance of New Crop Varieties:** Assess the agronomic performance, yield, and resilience of the newly bred varieties in different environments.
- **Measure Nutrient Retention in Crops/Food:** Analyze the stability of nutrient levels in the crops from harvest to consumption to ensure they remain high throughout the food supply chain.
- **Evaluate Nutrient Absorption and Impact:** Conduct studies to confirm that the nutrients from biofortified crops are effectively absorbed by the human body and improve health outcomes.

3. Dissemination:

- **Develop Strategies to Disseminate Seeds:** Create effective distribution networks to ensure that biofortified seeds reach farmers, especially in regions with high malnutrition rates.
- **Promote Marketing and Consumption of Biofortified Food:** Implement marketing strategies and awareness campaigns to encourage the adoption and consumption of biofortified crops by consumers.

4. Outcomes:

- **Improve Nutritional Status of Target Populations:** Monitor and document the improvements in the nutritional status of the populations consuming biofortified crops to assess the long-term impact of the biofortification programs.

These steps outline a comprehensive approach to enhancing the nutrient content of crops through conventional plant breeding, ultimately aiming to alleviate micronutrient deficiencies and improve public health (Bouis and Saltzman, 2017).

Genetic engineering

When variation in nutrient content among varieties of plants is minimal, transgenic methods offer a feasible option for developing biofortified crops. Using a large genetic pool, this strategy permits the transfer and expression of beneficial genes from one plant species to another, overcoming evolutionary and taxonomic obstacles and providing practical options for improving crops with micronutrients that are not normally present. Transgenic crop development is dependent on gene discovery, identification, characterization and subsequent modification to modify plant

metabolism. Incorporating processes from bacteria and other organisms into crops can lead to new metabolic engineering paths (Garg *et al.,* 2018). Agricultural crops that have been genetically engineered to improve traits like higher nutritional content, better taste, less bitterness, longer ripening, seedlessness, increased sweetness, and lower levels of anti-nutritional compounds are examples of elite crop cultivars that have benefited greatly from genetic engineering. This approach also increases opportunities for conferring additional health benefits and enhancing nutritional value. Genetically modified crops have been designed to boost their micronutrient content, focusing on vitamins, minerals, essential amino acids, and essential fatty acids. Multiple genes are utilized in this process to enhance crop nutritional value. Genes like ferritin and nicotinamide synthase target mineral nutrients, lycopene-cyclase is used for vitamins, albumin targets essential amino acids, and Δ^6 desaturases are utilized for essential fatty acids. The following transgenic crops, high lysine maize, high unsaturated fatty acid soybean, high provitamin A and iron-rich cassava, and provitamin A-rich golden rice, are all successful examples (Hirschi, 2009).

Biofortification of major Agricultural crops

Biofortification has been successfully applied to a variety of major agricultural crops, enhancing their nutritional value through various techniques. Fruits like bananas, strawberries, apples, tomatoes, and plums have been biofortified using genetic engineering and agronomic approaches to increase essential nutrients such as beta-carotene, antioxidants like selenium, and vitamins. Cereals such as Golden Rice and biofortified rice varieties have been developed through genetic engineering to enhance pro-vitamin A content and increase levels of essential minerals like zinc and iron. Resistant starch-rich rice and fortified wheat utilize breeding techniques and genetic modification to improve dietary fiber content and boost levels of iron and zinc. Wheat variants like low phytic acid (PA) wheat and anthocyanin-rich wheat employ RNA interference and conventional breeding to reduce anti-nutrient levels and increase antioxidant anthocyanin content. Maize has seen genetic modifications to enhance pro-vitamin A, quality protein, and selenium, while barley has been biofortified to boost zinc, selenium, and iron content. Legumes like soybeans are genetically modified to increase polyunsaturated fatty acids and essential amino acids. Vegetables such as sweet potatoes, potatoes, cassava, linseed, and canola have also undergone genetic engineering and agronomic biofortification to enhance beta-carotene, vitamin C, and essential fatty acids, providing substantial health benefits to consumers worldwide (Naik, 2024).

Conclusion

Biofortification of crops significantly improves the nutritional value of staple foods, making a substantial impact on global malnutrition. Using genetic engineering, metabolic engineering, and conventional breeding methods, crops have been engineered to have increased levels of vital nutrients like vitamins, minerals, antioxidants, and more. Biofortified varieties provide a sustainable and cost-effective solution for addressing micronutrient deficiencies in vulnerable populations worldwide. Research and investment in biofortification can potentially enhance the health benefits for those depending on these enhanced crops. Adopting biofortification as part of comprehensive agriculture policies enhances global food security and advances public health in response to emerging nutritional issues.

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ADVANCING AGRICULTURAL EFFICIENCY: THE *NAMO DRONE DIDI SCHEME*'S EFFECT ON EMPOWERING RURAL WOMEN THROUGH DRONE TECHNOLOGY

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Abstract
The *Namo Drone Didi scheme* marks a revolutionary advancement in India's agricultural sector. It ushered in a new era by blending advanced drone technology with traditional farming methods. This integration is chiefly achieved by empowering rural women with access to and training in drone technology. These initiatives are designed to greatly improve agricultural efficiency and precision in tasks such as fertilizer and pesticide spraying, thereby boosting overall productivity. As a result, the scheme plays a crucial role in spearheading a modern agricultural revolution focused on technological progress and empowering women in rural economies.

Keywords : Drone Technology, Government Scheme, Rural Development, Women Empowerment.

Introduction

India has transformed its food system from a highly deficient one in the 1950s to one that is self-reliant and surplus now. Feeding India's growing population may remain a major challenge in the future, because of the climate challenge affecting quality of natural resources such as land, water and air. While India grapples with such challenges, the agricultural sector is undergoing a transformative journey driven by technological advancements.

The other challenge is to enhance farmers' income and for this the adoption of improved agricultural technologies is the way forward. It has the potential to revolutionize farming, making it more efficient, profitable and sustainable. From farm mechanization that reduces costs and increases productivity to Artificial Intelligence (AI)-powered crop monitoring, data-driven decision-making and crop advisory services carry the potential in enhancing efficiency, sustainability of farming.

Agriculture serves as the backbone of the Indian economy, contributes approximately 15 % to the nation's annual Gross Domestic Product (GDP), serving as a primary source of livelihood for an estimated 60-70 % of its population. The Sector today finds itself entrapped in challenges that demand innovative solutions. The Sector is witnessing today a paradigm shift, transitioning into an era of technological innovation. In the forefront of this transformative wave is the advent of Drone technology, which is promising the country's soaring journey into the Future.

Drone technology is increasingly recognized for its transformative potential in Indian agriculture. Its applications range from precision farming to crop health monitoring, contributing significantly to the modernization and efficiency of the agricultural sector.

Importance of Women in Agriculture

Women play a crucial role in India's agricultural economy, contributing significantly to various aspects of agricultural production, processing and marketing. They constitute a substantial portion of the agricultural labour force, with estimates indicating that women account for about 60-80% of farm labour. Their participation spans a range of essential tasks including sowing, weeding, harvesting and post-harvest processing. This substantial involvement not only supports the agricultural workforce but also highlights the reliance of India's agricultural productivity on women's labour.

Increasingly, women are taking on leadership roles in rural cooperatives, Self-help groups (SHGs) and farmers' organizations. These positions empower them to participate in decision-making processes, influence agricultural policies and access credit and resources. Leadership roles also provide women with opportunities to advocate for their rights and needs, contributing to more inclusive and equitable agricultural development.

Empowering women in agriculture has broader economic and social benefits. It can lead to poverty reduction, improved health and education outcomes for families and overall rural development. Women's economic empowerment is closely linked to achieving Sustainable Development Goals (SDGs), as it contributes to economic growth, food security and social well-being. Addressing gender disparities and empowering women farmers is essential for achieving inclusive and sustainable agricultural development in India. By supporting women in agriculture, we can ensure a more equitable, productive and resilient agricultural sector that benefits all members of society.

Training women in drone technology for agriculture is crucial for empowering them, creating economic opportunities and enhancing agricultural efficiency. As key players in farming, women equipped with these skills can improve crop monitoring, resource use and overall productivity. Their involvement fosters innovation, community development and gender equality, contributing to sustainable development goals by improving food security, reducing poverty and promoting environmental sustainability. This approach led the Government to start an innovative initiative: *Namo Drone Didi Scheme*.

Emergence of the innovative initiative

The Indian Government has embarked on a transformative journey to reshape rural agriculture. It's introducing a pioneering drone distribution program aimed at Women Self-Help Groups (SHGs) in agriculture. This progressive initiative utilises the cutting-edge technology with traditional farming methods, fostering rural women's empowerment through modernized agricultural tactics and entrepreneurial opportunities.

Hon'ble Prime Minister in his 77th Independence Day address said "*We will train women in SHGs to fly drones and also repair drones. The Government of India will provide drones to thousands of Women Self Help Groups.*" Accordingly, a new Central Sector Scheme '**Namo Drone Didi'**, was conceptualized for providing drones to the women SHGs. The Union Cabinet approved the Scheme with an outlay of Rs. 1261 Crores for the period from 2024-25 to 2025-26 (Press Information Bureau, 2024).

On March 11, 2024, Prime Minister Narendra Modi launched the Namo Drone Didi Scheme as part of the *Sashakt Nari-Viksit Bharat* programme to empower women in rural areas and help them become financially independent.

During the launch, PM Narendra Modi gave drones to 1,000 *Namo Drone Didis* from different parts of the country. These women demonstrated their drone piloting skills from 10 different locations simultaneously.

The scheme aims to connect 15,000 Self-Help Groups (SHGs) and train women to become drone pilots. The drones will be used for agricultural tasks like monitoring crops, spraying fertilizers and sowing seeds. This initiative creates new income opportunities for women and aims to improve agricultural productivity by integrating modern technology (Times of India, 2024).

By utilizing drone technologies, women can engage in precision farming, which employs advanced technology to enhance agricultural production and productivity, utilizing high-tech sensors and analytical tools for better crop yields and decision-making. Drones equipped with sophisticated sensors and imaging capabilities play a crucial role in this paradigm shift. They provide real-time data and aerial insights that were previously inaccessible to farmers, facilitating tasks from soil analysis and crop monitoring to irrigation management and pest control. This technological advancement promises to revolutionize agriculture by enhancing productivity and sustainability.

Drones, armed with thermal sensors, contribute significantly to water management by assessing soil moisture levels. This capability enables precise irrigation, conserving water and ensuring optimal moisture for crops. Moreover, drones improve pesticide application through accurate spraying, reducing chemical usage and minimizing environmental impact. They also aid in monitoring crop health with high-resolution cameras and multispectral imaging, enabling early detection of diseases and nutrient deficiencies. This proactive approach helps farmers make informed decisions to safeguard crop health and maximize yields (Hindustan Times, 2024).

Prime Minister Narendra Modi highlighted drones as the future of farming, envisioning their widespread adoption to revolutionize agriculture. Drones are lauded for their speed in chemical application, versatility in farm operations and cost-effectiveness. Their potential extends beyond spraying chemicals; they can analyse terrain for weeds, assess moisture levels, detect pest infestations, recommend field planning, evaluate crop health and create nutrient maps. With their multifaceted capabilities, drones are poised to redefine modern agriculture, making farming more efficient, sustainable and productive.

Key strategies for implementing the Namo Drone Didi scheme include integrating resources from the Ministry of Agriculture, Rural Development and Department of Fertilizers. Selection criteria focus on identifying suitable rural clusters under Deendayal Antyodaya Yojana – National Rural Livelihoods Mission (DAY – NRLM), ensuring economic feasibility for drone deployment. Progressive women SHGs from these clusters are chosen to receive drones, with one member per SHG undergoing a 15-day training program. This includes 5 days of drone pilot training and 10 days covering agricultural applications such as nutrient and pesticide management. Financial assistance and loans are provided to SHGs for drone purchase. Lead Fertilizer Companies (LFCs) facilitate procurement and maintenance through agreements with drone suppliers, promoting Nano Fertilizers for enhanced agricultural efficiency (YouTube, 2024).

Constraints

Despite the promising future ahead, the integration of drones into Indian agriculture faces several challenges. These include regulatory obstacles, ensuring affordability of technology and the necessity for trained personnel to operate drones effectively. These challenges are acknowledged as significant hurdles on the path to progress. However, both the Indian Government and private stakeholders are actively addressing these issues. They are implementing initiatives aimed at providing training, subsidies and supportive policies to create an environment conducive to drone-friendly farming practices. These efforts are gradually overcoming barriers and paving the way for the adoption of drone technology in agriculture.

Conclusion

The Indian Government's initiative to implement drone technology in agriculture strategically aims to empower rural areas with advanced tools, aiming to achieve economic and gender equality objectives. While currently impacting only some Self-Help Groups (SHGs), the program provides substantial financial assistance, efficiency enhancements and labour-saving advantages, setting a promising precedent for broader application. Moving forward, the adaptability and efficiency of drone technology are expected to encourage more farmers to adopt these modern farming techniques. This initiative represents more than just the adoption of technology—it signifies a major advancement towards sustainable, empowered and efficient farming practices throughout rural India.

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IMPORTANCE OF DIETARY DIVERSITY TO COMBAT MALNUTRITION

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Abstract
Child malnutrition is a severe global concern, leading to 2.6 million deaths each year and highlighting socio-economic inequalities. Although there has been some improvement, stunting remains widespread, particularly in developing nations like India, where 40.4% of children are underweight and 44.9% are stunted. Protein-energy malnutrition and iron deficiency are major health issues. Preschool children are especially at risk due to their high nutritional needs and vulnerability to illnesses. Balanced diets with diverse food groups are essential to prevent nutrient deficiencies. Poor populations often lack dietary variety, relying on nutrient-deficient starchy staples. Enhancing access to safe water and sanitation can improve health outcomes. Regular monitoring of child growth and nutrition is vital for public health strategies, especially in areas like Punjab, India.

Children and their wellbeing is the basic concern of every nation. Their health is not only an indicator of socio-economic status and standard of living of the country but also reflects the values and beliefs of society

Malnutrition is an underlying cause of death of 2.6 million children each year, one-third of the global total of children's deaths. Global progress on stunting has been extremely slow. The proportion of children who are stunted fell from 40% in 1990 to 27 percent in 2010, an average of just 0.6 percentage points per year. Seven countries are projected to see an increase in number of stunted children by 2015. According to National Family Health Survey (2005-06), 40.4% of Indian children are underweight (low weight for age) and 44.9 % of Indian children are stunted (low height for age) and 22.9 % of Indian children are wasted (low weight for height).

Protein energy malnutrition and iron deficiency anaemia are major public health problems in developing countries. The problem of malnutrition holds extraordinary significance because child nutrition is not only responsible for 22 % of India's disease burden and for 50% of the 2.3 million child deaths in India, but is also a serious economic hazard. According to National Family Health Survey (NFHS III 2007), 46% Indian children suffer from malnutrition and the level of malnutrition in Punjab vary from 27-33 %.

Preschool children are the most vulnerable group and they need to be given special attention as preschool child is an easy victim of malnutrition. Secondly, the nutrition of this segment population is paramount importance since the foundation for life time health, strength and intellectual capacity is laid during this period. Much of the burden of deaths resulting from malnutrition, estimated to be over half of childhood deaths in developing countries, can be attributed to mild or moderate malnutrition. Several biological and social economic factors contribute to malnutrition.

Children are particularly vulnerable to micro-nutrient deficiencies owing to their high nutrient requirements for growth and susceptibility to infectious diseases such as diarrhoea and respiratory infections, which can inhibit nutrient absorption and decrease appetite. The nutrient density of the diet given to young children is often insufficient to meet their nutrient requirements and increasing the diversity of foods provided to young children particularly meat, poultry, fish, eggs, fruits and vegetables is recommended to improve micro-nutrient intakes.

Balanced diets are not accessible to a large proportion of the world's population, particularly those who live in developing countries. Indeed, most of populations in these regions subsist on stable plant-based diets that often lack diversity with insufficient quantity consumed, thus results in nutritional deficiencies.

Dietary diversity has long been recognized by nutritionists as a key element of high-quality diets. Increasing the variety of foods across and within food groups is recommended by most dietary guidelines, in the United States (U.S. Department of Agriculture Human Nutrition Information Services (1992) as well as internationally (WHO/FAO 1996), because it is thought to ensure adequate intake of essential nutrients and thus to promote good health. Additionally, with the increased risks of chronic diseases, dietary recommendation promote increased dietary diversity along with reducing intake of selected nutrients such as fat, refined sugars, and salt. To make a good combination of various foods and 'eat well-balanced meals' is the key to dietary diversity.

Some studies have specifically addressed the association between dietary diversity and household socio economic characteristics. In the southern Andes, dietary diversity was found to be higher in urban as compared to rural areas Within urban areas, poorer households also consumed less diverse diets compared to wealthier households and the differences were mainly due to their significantly lower intake of meals containing meat, dairy products and vegetables. Ferguson and colleagues also made reference to differences in dietary diversity between households from different socio-economic status in their study among preschool Ghanian and Malawian children.

The rationale for emphasizing dietary diversity in developing countries stems from a concern related to nutrient deficiency and the recognition of the importance of increasing food and food group variety to ensure nutrient adequacy. Lack of dietary diversity is a particularly severe problem among poor population in the developing world, because their diets are predominantly based on starchy staples and often include little or no animal products and few fresh fruits and vegetables. These plant-based diets tend to be low in a number of the micronutrients and the micronutrients they contain are often in a form that is not easily absorbed. Although other aspects of dietary quality, such as high intake of fat, salt, and refined sugar have not typically been a concern in developing countries, recent shifts in global dietary and activity pattern resulting from increases in income and urbanization are making these problems increasingly for countries in transition as well.

The safety and accessibility to water are major concerns throughout the world. Health risks may arise from consumption of water contaminated with infectious agents, toxic chemicals and radiological hazards. Improved access to safe drinking water can result in tangible improvements to health. Lack of access to safe water and adequate sanitation put children at high risk of not living beyond his/her fifth birthday, but those who survive serious illness (due to water related

diseases) often do not reach their full physical, intellectual and social potential due to the effects of poor health care and nutrition.

In any community, under five children are one of the most vulnerable groups for nutritional deficiencies owing to many factors ranging from low birth weight to maternal ill health to socio-economic and environmental factors. It must be stated that although the words under nutrition and malnutrition are being used interchangeably, malnutrition is a broader term that includes under nutrition and over nutrition. For grading the degrees of under nutrition, weight for age classification (Gomez and IAP) are the most commonly used. Height for age and weight for height classification (Mclaren and Waterlow) have been used less frequently. The current WHO recommendation is to use the Z score or SD system to grade undernutrition. This system allows to measure all the three indices and express the results in terms of Z sores or SD units from the median of the International reference population.

Malnutrition and impaired growth are closely related. A majority of malnourished children fail to achieve their full genetic potential in bodily dimensions and may develop stunting and wasting, besides other deficiency disorders. It was estimated that in the year 2000, 182 million preschool children, or one third of children less than 5 years old in developing countries were stunted, reflecting long term cumulative inadequacy of health and /or nutrition Approximately 27% were estimated to be underweight. The status of growth of children is considered as an index of the health and wellbeing of community. Therefore, regular monitoring of child growth and nutritional profile is now one of the major concerns for the public health policy makers and planner of country. Punjab is one of the most prosperous states of India with one of the highest per capita income.

The approach of evaluating total diet quality is receiving increasing attention. This could add value to food and nutrition monitoring systems in developing countries, where energy intake or energy availability alone is often used to asses food security. Therefore, planning a study to determine the relationship of dietary diversity with child growth and nutritional adequacy among rural Punjabi preschool children is imperative to determine accurately the malnutrition among this group as this will provide valuable information to the policy makers for formulating the child health programmes.

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ESTABLISHMENT AND PROMOTION OF FISH FERTILITY CLINICS IN INDIA FOR SUSTAINABLE SEED PRODUCTION

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Introduction

Cultured teleost fishes including freshwater, brackish water and seawater exhibit different types of reproductive problems due to absence of natural breeding conditions as that of wild environment. Presently, the cultured female fish exhibit following problems: delay in the onset of first maturity (pubertal onset), meiotic failure in developing oocyte, delay and failure in completion of vitellogenesis, completion of final oocyte maturation and failure to undergo spontaneous spawning in captivity. In males, delay in the differentiation and transformation of spermatogonia to spermatocyte, failure to undergo spermiation and delay in the mating process when the female is ready to undergo spawning. In all the above problems, commercially available synthetic hormones and natural preparations can be administered to fish to override these problems. Depending on the type of reproductive problem, hormones need to be selected and administered to fish. A major drawback with the use of synthetic hormones is the non-availability of these reproductive hormones on all the places of fish seed production, excepting human chorionic gonadotropin (HCG) which is available in all pharmaceutical shops of India. In light of this background, there is a great need to establish and promote fish fertility clinics in different major fish seed production centres of country.

Components of Fish Fertility Clinics

A. Screening lab to identify the type of reproductive problem

This lab will be supported with basic equipments like refrigerator (for storing oocyte clearing solution and other necessary chemicals), gonadal histological analysis (microtome, slide staining system, digital microscope with photography), catheter tubes and syringes and fish holding tanks placed nearby this lab. In the long run, this lab can be upgraded for gene expression analysis to identify the expression level of reproductive genes like gnrh, fshβ, lhβ which will help to identify the exact site of reproductive dysfunction at tissue level. These labs can be accredited with NABL status for wide range of uses.

B. Laboratory for storage of commercially available synthetic hormones

This lab will be having the facilities for storing different classes of hormones: Brain GnRH based analogues (Ovaprim, Ovatide, Gonopro FH, WOVA-FH); Pituitary Gonadotropin based analogues (mammalian pituitary extract, human chorionic gonadotropin, crude and semi-purified fish pituitary extract); sex steroids (Testostetone, 11 ketotestosterone, estradiol-17 beta, MIH - 17α, 20β P, 20-β S); novel inducing agents (kisspeptins, neurokinin B and dynorphin). Based on the request from fish farmers, these products will be supplied to fish farmers on Govt. fixed price.

C. Laboratory for development of cheaper and novel hormones

This laboratory will be working on development of cheaper hormones for fish farmers like use of ready to use pituitary extract (freeze dried form), screening of chicken GnRH-II hormones from chicken brain and extraction and purification of kisspeptin hormone from pregnant women urine. Also, based on emerging publications, novel inducing agents will be evaluated in cultured finfish.

D. Administrative Office

This office will be maintaining the bills and receipts of different components of fish fertility clinics. Also, the data of pituitary gland collection and storage will be maintained here.

In conclusion, the concept of fish fertility clinic is a novel concept in aquaculture and need to be promoted in India for sustainable seed production. Also, due to recent climate change and its impact on fish seed production particularly an increase in water temperature has resulted in different type of reproductive problems including delay in sexual differentiation and biased sex ratio which need to addressed through proper analysis of the gonadal tissues. Also, pituitary gland banks need to be established in major fish seed production states of the country (Selvaraj et al., 2024).

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OPTIMIZING REPRODUCTION IN *Litopenaeus vannamei* : THE PRACTICE AND ETHICS OF EYESTALK ABLATION IN SHRIMP FARMING

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Introduction

The shrimp farming sector has faced a tremendous change with the introduction of exotic white leg shrimp (*Litopenaeus vannamei*), which has become a foundation in global aquaculture. Since 2001-02, many Southeast Asian countries, including Thailand, Vietnam, and Indonesia, transitioned to culturing *L. vannamei* due to the availability of Specific Pathogen Free (SPF) and Specific Pathogen Resistant (SPR) broodstock. This has resulted in increased production and stability in the industry. In India, the pre-production operation of introduction of *L. vannamei* began in 2003. Followed by a risk analysis study, large scale operation for the introduction was permitted in 2009. Commercial farming of the shrimp started in 2009-10 and quickly turned out to become the largest cultured shrimp in terms of production and productivity. Andhra Pradesh leads in culture area and production, followed by Tamil Nadu and Gujarat. *L. vannamei* is ideal for semi-intensive culture due to its availability of pathogen free seed. Key considerations for its successful cultivation include maintaining biosecurity and water quality through constant monitoring. Additionally, achieving sustainable production requires advanced technical knowledge, making *L. vannamei* a crucial species in the global shrimp farming industry.

The practice of eyestalk ablation in shrimp farming for *L. vannamei,* was first introduced in the mid 20th century. The exact date of the first implementation *for L. vannamei* has not been precisely documented, but the technique itself has been a standard in aquaculture since the 1960s and 1970s. As the commercial farming of *L. vannamei* gained popularity in the early 2000s, eyestalk ablation became a crucial method for optimizing production and meeting the increasing global demand for shrimp. It has been taken up and used practice in shrimp farming, particularly for inducing reproductive maturation in females of *L. vannamei*. This procedure involves the removal or destruction of one or both eyestalks, which contain the X-organ sinus gland complex responsible for producing hormones that inhibit reproduction. By reducing or eliminating these hormones, eyestalk ablation significantly increases the reproductive capacity of female shrimp, leading to higher egg production and more frequent spawning.

Why so much significance…?

This procedure disrupts the balance of hormones, particularly inhibiting the production of the hormone responsible for molting (ecdysis), which triggers the female shrimp to molt into a reproductive state known as gravid. This state is characterized by the development of ovaries and the release of eggs. The importance of eyestalk ablation lies in its ability to synchronize and control the reproductive cycle of the female shrimp, particularly in captivity. By inducing maturation and egg release, it enables farmers to optimize the spawning schedules, increase production efficiency. Also, eyestalk ablation can enhance the quality of harvested shrimp by

promoting uniform size and reducing the risk of reproductive disorders such as ovarian degeneration. Despite its effectiveness, there are ethical concerns surrounding this practice, leading to ongoing research into alternative methods for inducing maturation in shrimp without the need for surgical intervention.

How is it done…?

Eyestalk ablation techniques encompass various methods, each with its variation and considerations. One of the commonly employed approaches involves gently pinching the eyestalk. This action, although effective, may leave an open wound. Another technique, Enucleation, involves a more complex process. It begins by slitting one of the eyes with a razor blade and then carefully crushing the eyestalk with the thumb and index finger. Making sure all the contents of the eyes are entirely removed. Here, the transparent exoskeleton is left intact, facilitating faster clotting of hemolymph and wound closure. Next method is the cauterization. This method employs the use of an electrocautery device or a red-hot wire to cauterize through the eyestalk. When executed accurately, it effectively seals the wound, promoting the formation of scar tissue. A variation of this technique involves initially severing the eyestalk with scissors or a sharp blade before proceeding with cauterization. Finally, ligation which offers a straight forward yet effective method for eyestalk ablation. It is done by tightly tying off the eyestalk with surgical or other thread, ensuring immediate closure of the wound.

What are the effects on the shrimp…?

Eyestalk ablation in female shrimps induces both direct and indirect effects on their reproductive physiology. Directly, it enhances total egg production by triggering more frequent spawning, although it does not necessarily result in larger spawns. Additionally, the procedure shortens the duration of the molt cycle and often leads to noticeable changes in ovarian coloration specific to *L. vannamei*. However, alongside these direct impacts, there are several indirect consequences. Eyestalk ablation significantly escalates the mortality rate of female *L. vannamei* shrimps, sometimes tripling the usual rate. Moreover, it deteriorates the overall condition of the females, potentially compromising their health and well-being. There is also evidence suggesting that eyestalk ablation may lower the hatch rates of eggs in some instances for *L. vannamei*. This procedure places increased energetic demands on the female shrimp, potentially affecting their overall metabolic balance. Over time, repeated eyestalk ablation can lead to a gradual loss in the quality of the produced eggs specific to *L. vannamei*. Furthermore, the offspring resulting from eyestalk-ablated female *L. vannamei* may exhibit heightened susceptibility to diseases such as White Spot Syndrome Virus (WSSV).

One or Two…?

Eyestalk ablation can be performed in two distinct types: Unilateral and Bilateral

Unilateral ablation involves the removal of one eye, allowing the animal to retain vision in the remaining eye. Conversely, bilateral ablation entails the removal of both eyes along with their stalks. Unilateral ablation, allows the animal to maintain vision in the remaining eye. Conversely, bilateral ablation, where both eyes and their stalks are removed, poses a risk to the shrimp's life at times. It has also been noted that the preferred method is unilateral as it does not compromise the health or vision of the shrimp.

In a recent study on *L. vannamei*, researchers investigated the effects of unilateral and bilateral eyestalk ablation on various physiological and metabolic processes. The results showed that eyestalk-ablated shrimp had significantly shorter molting cycles compared to those that were not ablated: 10 days for bilateral ablation, 17 days for unilateral ablation, and 24 days for untreated shrimp. Additionally, mortality rates were significantly higher in both unilaterally (35%) and bilaterally (68%) ablated shrimp compared to untreated shrimp (2%). This increased mortality may be due to impairments in physiological functions mediated by eyestalk hormones and direct nervous system injury. Males and females responded differently to eyestalk ablation in terms of hemolymph glucose, triglycerides, and protein concentrations. Glucose and lactate levels were lower in bilaterally ablated shrimp, which aligns with the role of crustacean hyperglycemic hormone in glucose metabolism. While cholesterol and hemocyte counts did not significantly differ among the treatments, prophenoloxidase and phenoloxidase activities were significantly lower in bilaterally ablated shrimp. This suggests a possible endocrine control of the immune response mechanism or reflects the physiological trauma caused by bilateral eyestalk ablation in this species.

Isn't it cruel …?

The potential ban of eyestalk ablation in shrimp maturation is a topic of ongoing debate and study. While there are ethical concerns surrounding the practice, particularly regarding animal welfare, its widespread use in the shrimp farming industry suggests that a ban may not be happen soon. However, there is growing pressure from consumer advocacy groups, animal rights organizations, and regulatory bodies to explore alternative methods for inducing maturation in shrimp. Efforts are underway to develop alternative approaches such as dietary manipulation, environmental cues, since the reproductive process is influenced by various environmental factors such as temperature, photoperiod, salinity, and water quality. Manipulating water temperature and photoperiod to simulate seasonal changes can trigger reproductive behaviors in shrimp and hormonal treatments that could achieve similar outcomes without the need for surgical intervention. Additionally, advancements in breeding techniques and genetic selection may offer ways to produce shrimp that mature naturally and without the need for eyestalk ablation. Selective breeding programs aim to develop shrimp strains that exhibit desirable traits. By breeding individuals with favorable genetic traits and possibly to produce shrimp that naturally mature at a younger age, high fecundity and with increased reproductive efficiency.

Conclusion

In the present scenario, most shrimp hatcheries in India practice eyestalk ablation to induce maturation in captivity. However, there is a great scope for developing an indigenous genetic line of shrimp broodstock that would not require eyestalk ablation to induce maturation in captivity. Though published literatures indicate that research in this direction has already been initiated in global shrimp producing countries and success has been achieved to some extent. Further research in this direction is highly warranted as most of the SPF *L. vannamei* broodstock used in Indian shrimp hatcheries are culled after six months after its usage for seed production. Also, if this method is successfully developed in shrimp industry, similar method can be applied for mudcrab seed production in India which is being promoted in different state of India.

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FUTURE PROSPECTS OF HORTICULTURE AND AGROFORESTRY IN INDIA'S AGRICULTURE

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Abstract
India's agriculture faces challenges like fragmented landholdings, water scarcity, and low productivity. Horticulture (fruits, vegetables, flowers, medicinal plants) and agroforestry (integrating trees on farms) offer promising solutions. These practices can diversify farm income, improve nutrition, and promote environmental sustainability. The horticulture sector is experiencing a surge driven by changing consumer preferences and technological advancements like precision agriculture and protected cultivation. The Indian government supports these practices through initiatives like MIDH and the National Agroforestry Policy. However, scaling up faces challenges like limited access to water, credit, and markets, along with knowledge gaps. Innovative solutions include community-based approaches, public-private partnerships, and farmer producer organizations (FPOs). Success stories showcase the positive impact on water use efficiency, farm incomes, and rural economies. Continued research and development are crucial in areas like climate-resilient crops, organic farming, and post-harvest management. Integrating these practices into national policy, investing in R&D and infrastructure, and facilitating market linkages are key for sustainable growth. Horticulture and agroforestry hold immense potential for revitalizing Indian agriculture, leading to greater food security, enhanced farm incomes, and environmental sustainability.

Keywords : Horticulture, Agroforestry, Sustainability, Organic Farming, Farmer Producer Organizations (FPOs)

Introduction

India's agricultural sector, a cornerstone of the nation's economy, faces significant hurdles. Fragmented landholdings, where farms are divided into smaller and smaller plots, make large-scale production difficult. Water scarcity, a growing concern due to climate change and population pressures, threatens crop yields. Additionally, dependence on traditional practices often leads to lower productivity, hindering the ability to meet the rising food demands of a burgeoning population.

Horticulture and Agroforestry:

Horticulture, encompassing the cultivation of fruits, vegetables, flowers, and medicinal plants, and agroforestry, the integration of trees on farms alongside crops and livestock, offer promising solutions to these challenges. By promoting diversification of farm income, these practices can create a buffer against volatile market fluctuations in staple crops. A wider range of produce improves nutritional security for both farmers and consumers. Additionally, horticulture and agroforestry contribute to environmental sustainability by promoting soil health, carbon sequestration, and biodiversity.

Growth and Trend:
The Indian horticulture sector is experiencing a surge, driven by changing consumer preferences. Organic produce, perceived as healthier and more sustainable, is gaining traction. Functional foods, enriched with additional health benefits, and convenient pre-cut or packaged options are also in high demand. Contract farming models are emerging as a vital link between producers and markets, offering farmers better access, pricing, and technical guidance.

Technological advancements are transforming horticulture and agroforestry practices. Precision agriculture utilizes tools like soil moisture sensors and variable rate technology (VRT) for fertilizer application. This allows for targeted resource use, reducing waste and optimizing yields. Biotechnology plays a crucial role in developing disease-resistant and climate-resilient varieties of horticultural crops and trees used in agroforestry. Additionally, protected cultivation technologies like greenhouses and net houses are gaining traction in various regions, significantly enhancing productivity by providing controlled environments for crops.

Government Initiatives:
The Indian government recognizes the potential of these practices and has implemented key initiatives to support their development. The Mission for Integrated Development of Horticulture (MIDH) and the National Agroforestry Policy aim to expand cultivated areas, improve infrastructure, and connect producers with markets. While these policies have shown success in specific regions, streamlining application processes and ensuring wider outreach remain crucial for maximizing their impact. International collaboration with research institutions and successful models from other countries can provide access to advanced technologies, best practices, and valuable insights for Indian policymakers and farmers.

Challenges to Scaling Up:
Despite the immense potential, scaling up horticulture and agroforestry in India faces several challenges. Fragmented landholdings, particularly acute in some regions, make it difficult for farmers to adopt new practices that require larger land areas. Limited access to water resources and credit facilities further restricts the expansion of these practices.

Market access remains a hurdle for many producers, especially those located in remote areas. Lack of proper infrastructure and connectivity limits their ability to reach wider markets and secure fair prices for their produce. Additionally, knowledge and skill gaps among farmers regarding advanced technologies and sustainable practices pose another challenge. Strengthening extension services and providing training programs on topics like precision agriculture, organic farming, and post-harvest management are essential for overcoming this obstacle.

Innovative Solutions:
Fortunately, innovative solutions and best practices are emerging to address these challenges. Community-based approaches, where farmers work together to share resources, knowledge, and negotiate better deals with buyers, can be highly effective. Public-private partnerships leverage private sector expertise and resources to improve infrastructure development, market access, and technology adoption. Building capacity through training programs and extension services equips farmers with the knowledge and skills necessary for successful implementation of horticulture and agroforestry practices. Establishing farmer producer organizations (FPOs) empowers farmers to collectively negotiate better prices, manage logistics, and access credit facilities.

Success Stories:

Highlighting success stories from different regions of India showcases the diverse applications and impact of horticulture and agroforestry. In the arid regions of Maharashtra, farmers have successfully adopted drip irrigation and shade net cultivation for high-value fruit crops like grapes and pomegranates. This approach has resulted in increased water use efficiency, improved fruit quality, and higher incomes for farmers. Himachal Pradesh's success story of apple cultivation demonstrates the potential of horticulture for transforming rural economies. Establishment of cold storage facilities and marketing infrastructure has played a crucial role in connecting farmers with national and international markets. Kerala's spice plantations exemplify a thriving agroforestry model. Integrating pepper vines with coconut trees and other perennial crops provides a sustainable source of income for farmers while maintaining a healthy ecosystem. These are just a few examples, and successful models exist across the country. By analyzing and learning from these case studies, stakeholders can identify best practices and replicate them in suitable regions, promoting wider adoption of horticulture and agroforestry.

Future Research and Development Needs:

Continued research and development (R&D) are essential. Research efforts should focus on developing climate-resilient crops and drought-resistant tree species suitable for different regions. Exploring organic farming practices and cost-effective certification processes are crucial for meeting the growing demand for organic produce. Advancements in post-harvest management technologies and collaborative research efforts between government, universities, and private companies can accelerate development and dissemination of new technologies and sustainable practices.

Strategic Recommendations for Sustainable Growth:

For horticulture and agroforestry to flourish, a multi-pronged strategic approach is necessary. Integrating these practices into the national agricultural policy framework will ensure their long-term sustainability. Increased investment in R&D, infrastructure development, and awareness campaigns are crucial. Facilitating market linkages, value chain development through processing units, and FPOs can ensure better market access, fair prices, and reduced post-harvest losses.

Conclusion

Horticulture and agroforestry offer immense potential for revitalizing Indian agriculture. By promoting these practices, India can achieve greater food security, enhance farm incomes, and contribute to environmental sustainability. Embracing innovative technologies, establishing robust policy frameworks, and fostering collaboration between various stakeholders are key to realizing this potential. By harnessing the combined strengths of horticulture and agroforestry, India can chart a course for a more vibrant and resilient agricultural sector.

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IMPORTANCE OF AWARENESS AMONG LIVESTOCK FARMERS FOR THE SUCCESS OF A VACCINATION PROGRAM

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India is a developing country where 70% of households depend on agriculture for their livelihood. Livestock contributes about 16% to the income of small households as a means of food (milk and meat), manure, draft, revenue generation, etc. Animal heath should be considered as a prime factor to achieve optimum production and value. Most often, the animal diseases like Foot and Mouth disease (FMD), Hemorrhagic septicemia (HS), and Peste-des-petits ruminants (PPR) cause drastic effects in animal health and simultaneously in the income of farmers. Therefore, to maintain the farmers and country's economic growth in the livestock sector, contributions of the research fraternity, veterinarians, para-veterinarians, extension workers, and most importantly, farmers are equally significant.

Field veterinarians and para-veterinarians play an important role in disease diagnosis, surveillance, and vaccination programs. The role of extension workers is to educate the farmers about the effect of diseases on animal health, upgradation of management practices, maintain good public relations and gain trust of farmers. Other important member are veterinary scientists who analyze the disease prevalence data, identify the circulating strains of pathogens, predict the outbreaks, and most importantly design management strategies, and develop diagnostics and vaccines. These three components of the veterinary fraternity cannot completely execute the disease control program in a country without the active contribution of livestock farmers.

Most of the small and marginal farmers do not have any formal education and they work with ancient knowledge of farming and animal rearing. They lack awareness and acceptability of updated methods of agricultural farming and livestock rearing (Girma et al., 2022). India is a major agricultural producer and the ancient practices need to be updated to meet the demand of the changing world for the nation's growth. The farmer is the ground-level person, who has to be aware to recognize the changes in animal health, understand the concept of different diseases, and report the diseases in time. Updating the knowledge of livestock farmers, and their attitude towards changing their livestock management practices according to the need of the hour is crucial for implementing an effective disease control program. The understanding of livestock farmers towards the application of vaccines and their acceptance towards scientific management strategies are important components of disease control (Robi et al., 2023). But there are several issues exist at the level of farmers that leads to the failure of effective control of diseases.

- The animals of small-scale livestock farmers are at higher risk of infection due to close proximity between their animals and households, use of common pasture lands and water resources, limited access to vaccinations, and absence of biosecurity measures (Hopker et al., 2021). Due to these factors, the herd immunity of a geographical region is

compromised and therefore the farmers need to be aware of role of management practices and vaccines for prevention of diseases.

- Due to very limited access to education or awareness, the farmers do not accept injecting or immunising a healthy animal. Experience of vaccine failure, improper handling of the animal (in a few cases), and difficulty in presenting animals to vaccination camps, the farmers are hesitant to vaccinate their animals. Therefore, veterinarians and para-veterinarians need to be professionally very sound to handle animals, share information about the importance of the vaccine, vaccinate and gain the trust of farmers.
- Based on surveys, it has been also found that farmers prefer antibiotics over the vaccination for their diseased animals. Therefore, to make farmers understand the role of antibiotics and vaccination has to be an important component of veterinary extension services (Kalam et al., 2022).
- The concept of different types of animal diseases is also difficult to comprehend for many farmers, therefore making them understand it and diminishing the notion that a single type of vaccine can protect animals from all diseases is another important component of the extension trainings (Girma et al., 2022). This would create an acceptance among livestock farmers that multiple vaccines are required to protect their animals from different diseases. And timely follow-up of their livestock vaccination can raise their income and food security significantly. Country-wise the vaccines and vaccination schedule based on the prevalence of animal diseases should be circulated (as pamphlets) with basic information among the livestock farmers as well. For example, in India the most common vaccines recommended are:

Table: List of commonly used vaccines in cattle, buffalo and goats in India and its schedule

S. No.	Vaccine		Manufacturer	Age	Booster dose
Cattle and Buffalo					
1.	Raksha (FMD)		Indian Immunologicals	3 months and above	2-4 weeks after primary vaccination Every6 months after booster and 4 months in endemic areas
2.	Raksha HS		Indian Immunologicals	6 months and above	Annually, 15 days before rainy season
3.	Bruvax (Brucella)		Indian Immunologicals	4-8 months	Only once
4.	Raksha-Anthrax		Indian Immunologicals	6 months and above	One month before grazing season

S. No.	Vaccine		Manufacturer	Age	Booster dose
Goats					
1.	Raksha PPR PPRV/Sungri/96		Indian Immunologicals IVRI and Hester Biosciences	3 month of age	After 3 years
2.	Raksha ovac Futvac		Indian Immunologicals Brilliant Biopharma	3 month of age	3-4 weeks after 1st injection and repeated after every 6 month
3.	Raksha HS BioHS oil		Indian Immunologicals Biovet	3 month of age	3-4 weeks after primary vaccination and repeated annually
4.	RakshaBlu Bio BT oil		3 month of age Biovet	3 month of age	After 1 month of primary vaccination and repeat annually
5.	GTPV vaccine Goatpox vaccine Live I.P.		IVRI, Mukteswar Hester Bioscience	3 month of age	3-4 weeks after primary vaccination and repeated annually

- Another important factor is that male respondents have a better understanding and positive attitude towards the use of vaccines compared to females. This could be due to differences in educational opportunities in developing countries like India, cultural beliefs, or variations in exposure campaigns conducted in villages (Grace et al., 2008). Therefore, more female engagements are needed in extension programs lead by female veterinarians to enhance acceptance as they are the primary handler of livestock in many parts of the country.
- Introducing the upgradation of managemental practices is another factor to ensure the prevention of disease and success of the disease control program (Ritters et al., 2017). Along with extension workers, veterinary students can also be involved with proper guidance. This strategy would help in utilizing more manpower for campaigns and training on livestock diseases and vaccination. Simultaneously, it will benefit the veterinary students to learn the extension activities from the very beginning and strengthen their knowledge of communication with farmers and field approach. Farmers have to understand the managemental strategies are not only to prevent disease transmission but also to protect them from zoonotic pathogens.

These factors indicate how important the awareness, understanding, and involvement of livestock farmers is in managing a disease, especially the small-scale farmers. Socio-demographic and socio-economic factor plays a major role in the differences in knowledge among farmers and education

plays an important role in the acceptance of new livestock management practices. The primary function of veterinarians or extension workers is to interact with the farmer, gain their trust at regular intervals of periods, and improve the acceptance of veterinary vaccines. The farmers need to be aware of the importance of vaccination and its impact on animal health and subsequently on their economic status.

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INNOVATIONS IN SOIL HEALTH MANAGEMENT FOR INCREASED CROP PRODUCTIVITY

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Introduction

Soil health is the cornerstone of sustainable agriculture, and its significance in achieving increased crop productivity cannot be overemphasized. Over the years, agricultural practices have evolved, giving rise to innovative approaches in soil health management. These techniques harness cutting-edge technology and sustainable practices to enhance soil fertility, structure, and nutrient content. In this article, we will delve into the distinct innovations that are revolutionizing modern agriculture.

1. Precision Agriculture Techniques

- **Utilization of Advanced Technology**: Precision agriculture leverages technologies like GPS, drones, and soil sensors to collect precise data on soil attributes such as nutrient levels, moisture content, and pH.
- **Customized Management Plans**: This data aids in creating tailored management plans, enabling farmers to apply fertilizers, irrigation, and other inputs precisely where they are needed, optimizing resource use and minimizing waste.
- **Enhanced Nutrient Uptake**: By ensuring that plants receive the right nutrients at the right time, precision agriculture improves nutrient absorption, contributing to better soil health and increased crop yields.

2. Conservation Tillage and No-Till Farming

- **Reduced Soil Disturbance**: Unlike conventional tillage methods, conservation tillage and no-till farming minimize soil disturbance, preserving its structure and preventing erosion.
- **Crop Residue Retention**: Leaving crop residues on the field acts as a natural cover, shielding the soil from erosion, retaining moisture, and fostering the growth of beneficial microorganisms.

- **Improved Organic Matter Content**: By preserving organic matter, these practices enrich the soil, promoting nutrient availability and overall soil health.

3. Cover Cropping

- **Multifaceted Benefits**: Cover crops, planted during off-seasons or alongside cash crops, serve as a versatile tool in soil health management.
- **Erosion Prevention**: Cover crops prevent soil erosion by anchoring it with their roots and providing a protective cover against wind and water.
- **Weed Suppression and Nutrient Fixation**: They suppress weed growth, reducing the need for herbicides, and some varieties, like leguminous cover crops, fix nitrogen, reducing reliance on synthetic fertilizers.

4. Organic Matter Management

- **Composting**: This involves the controlled decomposition of organic materials, creating nutrient-rich compost that enhances soil fertility and structure.
- **Green Manuring**: Specific crops are grown and then incorporated into the soil, increasing organic matter content and providing additional nutrients.
- **Mulching**: Covering the soil with organic or synthetic materials retains moisture, moderates temperature, suppresses weeds, and contributes to organic matter content.

5. Biological Soil Amendments

- **Beneficial Microorganisms**: Incorporating beneficial microorganisms like mycorrhizal fungi and rhizobia bacteria establishes symbiotic relationships with plants.

- **Enhanced Nutrient Uptake**: These microorganisms enhance nutrient absorption, particularly phosphorus and nitrogen, supporting robust plant growth.
- **Disease Suppression and Nutrient Cycling**: They contribute to a balanced soil microbial community, which aids in disease control and efficient nutrient cycling.

Conclusion

Innovations in soil health management represent a pivotal shift in modern agriculture. By implementing these practices, farmers are not only boosting crop productivity but also ensuring the long-term sustainability of their operations. The combination of precision techniques, conservation practices, cover cropping, organic matter management, and biological amendments leads to resilient, fertile soils that support healthy plant growth. As these innovations continue to evolve, the potential for even greater advancements in soil health management is on the horizon, promising even more bountiful harvests and a healthier planet for future generations.

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UTILIZING NANOPARTICLES FOR THE MANAGEMENT OF PLANT DISEASES

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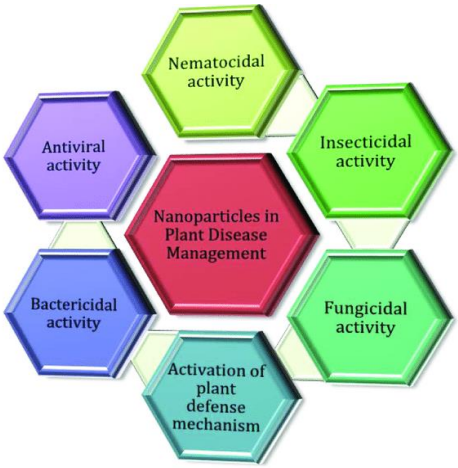
Abstract

Plant diseases represent a substantial threat to global agriculture, leading to significant crop losses and economic impacts. Traditional disease management methods, primarily reliant on chemical pesticides, have drawn criticism for their environmental and health hazards. Recent advancements in nanotechnology offer novel approaches to plant disease management, utilizing the unique properties of nanoparticles (NPs) for enhanced efficacy and reduced environmental impact. This article explores the various types of nanoparticles, such as silver, copper, silica, and zinc oxide, and their mechanisms of action in controlling plant pathogens. It also highlights the benefits of NPs, including increased efficacy, reduced chemical usage, sustained release of active agents, and environmental safety. Case studies demonstrate the practical applications of NPs in managing plant diseases in crops like tomatoes, grapevines, and rice. Despite the promising potential, challenges such as toxicity concerns, regulatory hurdles, and cost considerations remain. Future research directions focus on optimizing NP formulations, understanding their interactions with plant systems, and ensuring their safe and sustainable use in agriculture. The integration of nanotechnology with traditional and biological methods could revolutionize plant disease management, contributing to global food security.

Introduction

Plant diseases present a major challenge to agriculture worldwide, causing significant losses in crop yield and quality. Traditional methods for managing these diseases, such as the use of chemical pesticides, have raised environmental and health concerns due to their toxicity and persistence in the ecosystem. In recent years, advancements in nanotechnology have offered innovative solutions for plant disease management, leveraging the unique properties of nanoparticles (NPs) to enhance disease control while minimizing negative impacts.



Types of Nanoparticles Used in Plant Disease Management

1. Metallic Nanoparticles

Silver Nanoparticles (AgNPs): Silver nanoparticles are renowned for their potent antimicrobial properties. They have been extensively studied and employed to control fungal and bacterial pathogens. Research has shown that AgNPs can effectively inhibit the growth of plant pathogens such as *Alternaria alternata* and *Fusarium oxysporum*. The mechanism by which AgNPs exert their antimicrobial effects involves the disruption of microbial cell membranes, leading to cell death.

Copper Nanoparticles (CuNPs): Copper has long been used as a fungicide in agriculture. The nanoform of copper enhances its efficacy due to its increased surface area and reactivity. CuNPs have demonstrated effectiveness against a range of fungal diseases, including those caused by *Pseudoperonospora cubensis* in cucumbers. These nanoparticles not only inhibit pathogen growth but also induce systemic resistance in plants, enhancing their overall defense mechanisms.

2. Silica Nanoparticles

Silica nanoparticles (SiO2NPs) are another class of NPs that can enhance plant resistance to diseases. SiO2NPs can act as carriers for pesticides, allowing for more precise and efficient delivery. This targeted delivery system reduces the required dosage and minimizes environmental impact. Furthermore, SiO2NPs can directly interact with pathogens, disrupting their biological processes and inhibiting their growth.

3. Zinc Oxide Nanoparticles (ZnONPs)

ZnONPs exhibit strong antimicrobial activity and can protect plants against a variety of pathogens. These nanoparticles have been reported to control bacterial diseases such as *Xanthomonas campestris*, which affects cruciferous vegetables. ZnONPs work by generating reactive oxygen species (ROS) that cause oxidative stress in pathogens, leading to their death. Additionally, ZnONPs can enhance the nutritional status of plants, contributing to their overall health and resistance to diseases.

4. Carbon-Based Nanomaterials

Carbon-based nanomaterials, including carbon nanotubes (CNTs) and graphene oxide (GO), have shown potential in plant disease management by enhancing plant immune responses and delivering antimicrobial agents. GO, for example, has been used to suppress the growth of *Botrytis cinerea,* a common fungal pathogen. These nanomaterials can penetrate plant cells and interact with their metabolic processes, bolstering their defense mechanisms.

Mechanisms of Action

Nanoparticles manage plant diseases through several mechanisms:

Direct Antimicrobial Activity: NPs can disrupt the cell membranes of pathogens, leading to their death. For example, AgNPs release silver ions that interfere with microbial respiration and replication. This direct antimicrobial action is often accompanied by the generation of ROS, which further damages the pathogen cell.

Induction of Plant Defense Mechanisms: NPs can stimulate plants' innate immune systems. Studies have shown that CuNPs can induce the production of defense-related enzymes such as peroxidase and polyphenol oxidase, enhancing the plant's ability to resist infections. This induction of systemic acquired resistance (SAR) involves the activation of signalling pathways that prime the plant to respond more robustly to pathogen attacks.

Enhanced Pesticide Delivery

NPs can serve as carriers for conventional pesticides, improving their stability and uptake by plants. This targeted delivery system reduces the overall amount of pesticide needed and minimizes off-target effects. For instance, SiO2NPs have been used to encapsulate fungicides, ensuring a slow and controlled release that provides prolonged protection against pathogens.

Benefits of Using Nanoparticles

1. Increased Efficacy: NPs have a high surface area-to-volume ratio, enhancing their interaction with pathogens and leading to more effective disease control. This increased efficacy means that smaller quantities of nanoparticles can achieve the same or better results compared to traditional pesticides.

2. Reduced Chemical Usage: By improving the delivery and efficacy of pesticides, NPs can lower the required doses, reducing environmental contamination and health risks. This reduction in chemical usage also helps in mitigating the development of pesticide-resistant strains of pathogens.

3. Sustained Release: Nanoparticles can provide a controlled release of active agents, ensuring prolonged protection against pathogens. This sustained release mechanism is particularly beneficial in preventing recurrent infections and reducing the frequency of pesticide applications.

4. Environmental Safety: NPs can be designed to be biodegradable, minimizing their persistence in the environment and reducing their ecological footprint. Biodegradable nanoparticles break down into harmless byproducts, ensuring that they do not accumulate in the soil or water systems.

Case Studies and Practical Applications

1. Silver Nanoparticles in Tomato Plants: A study demonstrated the use of AgNPs to control *Phytophthora infestans*, the causative agent of late blight in tomatoes. The application of AgNPs not only inhibited the growth of the pathogen but also reduced the severity of the disease in treated plants. This study highlighted the potential of AgNPs as an alternative to conventional fungicides in managing devastating plant diseases.

2. Copper Nanoparticles for Downy Mildew: Research involving CuNPs showed significant control of downy mildew in grapevines. The nanoparticles were applied as a foliar spray, resulting in reduced disease incidence and improved grape yield. This case study illustrated the effectiveness of CuNPs in controlling fungal diseases while enhancing crop productivity.

3. Silica Nanoparticles in Rice Cultivation: SiO2NPs were used to deliver a systemic fungicide in rice plants, providing protection against *Magnaporthe oryzae*, the pathogen responsible for rice blast. The encapsulated fungicide showed a slow-release profile, ensuring sustained protection throughout the growing season. This application demonstrated the potential of SiO2NPs in improving the efficacy and longevity of pesticide treatments.

Challenges and Future Directions

Despite the promising potential of nanoparticles in plant disease management, several challenges remain:

- **Toxicity Concerns**: The long-term effects of NPs on non-target organisms and soil health need to be thoroughly evaluated. Studies have shown that high concentrations of NPs can

be toxic to beneficial soil microorganisms and plants themselves. Understanding the safe and effective dosages is crucial for their sustainable use.

- **Regulatory Hurdles**: The development and use of NPs in agriculture are subject to regulatory scrutiny, which can delay their adoption. Regulatory bodies require comprehensive safety and efficacy data before approving new nanomaterials for agricultural use. This process can be time-consuming and costly.
- **Cost**: The production of nanoparticles can be expensive, and cost-effective methods for large-scale synthesis are required. Scaling up the production of NPs while maintaining their quality and efficacy is a significant challenge. Research efforts are focused on developing more economical and sustainable manufacturing processes.

Future research should focus on understanding the interactions between nanoparticles and plant systems, optimizing formulations for specific crops and pathogens, and assessing the environmental impact of NP-based treatments. Integrating nanotechnology with traditional and biological methods could lead to more sustainable and effective plant disease management strategies.

Conclusion

Nanoparticles offer a promising alternative to traditional plant disease management methods, providing enhanced efficacy, reduced chemical usage, and potential environmental benefits. While challenges remain, ongoing research and technological advancements are likely to overcome these obstacles, paving the way for the broader adoption of nanotechnology in agriculture. The future of plant disease management lies in the innovative integration of nanotechnology, ensuring sustainable and effective solutions for global food security.

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THE NUTRITIONAL POWER HOUSES: EXPLORING THE HEALTH BENEFITS OF SMALL MILLETS

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Abstract

Small millets are highly drought tolerant nutricereals as they encompass the goodness of a majority of essential nutrients especially good quality protein, vitamins, fiber and other phytonutrients and considered as functional food.Small Millets such as little (*Panicum miliare*), foxtail (*Setaria italica*), kodo (*Paspalum scrobiculatum*), common (*Panicum miliaceum*), barnyard (*Echinochloa frumentacea*), and finger (*Elusine coracana*) millets are a group of small seeded species of cereal crops, widely grown around the world for food and fodder. Small millets were neglected despite their versatility because of institutional encouragement of fine cereals. In this article, the status of production of small millets, nutritional status and their values on human health are discussed elaborately.

Keywords : Small millets, nutritional values, Human health

Introduction

The word Millet is derived from French word "mille" means that a handful of millet contains thousands of seed grains. (Taylor and Emmambux, 2008). Smallholders and tribal farmers primarily grow millets, which are coarse cereals, in rainfed environments. Millets are mostly found on the continents of Asia, Africa, and some parts of Europe. These are some of India's most renowned historically grown crops. There are two types of millets: major and minor, or small millets. While small millets are mostly used as bird feed in Japan, they are mostly used for food and related purposes in India, Africa, and other parts of the world. In light of their nutritional content and composition, these coarse grains have recently been reassessed as "nutri-cereals." Due to their smaller carbon footprint compared to other cereals, drought tolerance, and reduced reliance on external inputs, small millets have garnered the interest of policymakers and growers in the current climate change aftermath. These positive effects guaranteed small millets' resurgence in emerging nations after decades of institutional neglect. Given the general public's access to food and nutrition, small millets can be regarded as appropriate staples. Due to their ecological soundness and capacity to mitigate climate change, small millets have become increasingly popular due to rising health consciousness and future food demands. Since the small millets are drought tolerant, nowadays, the crops attracted the growers and policy makers and register a comparatively lower carbon footprint than other cereals. These significant impacts bring small millets in cultivation after a few decades in the developing countries.

Current status of Small Millet production

In hot and arid parts of the developing world, particularly in Africa and Asia, millets represent a vital staple food source for underprivileged farmers. More than 93 countries cultivate millets,

including pearl millet and lesser millets. Sorghum is the most extensively farmed millet crop, cultivated across 42.1 million hectares in 105 countries; production data for other minor millets, such as pearl millet, are known for 93 countries (Obilana 2003). The majority of millets are grown and consumed in developing nations, particularly those in Asia and Africa. With 83% of Asia's and 26.6% of the world's millet cropping area, India is the world's largest millet grower.

The area cultivated with millets decreased by about 25.71% on all continents between 1961 and 2018(FAOSTAT 2018). During the same period, the production of millet increased by 36% globally, from 575 kg/ha to 900 kg/ha. With the exception of Africa, the average statistics over the previous 58 years showed a decline in millet output over much of the world. West Africa recorded the largest increase, about twice as much as in the 1960s. While the area under millet cultivation has decreased throughout Asia, the production trend has been gradually increasing, which has improved productivity. In the case of India, millet output peaked in the 1980s and then steadily declined as a result of a dramatic fall in the area under cultivation. With 37.5% of the world's millets produced, India leads the world's millet producers, Nigeria and Sudan coming in second. From 2011 to 2017, millets registered the largest global import and export values (155.26 and 127.60 million US dollars, respectively) in terms of trade. The area under millets has been steadily declining worldwide, which may be related to changing agricultural lands for other crops, dietary changes, guaranteed irrigation systems, and guaranteed yields from large commercial crops.

One of the biggest producers of these minor crops is India. India topped the global millet grain production chart with an annual production of 334,500 tonnes, accounting for 43.85% of the total production of 762,712 metric tonnes, according to Chandel et al. (2014). In the Indian states of Odisha, Madhya Pradesh, Jharkhand, Rajasthan, Karnataka, and Uttarakhand, millets are a staple of the tribal diet. The majority of India's millet crop is grown in arid, dry areas with little or no rainfall. Pearl millet, which makes up 56% (9 Mt) of all millet produced in India, is the most commonly produced type and is mostly farmed in the states of Rajasthan, Uttar Pradesh, Gujarat, Madhya Pradesh, and Haryana. Finger millet, with an output of 1.79 Mt from the total planted area of 1.17 M ha, is the most commonly produced minor millet in India. More than 90% of the nation's production of finger millet is produced in the principal growing states of Karnataka, Uttarakhand, Maharashtra, Tamil Nadu, Odisha, and Andhra Pradesh. In India, kodo millet is the most often produced minor millet after finger millet. But because of their enormous nutraceutical potential, they have also gained popularity in cities in recent years.

Millets are now considered marginal or underused grains due to the consistent drop in the amount of land under cultivation for them worldwide over the past few decades. Millets are superior to other commercial crops in agriculture because of their adaptability to marginal and low-input farming.

Cultivation of small millets

Millets are typically cultivated up to 2,100 meters above sea level in both tropical and subtropical climates. They are heat-loving plants, and a minimum temperature of 810°C is needed for them to germinate. During growth, a mean temperature range of 26–29°C is ideal for healthy development and high crop output. It is grown in areas with 500–900 mm of rainfall annually. Kodo millet requires a lot of water to thrive, yet it can withstand 50–60 centimetres of moderate rainfall. Millet can withstand a certain amount of alkalinity and is very adaptive to a variety of soil types,

from extremely poor to quite fertile. Alluvial, loamy, sandy soils with good drainage are the greatest types of soil. on areas with stony and gravelly soil, as those on hills, kodo millet can be produced. When the monsoon season begins, the initial ploughing should be done deeply with a soil-turning plough. For optimal germination and crop establishment, fine tilth is essential. Typically, line sowing is done at a depth of 3–4 cm to maximize yield. For small millet crops, the transplanting method of cultivation is also used. Four kilograms of seed is sufficient to produce enough seedlings to transplant one hectare of land, thus the seed should be sown in nursery beds that have been adequately prepared. Three- to four-week-old seedlings should be inserted two per hill, separated by 25 by 8 cm, or inserted two to three centimetres deep. In order to enrich soil nutrients and crop growth, 5-10 tonnes of FYM may be applied to a hectare land along with N-60Kg/ha, P2 O5-30Kg/ha, K2O-30Kg/ha. The inter-cultivation and weeding should be done with hand hoe, three hoeing would be sufficient to control the weeds in problem areas.

Nutritional values in small millets

Compared to rice or wheat, small millets are an excellent source of nutrients, containing 60–70% dietary carbohydrates, 6–10% protein, 1.5–5% fat, 12–20% dietary fiber, and 2-4 minerals. They also contain many essential phytochemicals, such as phenolics, flavanoids, tocopherols, and carotenoids, and provide several health benefits to their consumers (Hadimani and Malleshi, 1993). There is a great deal of potential for creating value-added products from small millets that may be good for human health. The term "finger millet" comes from the way its panicles resemble fingers. Protein (7.5–14%), fat (1.3%), dietary fiber (18.6%), calcium (344 mg/100 gm), carbohydrates (65–75%), and minerals (2.3–2.7%) make up the significant nutrients of finger millet. Finger millet is an annual cereal grass that grows up to 170 cm and is mostly used for food rather than fodder.

According to analyses, finger millet has a high calcium content 450 mg/100 gm of grains in some cultivars (Gupta et al., 2011). Finger millet is used to make flour for roti and is boiled (Ambali) and mudded before being mixed with curd. Its residues are ideal for use as fodder and contain around 60% digestible elements. Compared to toothers, finger millet has a lower amylose content of 16 percent. Iron, zinc, magnesium, copper, selenium, and molybdenum are all present in finger millet. Among the minerals found in its seed coat are phytochemicals and an abundant supply of calcium (Devi et al., 2014). When compared to rice (6.85% protein and 0 mg/100 gm grain), foxtail millet has 12.3% protein and 32 mg of vitamin A per 100 gm grain. It also has 4.3% fat content when compared to wheat and rice. Beta-carotene and vitamin A are abundant in this grain (Murugan and Nirmalakumari 2006). There is 17.5% of amylose present. abundant in other amino acids and lacking in tyrosine (Shobana et al., 2013).

Kodo millet has 9.0% crude fiber and 8.3% protein. According to Hegde and Chandra (2005), it is the millet crop with the lowest phosphorus concentration when compared to others, and the mineral matter is 2.6 grams per 100 grams of grain. In kodo millet, gluten is the most significant protein (Sudharshana, et al., 1988).

When compared to other phenolic-rich foods like ragi (7.2%) and foxtail millet (2.5%), little millet has a phenolic content of 10.3%, which reduces the incidence of breast and colon cancer in mice (Rao et al., 2010). Little millet (4.7%) has the highest fat content, followed by bajra (5%). The adaptable crop known as barnyard millet is grown for food and fodder. Good supply of mostly

digestible dietary fiber (13.5g/100gm) and phosphorus (Hadimani and Malleshi 1993). Excellent source of mineral materials and iron.

Small Millets on Human health

Because there is a shortage of proper nutrition in underdeveloped nations, malnutrition is a major issue. Millets, on the other hand, are very nutritious and useful in fighting with many health problems like cardiovascular obesity, illnesses, cancer, diabetes, celiac disease, etc. They are abundant in low-glycemic index B-vitamins, antioxidants, gluten-free protein, and minerals (calcium, iron, copper, magnesium, etc.). They are rich in nutrients that help with a variety of health-related issues. For example, their high protein content aids in a child's growth and development, their calcium content aids in the development of bones in both children and the elderly, their good iron content aids in the treatment of anaemia, and their gluten-free qualities benefit those with celiac disease and helps in gluten insensitivity.

Antioxidants included in millets also aid in shielding our cells from the damaging effects of free radicals. The waxy coats of millet include cardioprotective chemicals called phytosterols and policosanols. They are helpful in managing insufficient dietary intake. Millets can therefore be processed into flour without being hulled, which has several health benefits.

Millets may be considered as functional foods. Functional foods are made with bioactive components that are good for human physiology and can help fight chronic illnesses (Banerjee and Ray, 2019). The phospholipid membranes surrounding nerves, the heart, muscles, and red blood are protected from reactive oxygen species attack by flavonoids such as tannin, anthocyanin, phenolic compounds, tocopherols, and carotenoids, which are naturally occurring antioxidants found in small millets. This prevents the development of cancer, cardiovascular diseases, and aging (Theriault et al., 1999).

Our everyday diets are rich in phenolics, flavanoids, tocopherols, and carotenoids, which are excellent sources of natural antioxidants and have been linked to positive health effects (Namiki, 1990). Vitamin E also acts as a natural antioxidant shielding fat in the membranes surrounding cells—such as those of the heart, muscles, nerves, and red blood cells—from potential oxygen damage and preventing carcinogenesis, cardiovascular diseases, and aging.

According to reports, carotenoids reduce atherosclerosis (Dwyer et al., 2001), preserve immune system function, protect the retina in the eyes (Beatty et al., 1999), and act as precursors of vitamin A. In reality, the "antioxidants" found in nutraceuticals are micronutrients with the power to counteract the effects of free radicals, which are potentially dangerous byproducts of several bodily functions and linked to the aging of cells and tissues. Due to their high content of phenolics, a potent antioxidant, little millets and the value-added goods made from them are in high demand among customers.

Furthermore, because finger millet has a higher fiber content than wheat and rice, eating a diet based on it results in much lower plasma glucose levels. Generally, the small millets are abundant in bound polyphenols, which lessen the action of digestive enzymes. Some polyphenolic substances that are known to combat the radical and prevent various diseases and morbid states are flavonoids, phenolic acids, and proanthocyanidins (Himansu et al., 2018). Because the nutrient-dense millets have the potential to provide health advantages both when ingested as a staple cereal and in value-added products, they are deserving of the title of nutri-cereals.

One of the healthiest grains is finger millet, which has a good amount of natural calcium that strengthens bones and lowers the risk of bone fractures. Regular consumption of finger millet whole grains and their derivatives can reduce the incidence of heart disease, diabetes type II, gastrointestinal malignancies, and other illnesses (Mckeown et al., 2002). To make flour, it is ground using testa, which is often high in dietary fiber and micronutrients (Devi et al., 2011). The portion of the seed coat that contains high dietary fiber, minerals, phenolics, and vitamins provides nutritional and health benefits.

According to Reddy (2017), finger millet has been shown to enhance hemoglobin levels and combat degenerative illnesses and malnourishment. Finger millet fibers provide a feeling of fullness, which helps to regulate overindulgence in meals (ICAR - Indian Institute of Millets Research, 2017 (IIMR). A versatile crop grown for both food and fodder is barnyard millet. It has a considerable amount of soluble and insoluble fractions and is a highly digested form of dietary fiber (Hadimani and Malleshi 1993). It is also a strong source of protein. Due to its low carbohydrate content and slow digestion, barnyard millet is considered a gift from nature for today's sedentary population (Veena et al., 2005). The best millet for lowering cholesterol and blood sugar is barnyard millet.

Because little millet is high in cholesterol, eating it raises excellent cholesterol levels in the body, which is beneficial for developing children and fortifies the body. Patients with diabetes benefit greatly from its complex carbohydrates' gradual digestion. Another benefit is its high fiber content, which makes it perfect for kheer or pongal in place of rice (Reddy, 2017). It has high levels of iron (9.3 mg/100g) and phosphorus (220 mg/100g). Those with low body mass should benefit most from it. Dosa, idli, pongal, and kichadi are a few dishes that may be made with minimal millet.

North America, Eastern Europe, China, and Russia are the nations that produce proso millet. Because wheat, maize, and other cereal crops are so abundant in Western countries, proso millet has little economic significance (Delost-Levis et al., 1992). As a result, proso millet grain is mostly utilized there for bird feed. But because of its superior proteins, it has started to gain popularity in recent years. According to Seetharam (1999), grains have nutritive qualities that are somewhat better than those of conventional cereals and are rich in minerals and vitamins. After drying, protein quantity increases but quality declines (Kalinova and Moudry 2006). Niacin (Vitamin B3) and protein make up proso millet.

A healthy alternative to wheat and rice, kodo millet is a grain. Compared to main cereals like rice, there is a significant increase in protein, fiber, and mineral content. Gluten is the main protein component of kodo millet (Sudharshana, et al., 1988). One traditional food that aids in weight loss is kodo millet. It is readily absorbed and high in antioxidants and phytochemicals that help prevent a variety of ailments linked to an unhealthy lifestyle. According to Deshpande et al. (2015), Kodo millet aids in lowering knee and joint discomfort as well as helping women's menstruation to be regular. Similar to other food grains, kodo millet protein's nutritional value could be enhanced by gelatinization (Shinoj et al., 2006) and added to baked goods like cakes and bread by supplementation with legume protein. In addition to being an abundant supply of nutrients, Kodomillet also has significant concentrations of phytic acids, phosphorus, tannins, and polyphenols. When the entire grain is boiled and dehulled, kodo millet's antioxidant activity

diminishes (Chandrasekara et al., 2012). These antinutrients decrease the solubility and bioavailability of micronutrients including iron, calcium, and zinc by forming complexes with them (Balasubramanian, 2013).

Foxtail millet According to Murugan and Nirmalakumari (2006), foxtail millet is an excellent source of beta-carotene, which is a precursor to vitamin A. Foxtail millet facilitates the constant release of glucose without interfering with the body's metabolism. Because foxtail millet is a high source of magnesium, eating it lowers the prevalence of diabetes and makes it a heart-healthy diet (Reddy, 2017). To make porridge, foxtail millet is combined with legumes; it is also used with soybeans to create mixed flour.

Conclusion

Small millets contain all essential nutrients carbohydrates, dietary fibres, proteins, fats, vitamins, essential elements and anti-oxidants that is require for human health. Nutraceutical research is gaining popularity due to public awareness of health and nutrition. Since, availability of huge nutrient sources and they can be used as functional food. Fifty years ago, tiny millet held a significant position in our people's eating habits. The modernization of lifestyles led to a shift in people's dietary preferences toward prepared foods. Currently, the people realised the importance of small millets and gaining popularity among all sectors of people. The concepts of food consumption have been changed and presently health-conscious people having higher purchasing capacity are in search of nutritious foods. The intake of food with nutraceutical ensures health benefits and well-being reducing hazards from chronic sickness.

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ECO-FRIENDLY MANAGEMENT OF LATE BLIGHT (*Phytophthora infestans*) DISEASE IN TOMATO

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INTRODUCTION

Tomato, *Solanum lycopersicum* L. (formerly known as *Lycopersicon esculentum* Mill.) is a major vegetable crop worldwide (FAOSTAT 2011). Tomato is thought to have originated in the Andean region of South America, now encompassed by parts of Peru, Chile, Colombia, Ecuador, and Bolivia (Jenkins 1948; Rick 1978), and domesticated in Mexico (Rick 1976). Although a tropical plant, it is grown and widely consumed vegetable in almost every corner of the world. It is a popular vegetable and important source of vitamins and minerals in human diet. However, tomato late blight is a devastating disease worldwide of tomato plants, caused by *Phytophthora infestans* to both fresh-market and processing tomato industries throughout the world, and economic losses resulting from crop damage or disease control measures are significant.

The crop is also widely cultivated vegetable crop in Manipur due to suitable climatic condition round the year. It occupies significant position in this region due to its economic potential planted both in open and low cost rain shelter condition. Similarly, late blight of tomato *Phytophthora infestans* reduces the marketable yield of tomato fruit due to severe attack of the disease and widely distributed in the region. Late blight is favored by high humidity dew, wet weather and moderate temperatures (50 to 80°F). When the environment is favorable, the disease can spread quickly and can defoliate fields within 3 weeks affecting foliage of both leaves and fruit, extensive defoliation, reduced photosynthetic leaf area, loss of plant vigor, plant death, loss of fruits and reproductive capacity, and loss of seeds causing total crop loss. In the past few decades, the frequency and severity of the disease have increased in many parts of the world including India and have been a serious threat to tomato production (Chowdappa *et al.,* 2011).

The applications of systemic fungicides are commonly used for management of late blight disease in tomato however, failed to control under disease favorable environmental conditions. Further, the regular fungicidal use encourages the development of resistance in *P. infestans*, increases the production cost and more important being it is detrimental to the environment (Siddique *et al.,* 2016). Biological control of crop disease is receiving increased attention as an environmentally safe alternative to chemical pesticides but, bio-control agents alone are not sufficiently potent enough to curb the menace of devastating late blight in field conditions (Ellis *et al.,* 1999).

Symptoms: Symptoms of late blight disease in tomato may be found on any above-ground part of the tomato plant.

1. **Initial Symptoms:** Infected leaves have green to brown patches of dead tissue surrounded by a pale green or gray border. The leaves appear irregularly shaped, water-soaked lesions, often with a lighter halo or ring around them when the weather is humid and wet. Lesions expand rapidly and the entire leaf becomes necrotic.


2. **Severe Symptoms:** Lesions become enlarged and leaves turn brown, shrivel and die. White, fuzzy growth may be found on the undersides of leaves or on lower stems. Stem and petiole lesions are brown and are typically not well defined in shape. Discoloration may also occur on the flowers, causing them to drop.

Late blight fungus can also attack tomato fruits in all stages of development. Symptomatic tomato fruits appear mottled, often with golden to dark brown, firm, sunken surfaces. White, fuzzy pathogen growth can also be found in association with the fruit lesions. Due to severe infection, disintegration of fruits leads to rotting of tissues.

Late blight disease is a hard to manage under organic condition. Therefore, farmers' should employ all available strategies to reduce late blight risk. The objective of the study was to evaluate field efficacy of Copper based fungicide spray for management of tomato late blight disease at Churachandpur district, Manipur.

RESULT AND DISCUSSION

The study was conducted at Saihenjang and Tollen villages of Churachandpur district, Manipur to develop eco-friendly management strategies of late blight disease which can reduce excessive fungicide applications. The result presented in table 1 indicated that percent disease incidence in tomato var. Amitabh demonstrated under open condition during *kharif* 2022 revealed that the percent incidence was 84.6 % against 100% in the untreated control plot during the cropping season. The data on disease severity showed that Copper Oxychloride @ 0.25% sprayed plot reduced the disease intensity significantly compared to control plot. Similarly, least percent disease severity was recorded with mean values of 6.6% and 9.5% in untreated control plot respectively. Spraying of Copper Oxychloride @ 0.25% at 10 days interval gave significant control of the disease. The percentage of fruit damage caused by late blight disease was observed 15.1% against the untreated control of 24.3%. There were significant differences within treatments on yield at study location. The yield obtained was 191.0 q/ha in the treated plot while 167.1 q/ha was

harvested from the control plot respectively. Overall, 14.3% of increase yield was obtained against the control plot receiving the cost benefit ratio of 2.80 and 2.45 respectively. The findings is in conformity with findings of Gopi *et al.,* 2020 who reported that copper oxychloride @ 0.25% was found most effective followed by copper hydroxide @ 0.25% for the management of late blight disease in tomato.

Table 1: Effect of copper based fungicide on the incidence of late blight disease and yield of tomato

Treatment	Parameters of demonstration (%)			Marketable yield (q/ha)	Increased yield over control (%)	B:C ratio
	Incidence	Disease severity	Fruit damage			
Copper oxychloride (COC) @ 0.25%	84.6	6.6	15.1	191.0	14.3	2.80
Untreated Control	100.0	9.5	24.3	167.1	-	2.45

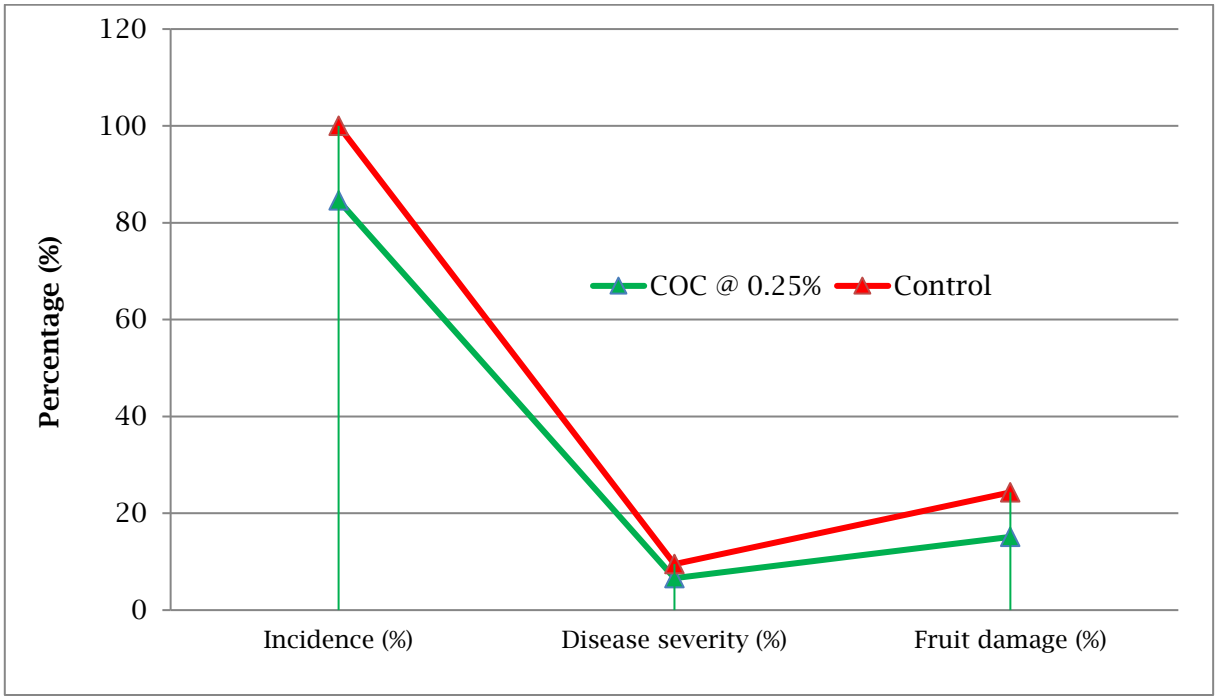

Fig 1: Percent incidence of late blight disease in tomato

CONCLUSION

Problems associated with pesticides and marketability are major constraints to tomato production, and both factors are associated with late blight disease. Although not always effective, chemical control dominates pest and disease management strategies for tomato cultivation. Hence, late blight disease has to be considered as an important peril and yield loss arising out of it has to be covered under national crop insurance programme. The present study indicated that copper oxychloride can be used for the management of late blight disease for increasing yield in tomato cultivated under organic conditions. This superiority has been observed

and confirmed by several tomato researchers. The findings also revealed that phytotoxic symptoms of any kind were not observed in copper fungicides treated plots during the study period. As copper based fungicides are protectant in nature, spraying must be done before infection or immediately after the appearance of disease. Weather conditions plays important role in secondary infection of disease therefore prophylactic treatment as per weather condition. Copper fungicides can be applied at 7-10 days interval until the disease becomes less severe or as soon as weather conditions are found to be favourable for disease development. Seed treatment is also beneficial in management of disease to check primary infection. Fortunately, research in this direction is underway, which will provide opportunities for pyramiding multiple resistance genes and developing tomatoes with stronger and more durable resistance against late blight disease in tomato.

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UTTARAKHAND'S FLORAL SYMPHONY: *Rosa banksiae*

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Abstract
The *Rosa banksiae*, also known as Lady Banks' rose, is a captivating climbing shrub native to China, now thriving in the hilly regions of Uttarakhand, India. This vigorous vine, reaching up to 6 meters, features smooth branches with sparse thorns, adorned with evergreen leaves and delicate, fragrant flowers in clusters. Blooming from April to May, its petals range from white to purple. There are two varieties: *R. banksiae* var. *banksiae*, with semi-double or double flowers, and *R. banksiae* var. *normalis*, with single flowers (Christopher Brickell 2008). Preferring sunny, well-drained, fertile soils, it tolerates partial shade and cold. Renowned for its ornamental value, *Rosa banksiae* is used in vertical greening and landscaping. Despite its beauty, the species faces threats from habitat loss, prompting conservation efforts. Its cultural significance in Uttarakhand underscores its importance, making it a cherished floral gem that symbolizes the region's natural beauty and ecological diversity.

Keywords : Blooming, ecological, habitat and *Rosa banksiae*

Introduction

Nestled amidst the rolling hills and valleys of the Uttarakhand region lies a floral gem that captures the hearts of all who encounter its ethereal beauty - the *Rosa banksiae*. With its delicate, cascading blooms and enchanting fragrance, this rare species of rose adds a touch of splendor to the rugged landscape of the Himalayas. The *Rosa banksiae*, or Lady Banks' rose, is a climbing shrub that can grow up to 6 meters tall. Its smooth branches are armed with short thorns and adorned with 3-5 small elliptical or oblong lanceolate leaves. The delicate flowers, often found in clusters resembling umbels, boast ovate calyxes and petals ranging from double to semi-double, showcasing a charming white hue. The blooming period in hills is from April to May, this species originates from Sichuan and Yunnan in China but is now widely cultivated across the country especially hilly regions. (Graham Murphy, 2003).

Taxonomy and Botany

Rosa banksiae, commonly known as Lady Banks' rose or Banks' rose, is a flowering plant belonging to the rose family. It *originates* from central and western regions of China (Akasaka M. 2002) The name of this rose species honors Dorothea Lady Banks, who was the spouse of the renowned botanist Sir Joseph Banks.

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a) Yellow petal

b) Dark pink petal

c) purple petal

d) Light pink petal

Figure 1 : *Rosa banksiae*at Central institute of Temperate Horticulture, Regional Station, Mukteshawar, Uttarakhand

It is a vigorous scrambling vine that can reach heights of up to 6 meters (20 feet). Unlike many other roses, it has very few thorns, though occasionally small prickles up to 5 mm long may be found, especially on robust shoots. Its evergreen leaves are typically 4-6 cm long and consist of three to five (sometimes seven) leaflets, each 2-5 cm long, with serrated edges. The calyxes have ovate shapes with pointed tips and smooth edges. Both the calyx tube and the outer surface of the calyxes lack hair, while the inner surface Is covered with soft white hairs. The flowers of Lady Banks' rose are petite, measuring 1.5-2.5 cm in diameter (Akasaka M. 2002) They have inverted ovate shapes, rounded tips and wedge-shaped bases. Known for its early bloom, this rose species typically flowers in mid-March in the hilly regions of Uttarakhand.

Varieties and Types

The petals colour varies from shades of white, pale yellow, pink or purple, (Fig 1) emitting a delightful fragrance.

There are two varieties of *Rosa banksiae*:

1. *R. banksiae* var. *banksiae*: This variety features semi-double or double flowers, characterized by numerous petals that replace most or all of the stamens. It is a cultivated form developed in Chinese gardens.
2. *R. banksiae* var. *normalis*: This variety bears single flowers with five petals, representing the natural wild form of the species. (Christopher Brickell 2008) (Fig 2)

Figure 2: *R. banksiae* var. *normalis* (single petal rose) at Central institute of Temperate Horticulture, Regional Station, Mukteshawar, Uttarakhand

Climate and Soil

Roses thrive in sunny conditions but can also tolerate partial shade. They exhibit resilience to cold temperatures and typically flourish in fertile, well-draining soils with adequate moisture. While they can endure dryness and poor soil quality, they prefer deep, loose and nutrient-rich soils that have good drainage. (AIPH 2015,2016) Additionally, they can adapt to heavy clay soils but do not tolerate water-logging well and should be kept away from stagnant water.

Importance in Landscaping and Gardens

During spring, the slender branches of the rose bush extend and intertwine, adorned with leaves and abundant clusters of flowers, creating their own unique presence. While the flowers may not be large individually, they bloom abundantly, seamlessly blending with the branches and leaves, resembling a silent poem or a three-dimensional painting that surpasses any artificially crafted sculpture. As summer heats up, the roses may not bloom as profusely as in spring, but they still open sporadically, offering a refreshing and tranquil atmosphere amidst the sweltering heat.

Functional Uses

- Roses have the ability to absorb exhaust gases, prevent dust accumulation and purify the air.
- Their dense, colorful flowers and fragrant aroma make them ideal for vertical greening projects, decorating structures like pillars, racks, corridors and walls.

- They serve as excellent hedge materials and are well-suited for home gardens.
- Renowned for their ornamental value, roses are commonly cultivated for use as climbing plants. (AIPH, 2015)
- Roses contain aromatic oils that can be utilized in the production of perfumes and cosmetics.
- The root bark possesses astringent and neutral properties, with applications in treating conditions such as chronic diarrhoea, bloody stools, children's diarrhoea, carbuncles and external bleeding. (Akasaka *et al.*, 2002).

Conservation and Cultural Significance

Despite its undeniable beauty and remarkable resilience, the *Rosa banksiae* faces threats to its survival, primarily due to habitat loss and degradation. As human encroachment continues to encroach upon its natural habitat, the Lady Banks' Rose is increasingly vulnerable to extinction.

Efforts are underway to conserve and protect this precious species, with initiatives aimed at preserving its native habitats and raising awareness about its ecological importance. By fostering a deeper appreciation for the *Rosa banksiae* and its role in the ecosystem, conservationists hope to ensure its survival for future generations to enjoy.

In addition to its ecological significance, the *Rosa banksiae* holds cultural importance in the hills of Uttarakhand. Revered for its beauty and symbolism, this elegant rose features prominently in local folklore and traditions.

Conclusion

Rosa banksiae stands as a testament to the remarkable diversity and resilience of the flora that graces the slopes of the Uttarakhand hills. With its delicate blooms and unwavering strength, this rare species of rose serves as a poignant reminder of the intricate beauty and fragility of the natural world.

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SAFFRON REVOLUTION : TRANSFORMING INDIA'S NORTHEASTERN LANDSCAPE

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Abstract
India's north-eastern region is undergoing a remarkable transformation into a saffron cultivation hub through the ambitious "Mission Saffron." This initiative aims to leverage the favourable climate and fertile lands to bridge the gap between supply and demand, potentially surpassing traditional saffron producing regions. Extensive research has identified promising sites for large-scale cultivation, involving local farmers, and promising economic opportunities. This initiative signifies an evolution in India's agricultural landscape, showcasing the power of innovation in agriculture and contributing to India's self-reliance in saffron production.

Introduction
The enchanting landscapes of India's northeast are witnessing a transformative journey as they emerge as the next hub for saffron cultivation. Spearheaded by the North East Centre for Technology Application and Reach (NECTAR), under the Ministry of Science and Technology, the ambitious "Mission Saffron" aims to revolutionise India's saffron industry. Traditionally synonymous with the famed saffron fields of Pampore in Kashmir, the high-value spice, often referred to as "red gold," now finds a flourishing home in the northeastern states of Yangyang in south Sikkim, Arunachal Pradesh, Mizoram, and Meghalaya. This endeavour has ignited excitement within the Saffron community as new possibilities unfold in these fertile lands.

Bridging the Supply-Demand Gap
In 2020–2021, India's annual saffron consumption was approximately 100 metric tonnes, while domestic production was only15 metric tonnes. Recognising this substantial gap, NECTAR initiated a mission to boost saffron cultivation to meet both domestic and international market demands. By leveraging the region's favourable climate and fertile soil, north-eastern states are poised to contend with the esteemed quality and yield of saffron traditionally associated with Kashmir. With these favourable conditions, the northeast holds the potential to surpass other regions in India concerning saffron production.

Climatic Parallels and the Saffron Dream
Extensive research has shown striking similarities between the climatic conditions of the northeast and the traditional saffron heartland of Jammu and Kashmir, making it ideal for saffron

cultivation. With prices ranging from Rs 1.5 to Rs 2 lakh per kilogramme, the economic potential of saffron cultivation in the northeast is immense. Through meticulous site selection and analysis,15 promising locations have been identified across the northeastern states, including Arunachal Pradesh, Meghalaya, Mizoram, and Sikkim, laying the foundation for a saffron revolution.

Mission Saffron: From Pilot to Expansion

"Mission Saffron" was launched in collaboration with state government departments to explore saffron cultivation. NECTAR evaluated comprehensive assessments on flowering yield, corm survival, daughter corm multiplication, and soil profiling. Based on these criteria, sites were classified as

- **High potential:** Exhibiting flourishing flowering with over 50% corm survival and high daughter corm multiplication.
- **Medium potential:** Showing moderate flowering with 10–20% corm survival and multiplication.
- **Low potential:** Minimal flowering observed, with no daughter corm multiplication.

Encouraged by positive outcomes, the project's scope has been expanded for the years2023–24. Large-scale cultivation has begun in Menchukha (Arunachal Pradesh) and Yuksom (Sikkim), with about 10 quintals of saffron corms deployed. Meanwhile, experimental cultivation continues at medium potential sites for further evaluation. An awareness and mobilization programme, training farmers on optimum saffron cultivation practices. Currently, 64 farmers (22 in Sikkim, 37 in Arunachal Pradesh, and 5 in Meghalaya) are benefiting from the initiative. By early November, more than 37,000 flowers had bloomed, with an expected yield of at least 200 grams of dried saffron.

Shaping the Global Saffron Landscape

Globally, saffron is largely produced in Iran, Afghanistan, India, Spain, and Greece. Iran dominates the saffron market, accounting for 88% of global output, while India, with the second-largest

saffron cultivation area, accounts for only 7%. Traditionally, Kashmir has been the primary saffron producer, but the northeastern regions are expected to have a significant impact on this industry.

Farmers Enthusiasm for Saffron Cultivation: A Ray of Hope

Farmers in the northeastern states are embracing saffron cultivation to improve their livelihoods. Farmers from Chug in Arunachal Pradesh expressed enthusiasm about the transformative influence of saffron farming in the region. The integration of saffron into their agricultural practices offers prospects of increased earnings and a more secure future.

NECTAR's Strategic Approach: Paving the Way for Success

To ensure a consistent supply of saffron corms, NECTAR suggests developing tissue culture laboratories for in-vitro corm production and establishing essential infrastructure, including storage facilities and drying units, accessible via a shared facility centre, to assist farmers with post-harvest activities.

A Turning Point in Agriculture

Saffron was introduced and assessed for quality and yield in several north-eastern states, rivalling Kashmir output. Over a thousand farmers have already participated in this revolutionary project, which aims to cover around 500 acres of land across the Northeast, promising increased saffron production and improved economic opportunities for the region's farmers.

The Versatile Essence of Saffron

Saffron, locally known as “Kesar” is not just a spice; it is a rich source of numerous bioactive compounds such as crocin, picrocrocin, and safranal, which provide various therapeutic properties. These include anti-convulsive, anti-cancer, anti-diabetic, anti-depressant, anti-psoriasis, anti-seizure, anti-nociceptive, anti-inflammatory, anti-genotoxic, and hypolipidemic effects. Additionally, saffron is widely used in the textile and cosmetic industries. In recent years, the demand for saffron has been rising while production is not enough to meet daily demands. Its versatility in applications across medicine, textiles, cosmetics, and cuisine makes it a valuable addition to the agricultural landscape of the northeast. As saffron, often called the “red gold” of the north, establishes new roots in the fertile fields of the northeast, this region is poised to claim a prominent spot on India's saffron map. The world eagerly anticipates the outcomes of this pioneering endeavour.

A Bright Future for Indian Agriculture

The successful cultivation of saffron in the Northeast marks a significant turning point in India's agriculture. It's not just about meeting the demand for a prized spice; it's about unlocking the potential of previously untapped regions. As saffron’s fragrance spreads from the fields of Kashmir to the lush landscapes of the Northeast, it showcases human ingenuity and the power of science and technology. Initiatives like the National Saffron Mission and the expansion of saffron production into the North-East are set to diversify the agricultural sector, bolstering the impact of the Atmanirbhar Bharat Abhiyan. The “saffron bowl” is expanding its horizons, promising a brighter future for India's saffron industry and the farmers embracing it.

Conclusion

The northeastern region of India, guided by NECTAR under the Ministry of Science and Technology, is set to become a saffron cultivation hub. Through sustainable practices and technological innovation, “Mission Saffron” aims to improve local livelihoods and reshape India’s

agricultural landscape. As the northeast blooms with saffron colours, it promises a new beginning for Indian agriculture.

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SMALL-SCALE INLAND CAPTURE FISHERIES AS A MEANS OF SUBSISTENCE: A CASE STUDY OF NORTH BIHAR, INDIA

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Introduction:

The disproportionate focus of policymakers in favor of Small-Scale Marine capture fisheries over Small-Scale Inland fisheries is often observed. With the increase in population and limited job opportunities along with rising costs, the livelihoods of many people have been adversely affected. In such situations, individuals turned to freely available resources such as Oceans and put additional pressure through exploiting fisheries resources. As a result, these resources are being overexploited, creating significant livelihood challenges poor communities like fishers whose livelihood is only fishing.

However, the small-scale inland fisheries in landlocked areas such as Bihar is also making a significant contribution towards the income and employment of many people. The Bihar state is boasting with extensive inland water resources, including rivers, reservoirs, and floodplain wetlands. The combined area of *mauns, chaurs,* and *dhars* amounts approximately 209,000 hectares. These *mauns* and *chaurs* are renowned wetlands in North Bihar, known for their high productivity. The total fish production of the state stands at 6.41 lakh tonnes which has been contributed by both inland capture fisheries and aquaculture (DoF, GoI, 2020).

The North Bihar which lies north of the river Gangaincludes 21 districts of Bihar namely Araria, Kishanganj, Madhubani, Madhepura, Saharsa, Samastipur, Saran, Siwan, Supaul, West Champaran, East Champaran, Darbhanga, Gopalganj, Katihar, Purnia, Sheohar, Sitamadhi, Muzaffarpur, Vaishali, Begusarai and Khagaria.

The inland fisheries resources of the North Bihar are available in the form of rivers such as Ganga, Kosi, Bagmati, Gandak, Budhi-Gandak, Kamala, Balan, Mahanada. Fishing in the rivers has become an important livelihood for people who have several disadvantages in the form of lack of money,

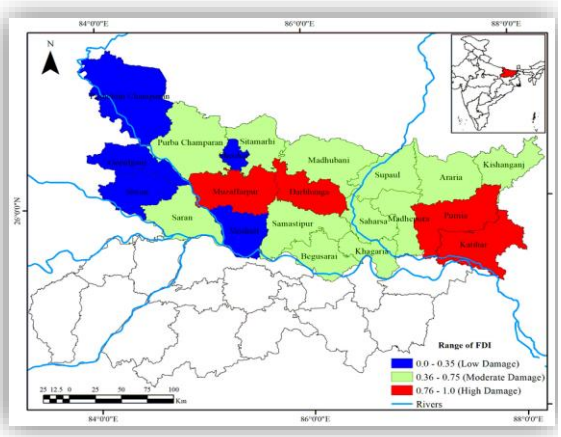

Fig: North Bihar

lack of education, lack of technical skills and use traditional fishing methods. Most common fish species caught from these water bodies are *Labeorohita, Cirrhinusmrigala,Cirrhinusreba, Labeogonius, Puntius sarana, Wallago attu, Mystusseenghala, Ompakpabda, H. fossilis, Channa spp., Puntius spp* etc. Beyond this, Makhana (*Euryale ferox*) culture is done in wetland area and itis very common in Darbhanga, Madhubani, Samastipur, Araria, Katihar and Kishanganj district of North Bihar. Bihar is also the leading producer of Makhana in the country.

Management of Inland water bodies of North Bihar

Inland water bodies of North Bihar are categorized as large and small inland water bodies.

Large inland water bodies: They primarily consists of rivers and reservoirs with rich sources of various fish species. These fisheries resources are open for exploitation, with no restrictions on fishing. Therefore, many people who are lack of other sources of income rely on these water bodies for their livelihood. A significant portion of rural population are engaged in fishing. While it may not be sufficient for everyone, it does ensure food security for rural residents in the form of cheap source of protein and fatty acids.

Fig: Fishing in River

Small inland water bodies : They include *mauns, chaurs,* and *dhars* which are highly productive. They are being leased-out to fisheries cooperative societies. The fish farmers and fishers particularly the rural people are organized under the cooperative societies to collectively engage in fish and makhana culture in these small water bodiesor *jalkars*. This organization allows them to benefit from various government schemes, helping rural fish farmers and fishers to break the vicious cycle of poverty.

Fig: Fish cum Makhan Culture in small inland water bodies

Nowadays, fishers in the state are started using gears that are harmful not only to fish stock but also to the entire ecosystem and biodiversity. Lack of gear registration and absence of required permissions for fishing in the large water bodies have led to overexploitation and significant increase in catch per unit effort (CPUE). The overexploitation creates livelihood insecurity for the fishers whose primary occupation is fishing.

In order to secure the livelihood interest of the traditional fishers, the Government of Bihar as to initiate the gear registration and enforce strict legal mesh size regulations. The use of destructive gears such as drag net has to be limited or ceased completely for its operation. Enforcement of fishing ban during monsoon enable fish stock recruitment. The government initiation to safeguard the fishers' livelihoods through *"Jal, Jivan, Hariyali"* scheme and river ranching program to enrich the fish stocks in large water bodies are worth to note. Measures has to be taken to curtail river pollution and to improve water quality. In near future it is hoping that the government may introduced schemes to further improve the economic and livelihood status of small-scale inland fishers in North Bihar.

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THE MAGIC OF SPICES AND HERBS: NATURE'S FLAVORFUL ANTIOXIDANTS AND FUNCTIONAL SPICE MIX

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ABSTRACT
Spices and herbs elevate meals with their robust flavors and health benefits. They add flavor, color, and taste to dishes while offering numerous health advantages. Spices like turmeric, ginger, and garlic boost immunity, reduce inflammation, aid digestion, and stabilize blood sugar levels. Making a spice functional mix at home is easy: roast and grind fenugreek, coriander, cumin, carom seeds, aniseed, and asafoetida into a fine powder. This mix can be used as a seasoning to enhance flavor and provide health benefits such as weight loss, improved digestion, and increased immunity. Additionally, selling spice mixes can generate income and promote self-employment, especially in rural areas. Embrace the benefits of spices for a healthier diet and lifestyle.

Spices and herbs are nature's magic touch, transforming everyday meals into flavorful masterpieces while packing a punch of health benefits. Here's how these natural wonders work their magic in your kitchen and your body:

The Role of Spices:

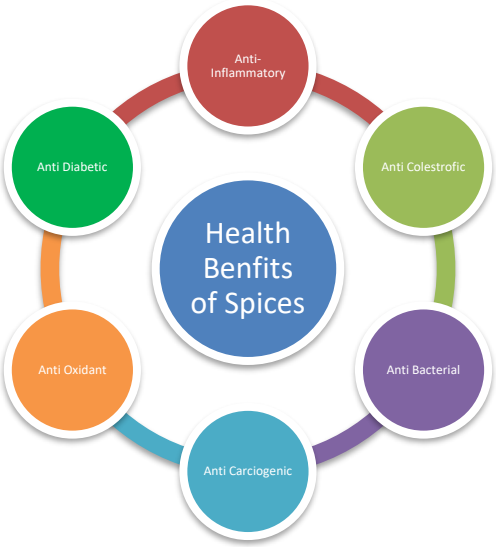
1. **Flavor Explosion**: Spices can turn bland dishes into culinary delights with their rich and complex flavors.
2. **Splash of Color**: Bright spices like turmeric, paprika, and saffron add a rainbow of colors to your food, making it as appealing to the eyes as it is to the taste buds.
3. **Taste Enhancers**: Spices balance and enhance natural flavors, making even simple ingredients irresistibly delicious.

Health Benefits of Spices:

Spices are not just tasty; they're tiny powerhouses of health. Here's why you should sprinkle a bit of spice into your life:

1. **Antioxidant Powerhouses**: Spices like cloves, cinnamon, and oregano are loaded with antioxidants that protect your cells and keep you feeling youthful and vibrant.
2. **Nature's Anti-Inflammatories**: Turmeric and ginger can reduce inflammation, helping to ease pain and protect against chronic diseases.
3. **Immune Boosters**: Garlic, ginger, and cayenne pepper can strengthen your immune system, helping you fend off colds and infections.
4. **Digestive Helpers**: Spices like fennel, cumin, and ginger aid digestion, reducing bloating and keeping your gut happy.

5. **Blood Sugar Regulators**: Cinnamon helps keep blood sugar levels stable, perfect for those with diabetes or anyone looking to avoid energy crashes.



6. **Brain Boosters**: Saffron and turmeric have been linked to better brain function and memory, potentially lowering the risk of Alzheimer's and other cognitive issues.
7. **Heart Health Champions**: Garlic and black pepper can improve heart health by lowering blood pressure, reducing cholesterol, and preventing blood clots.
8. **Natural Detoxifiers**: Cilantro and coriander help your body detoxify by eliminating heavy metals and other toxins.
9. **Mood Lifters**: Spices like nutmeg and saffron can enhance your mood and may help combat symptoms of depression and anxiety, adding a bit of happiness to your meals.
10. **Skin Savers**: Certain spices like turmeric and cumin have been known to improve skin health, giving you a radiant and clear complexion.

Commonly Used Spices and its medicinal value

S. No.	Spices	Active Compound	Used	Medicinal Value
1	Ajwain	Thymol	Biscuit, Bhujia, Pickels, Beverages, Curry and snacks	Anti-spasmodic Carminative Effect Improves Digestion
2	Aniseed	Anethole	Mouth Freshener Bakery products Pickels	Treat colic pain Remove flatulence
3	Asafoetida	SH-Compound 2-butylpropyl disulphide	Seasoning agent	Anti-microbial activity Treat cough, bronchitis and remove flatulence Act as a detoxificant agent

S. No.	Spices	Active Compound	Used	Medicinal Value
4	Bay Leaves	Volatile Oil	Pickels Biryani Curry	
5	Cardamom	Cineoil Terpinyl acetate porneol	Flavoring agent Sweet Preparations like food preserves and bakery products	
6	Chillies	carotenoids	Curries Gravy Food Preserve	Anti-microbial Sore Throat Anti Cancerogenic
7	Cinnamon	Eugenol Cineole Cinnamaldehyde	Cakes, Cookies, Puddings Sauces, Pickels, Birayani	Anti-Oxidant
8	Clove		Flavouring agent in additives, pickels, chewing gum, tooth paste, ketchups etc.	Anti-microbial Anti-Fungal
9	Coriander Seed	Isomer of geraniol	Curry, preserves, chutneys, fried foods etc.	
10	Cumin Seed	Aldehyde cumino	Soups, curry, lassi, candies, pulav etc.	Stimulant Carminative agent
11	Fenugreek Seed	Insoluble Fibre	Sambhar, curries	Blood Glucose Level Dysentery
12	Garlic	Allicin Allyldisulphide	Rasam, pickels, chutneys, saucages,	Digestive disorders Anti-cholestroic Anti-bacterial
13	Ginger	Gingerol Shogal	Curry, pickels, tea, beverages, marmalades etc.	Removes joint pain, migraine, headache, cough, motion sickness etc.
14	Mustard Seed	Allyl Isothiocynate	Sandwiches, salad dressings, pickels etc.	Treatment of Cold, congestion, aflatoxins etc.
15	Onion	Allyl Propyl Disulphide	Flavour and thickness of gravies	Anti-bacterial, stimulant, diuretic, maintain normal blood glucose level etc.
16	Pepper	Oleoresin	Seasoning in vegetables, salad, poultry and fish	Cures throat infection, cough, congestion, muscle

S. No.	Spices	Active Compound	Used	Medicinal Value
				pain, headache etc.
17	Saffron	Crocin	Soup, sauces, sweets and milk products etc.	Sedative agent for eyes infections
18	Tamarind	Tartaric acid	Rasam, sambhar and chutneys	Anti-oxidant
19	Turmeric	curcumin	Curry powder, pickels etc.	Anti-cancerogenic

By adding a variety of spices to your meals, you're not just making your food taste better—you're also giving your health a boost. Whether fresh or dried, whole or ground, spices and herbs are an easy, delicious way to enjoy a more vibrant, flavorful diet and a healthier life. So, go ahead and sprinkle a little magic on your next meal!

Spice Functional Mix

Spices are wonderful since they enhance the flavor of food while also being beneficial to one's health. Spices, as opposed to herbs, are derived from plant components such as seeds, fruits, roots, bark, or leaves. They can not only provide taste, but also fight viruses, heal, and improve health. Spices are considered functional foods because they provide health advantages that go beyond simple nutrition. Including a variety of spices in your diet can help you avoid illnesses, minimize health risks, and enhance your general well-being. For example, turmeric includes curcumin, which has powerful anti-inflammatory and antioxidant effects. Cinnamon can help regulate blood sugar levels, while ginger promotes digestion and alleviates nausea. Cloves offer antimicrobial properties, and black pepper helps your body absorb nutrients more effectively. These advantages make spices necessary for a healthy diet. However, adding a variety of spices to your meals every day might be difficult and time-consuming. The simplest method to get their health advantages is to convert them into a handy powder mix that you can quickly incorporate into your food. Making a personalized spice mix allows you to select your favorite flavors while also ensuring that you get a balanced intake of these strong components. Consider starting your day with a sprinkling of a colorful spice blend in your morning smoothie for an instant health boost. Alternatively, add a dab to soups, salads, and even desserts to easily boost taste and nutrients. A well-made spice mix may also serve as a unique present, allowing friends and family to reap the advantages of good health. Making your own spice blend may be enjoyable and creative. You may experiment with various combinations to find which ones work best with particular foods. Furthermore, by preparing your own mix, you may eliminate the chemicals and preservatives found in store-bought mixes, resulting in a more natural and healthy alternative.

Spice mix can be prepared easily at home with the simple instructions mentioned below:

How to prepare spice functional mix at home:

S. No.	Ingredient	Quantity (g)
1	Fenugreek seed	100
2	Coriander Seed	100
3	Cumin	100
4	carom seed	100
5	Aniseed	100
6	Asafoetida	5

Procedure:

1. Clean all the spices to remove the foreign matter.
2. Roast Coriander seed, fenugreek seeds, cumin and carom seeds separately.
3. Then grind all the spices with the help of food mixer grinder to make it into fine powder form.
4. Add asafetida in the prepared spice mixture and mix well.
5. Store it in an air tight container.

Usage of spice functional mix:

1. Use it as an seasoning agent at homely prepared food items like vegetables, dal, curd, chapatti or puri to enhance its aroma, flavor, taste, colour and texture.
2. Take as 5g/day at anytime with water for health benefit.

Health Benefit of Spice Mix:

- ✓ Weight Loss
- ✓ Maintains Normal Blood Pressure Level
- ✓ Maintains Blood Glucose Level
- ✓ Improve Digestion
- ✓ Increase Immunity
- ✓ Increase Palatability

Employment Opportunities:

- ✓ The sale of Spice Functional mix can be an additional source of income generation among the rural strata due to its therapeutics effects.
- ✓ The processing technology of spice function mix is very simple and easy to make.
- ✓ It's an innovative technology for self-employment.

Using a spice mix in your everyday routine helps you stay on track with your health objectives. It's a simple, effective technique to improve your nutrition with little effort. By keeping a jar of your favorite mix on hand, you can easily add a burst of flavor and health benefits to any meal, making it simpler to stick to a healthy eating plan.

In summary, converting spices into a powder mix not only makes them easier to use, but it also enhances their ability to improve your health and culinary experience. Accept the power of spices and allow them enhance your meals and well-being, one sprinkle at a time.

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THE UNIQUE IMMUNE SYSTEMS OF FISH AND SHRIMP

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Abstract
The immune system is essential for protecting organisms against pathogens, encompassing both the innate (non-specific) and adaptive (specific) immune systems. In vertebrates, the immune response is facilitated by various cells and organs. Factors like age, health, and environmental conditions significantly influence immune function, with high stress levels potentially leading to immune collapse. White blood cells, or leucocytes, play a crucial role in the immune system, present in blood and tissues, and are classified into lymphocytes, macrophages, and granulocytes. Lymphocytes generate immunological memory and antibodies; granulocytes engage in non-specific defenses; and macrophages eliminate pathogens through phagocytosis and the release of toxic substances. In fish, lymphoid tissues include the anterior kidney, thymus, spleen, and mucosal-associated tissues. Intrinsic and extrinsic factors impact fish health and immune responses, potentially leading to immune collapse under stress. In shrimp, innate immunity is the primary defense mechanism, as they lack a fully developed adaptive immune system. Shrimp rely on physical barriers like the cuticular exoskeleton and gut enzymes, and immune responses are triggered by pattern recognition receptors (PRRs) detecting pathogen-associated molecular patterns (PAMPs). The shrimp immune system includes both cellular (phagocytosis, encapsulation) and humoral (antimicrobial peptides, clotting proteins) components. Haemocytes, including hyaline, semigranular, and granular cells, play vital roles in these immune responses. Pathogen recognition in shrimp involves various PRRs, which initiate immune responses through signal transduction pathways. Despite lacking adaptive immunity, shrimp possess mechanisms analogous to the interferon system in vertebrates, helping them combat viral infections. Immunostimulants can enhance non-specific immune responses in both fish and shrimp, acting as the first line of defense against a wide range of pathogens. This underscores the importance of non-specific immune mechanisms in maintaining health and defense in aquatic organisms.

Keywords : Specific immune system, Non-specific immune system, Fish, Shrimp

Immunological system in fish

The immune system plays a continuous and crucial role in defending the body against pathogens, providing essential protection. There are two types of immune systems: the non-specific immune system, also known as the innate immune system, and the acquired immune system, referred to as the adaptive immune system. The vertebrate immunological system's key function is to respond to and safeguard against infectious pathogens. The effective operation of the fish immunological system involves various cells, organs, and factors influencing the fish's immune response.

Intrinsic factors like age and health, as well as extrinsic elements such as temperature and changes in abiotic parameters, impact the health condition and subsequently influence the

immune response. These changes induce stress, and if stress reaches high levels, it can lead to a collapse of the immunological system (Lulijwa, 2020).

White blood cells, or leucocytes, are the cells involved in the immune system, present in the bloodstream and tissues. In fishes, lymphoid tissues include the anterior kidney, thymus, spleen, and lymphoid tissues associated with mucus and the intestine (Stosik et al 2023). Leucocyte classification in vertebrates is based on morphological criteria, leading to the differentiation of various groups, namely lymphocytes, macrophages, and granulocytes (Lulijwa et al 2020). A brief explanation of each group is provided below to understand their main characteristics and functions.

Lymphocytes

Distinguished by their remarkable ability to respond to stimuli, lymphocytes are a prevalent type of cell with irregular surfaces Among them, mature lymphocytes are the most common, exhibiting high metabolic potential owing to a substantial number of organelles in the cytoplasm, including mitochondria, golgi apparatus, ribosomes, and endoplasmic reticulum, circulating throughout the body via the bloodstream, they congregate in lymphoid organs, and their quantity varies widely.

The principal function of lymphocytes is to generate immunological memory, antibodies, and regulatory factors such as lymphokines, responding to both humoral and cell-specific immune processes (Fazio, 2019). B lymphocytes originate from the bone marrow, while T lymphocytes are derived from the thymus. T lymphocytes play a pivotal role in cell-mediated immunity and also provide assistance to B lymphocytes, which are responsible for producing antibodies against antigens (Germain, 2001).

Granulocytes

The occurrence and functions of granulocytes vary among fish species, and their origin is traced back to kidney tissues. In teleost fish, there are three types of granulocytes, which include neutrophils, basophils, and eosinophils, with neutrophils being the most prevalent. Granulocytes exhibit a responsive action in the presence of foreign particles entering the body, although they do not specifically identify antigens. This mechanism is termed as a non-specific defense mechanism, elaborated on below.

In the event of an invasion, these cells migrate and undertake the destruction of foreign particles through processes such as phagocytosis or by employing a cytotoxic response (Hine, 1992).

Macrophages

Numerous studies across various fish species suggest that macrophages can serve as a valuable health indicator. These cells play a crucial role in the immune response by actively eliminating pathogens. According to Stosik et al (2023) and several earlier studies, macrophages are identified as the primary phagocytic cells in fishes. They employ two mechanisms to eliminate pathogens: the release of toxic substances and ingestion, a process known as phagocytosis. This activity involves the production of reactive oxygen species (ROS) or microbiocidal oxygen radicals, collectively referred to as respiratory burst.

The regulation of macrophage functions is influenced by lymphokines, with macrophage activating factor (MAF) being a notable example (Bedekar et al 2022). The immunological system of fish is categorized into two branches based on functionality: the natural or nonspecific immune system

and the acquired or specific immune system. The non-specific immune system, notably the natural immune response, is considered more crucial for immunization purposes.

Shrimp immune system

Invertebrates like shrimp primarily rely on innate immune mechanisms since they do not have a fully developed adaptive immune system. While their innate immunity is generally viewed as simpler compared to that of vertebrates, invertebrates thrive in a wide range of environments and have highly effective innate immune responses. These robust defenses enable them to protect against a vast array of pathogens (Jiravanichpaisal et al. 2006).

The shrimp's cuticular exoskeleton serves as the initial barrier, preventing pathogens from attaching and penetrating. Similarly, the oral tract, another potential entry point for pathogens, contains gut enzymes and acids capable of breaking down these invaders. Additionally, the peritrophic membrane, a chitinous layer, shields the intestinal epithelium from direct contact with pathogens that enter through the mouth. However, pathogens can occasionally bypass the initial defense by exploiting damaged cuticles or during intermolt periods. When pathogens penetrate these barriers, they are detected by germline-encoded sensors known as pattern recognition receptors (PRRs) (Cueva et al. 2006). This triggers the activation of both cellular and humoral immune components to mount a defense. Cellular immune responses include phagocytosis, nodulation, and encapsulation, which lead to melanization. These are complemented by humoral responses such as the release of clotting proteins, agglutinins, antimicrobial peptides (AMPs), proteinase inhibitors, and reactive oxygen or nitrogen intermediates. The haemolymph and haemocytes of shrimp primarily produce these cellular and humoral immune responses (Fajardo et al. 2022).

Pathogen recognition

Although crustaceans lack a true adaptive immune system, they have highly organized innate defense mechanisms based on the recognition of non-self entities, providing a nonspecific yet highly effective response to pathogen invasion. Microbial detection is achieved through specific germline-encoded proteins called pattern recognition receptors (PRRs), which are expressed in various cells. These PRRs identify pathogen-associated molecular patterns (PAMPs), which are conserved molecular structures found across different microorganisms, as well as damage-associated molecular patterns that signal cellular stress (Suresh et al. 2022).

Key pathogen-associated molecular patterns (PAMPs) include lipopolysaccharides (LPS) from Gram-negative bacteria, peptidoglycans (PGN) from Gram-positive bacteria, double-stranded RNA (dsRNA) from viruses, and β-glucans (GLU) from fungi. In vertebrates, the interaction between PRRs and their corresponding PAMPs triggers the expression and upregulation of specific pro-inflammatory cytokines and antimicrobial molecules during infection, helping to limit the spread of pathogens (Wilkins & Gale 2010). Cytokines play a crucial role in enhancing the immune responses in shrimp against viral infections. During WSSV infection in shrimp, there is an upregulation of three specific cytokines: the Fas receptor (Fas), platelet factor 4 (PF4), and interleukin 22 (IL-22) (Chen et al. 2022).

Vertebrate pattern recognition receptors (PRRs) are categorized into five families based on protein domain similarities: C-type lectins (CTLs), Toll-like receptors (TLRs), retinoic acid-inducible

gene I-like receptors (RLRs), nucleotide-binding domain and leucine-rich repeat-containing proteins (NLRs), and Absent in melanoma-like receptors (ALRs). These receptors are found in both immunologically active cells and non-immune cells.

Individual members of these receptor families can be differentiated based on their ligand specificity, cellular localization, and the activation of downstream signalling pathways. Utilizing multiple families of PRRs enables the host to detect and respond to a diverse array of pathogenic microorganisms (Kawaguchi et al. 2023). These families are categorized into membrane-bound receptors and unbound intracellular receptors. Membrane-bound receptors include TLRs and C-type lectin receptors (CLRs), which are located on the cell surface or within endocytic compartments. These receptors identify microbial ligands present in the extracellular environment and within endosomes.

The latter group, comprising NLRs, RLRs, and ALRs, is located in the cytoplasm where these receptors monitor the presence of PAMPs and molecules derived from tissue damage. To date, eleven PRR families have been identified in shrimp, including lipopolysaccharide and β-1,3-glucan binding proteins (LGBPs), C-type lectins (CTLs), galectins, thioester-containing proteins (TEPs), fibrinogen-related proteins (FREPs), scavenger receptors (SRs), Down syndrome cell adhesion molecules (Dscam), TLRs, β-1,3-glucan binding proteins (BGBPs), serine protease homologs (SPHs), and trans-activation response RNA-binding proteins (TRBPs) (Wang & Wang 2013a). Numerous studies have documented the expression of various PRRs across different tissues in several crustacean species, shedding light on their responses to a range of ligands and microbial pathogens. These PRRs are generally found to be ubiquitously expressed across all analyzed tissues. Immune challenge experiments have revealed that PRRs exhibit differential responses to various infectious agents, including white spot syndrome virus (WSSV) and bacteria.

In invertebrates, the activation of PRRs initiates a cascade of cellular or humoral responses, either directly or indirectly. These responses include the prophenoloxidase-activating system (proPO), clotting mechanisms, phagocytosis, and the release of NF-kB dependent antimicrobial peptides (AMPs). The regulation of these innate immune responses is mediated by signal transduction pathways, which are activated when PRRs bind to specific PAMPs.

Shrimp possess antiviral regulatory mechanisms similar to the interferon (IFN) system. A novel interferon regulatory factor (IRF) has been identified in shrimp (Li et al. 2015a, b), which controls the expression of the Vago gene, an antiviral cytokine in arthropods, and activates the JAK-STAT pathway to combat viral infections (Wang et al. 2022). Certain Toll receptors in shrimp, when bound to PAMPs like dsRNA, can induce the expression of IRF and its downstream targets Vago4/5. Additionally, an IFN activator involved in antibacterial immunity has been characterized in shrimp.

In shrimp, the presence of a DNA sensing pathway and its interaction with an IFN activator have been shown to trigger an antiviral immune response. This response involves the activation of IFN-β and NF-κB signalling pathways (Soponpong et al. 2022).

The innate immune system of shrimp consists of both cellular and humoral components. Cellular components encompass reactions directly mediated by haemocytes, such as phagocytosis, encapsulation, and nodule formation. In contrast, humoral components primarily involve the

prophenoloxidase-activating system, agglutinins, protease inhibitors, antimicrobial peptides (AMPs), phosphatases, and lysozymes.

Shrimp haemocytes play a crucial role in defending against pathogens by triggering various cellular and humoral responses, including clotting, lysing pathogens, and wound healing. According to established classifications, crustacean haemocytesare categorized into hyaline cells, semigranular cells (SGCs), and granular cells (GCs).

Hyaline cells, the smallest and agranular among the three haemocyte types, function as active phagocytes. Semigranular cells (SGCs), which can constitute up to 65% of haemocytes, contain numerous small eosinophilic granules and play a crucial role in recognizing microorganisms, leading to encapsulation, coagulation, and occasional phagocytosis. Additionally, the cell adhesion protein peroxinectin has been localized in SGCs (Zhu et al. 2022).

Encapsulation of microorganisms is typically accompanied by melanization, a process driven by prophenoloxidase (proPO) stored in its inactive form within the densely packed large eosinophilic granules of granular cells (GCs). Besides proPO, GCs also contain antimicrobial peptides (AMPs), protease inhibitors, and the cell adhesion/degranulating factor known as peroxinectin (Quyoomet al. 2023).

Immunostimulation of non-specific defense mechanisms

Compounds with immune-stimulatory properties in fish and shellfish exhibit the potential to enhance the nonspecific immune responses of these organisms The nonspecific immune response serves as the first line of defense against invading pathogenic microbes and is the primary immunological mechanism through which invertebrates safeguard themselves from diseases In contrast to specific immunity, which targets particular antigens or pathogens, each element of the nonspecific reaction can recognize a broad spectrum of foreign agents Fish and shellfish are believed to rely more on nonspecific immune responses, leading to a significant focus on research aimed at improving these responses (Florean et al.2022).

Mononuclear phagocytes or macrophages play a pivotal role in the cellular component of the nonspecific defense mechanism in fish (Wang et al 2017) In shrimp, the primary defense mechanisms involve the prophenoloxidase (proPO) system and the haemocytes system Both granular and semi-granular cells execute the functions of the proPO system (Zhao et al 2023) Within the proPO activation system, phenoloxidase acts as the terminal enzyme and is activated by peptidoglycans or lipopolysaccharides from bacteria and β-1, 3 glucan from fungi through pattern recognition molecules (Ngambi et al 2016) Phenoloxidase activity has been identified in many species of penaeid shrimp (Nguyen et al 2017).

The activation state of these enzyme systems and cells is commonly used to measure nonspecific immunostimulation Additional measures for this purpose include cell migration, bactericidal activity, phagocytosis, as well as changes in the numbers of leucocytes and the energizing potential of cells upon induction, measured by enzymes and oxidative radicals (Wang et al 2017). Nonspecific defense systems, such as phagocytosis and the production of oxidative radicals, are rapidly triggered by immunostimulants, aiding in the protection of the host against a wide range of pathogens (Munangandu et al 2021).

Conclusion

The immune systems of fish and shrimp demonstrate remarkable diversity and specialization, reflecting their adaptation to various aquatic environments and the constant threat of pathogens. In fish, the immune system is composed of both innate and adaptive responses. Key components include various leucocytes such as lymphocytes, granulocytes, and macrophages, which play distinct roles in pathogen detection, response, and elimination. Lymphocytes, particularly B and T cells, are crucial for adaptive immunity, generating immunological memory and specific responses to pathogens. Granulocytes and macrophages are essential for innate immunity, with granulocytes participating in non-specific defense mechanisms and macrophages acting as primary phagocytic cells.In contrast, shrimp rely solely on their innate immune system due to the absence of an adaptive immune response. Their defense mechanisms are sophisticated, involving both cellular and humoral components. The shrimp's initial barriers include the cuticular exoskeleton and the peritrophic membrane. Once pathogens breach these barriers, the innate immune system, characterized by pattern recognition receptors (PRRs), plays a pivotal role in pathogen detection. These receptors recognize pathogen-associated molecular patterns (PAMPs) and activate downstream signalling pathways, leading to various immune responses such as phagocytosis, melanization, and the release of antimicrobial peptides (AMPs).The understanding of these immune systems highlights the importance of both intrinsic and extrinsic factors in modulating immune responses. Factors such as age, health, temperature, and environmental changes significantly influence the efficacy of the immune system in both fish and shrimp. Stress, particularly at high levels, can lead to immune system collapse, underscoring the delicate balance required for maintaining immune competence.Enhancing nonspecific immune responses through immunostimulants has been a focus of research, particularly for aquaculture applications. These compounds aim to bolster the innate defenses of fish and shrimp, providing a broader protective mechanism against a variety of pathogens. The activation of mononuclear phagocytes, the prophenoloxidase (proPO) system, and other nonspecific defense systems like phagocytosis and oxidative radical production, are critical measures of immunostimulation. Overall, the immune systems of fish and shrimp are well-adapted to their respective environments, with each system having evolved unique mechanisms to combat infections. Understanding these systems provides valuable insights into improving health management practices in aquaculture, ensuring the sustainability and productivity of these vital resources.

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UNLOCKING THE POWER OF SOY: THE VERSATILE WORLD OF SOY PROTEIN ISOLATE

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Abstract
Soy protein isolate (SPI) is a concentrated soy protein with 90% or more protein content, it is often used in food fortification, meat substitutes, and supplements. It is valued for its complete amino acid profile and low allergenic potential. The production process of SPI involves extracting protein from defatted soybean flakes, followed by washing and drying into a fine powder. While SPI contributes significantly to protein-enhanced foods and dietary products, potential allergenicity and digestive tolerance should be considered. Soy isolate is good for people aiming to reduce fat, build lean muscle, and lower cholesterol levels. It is a complete protein with all nine essential amino acids, similar in quality to meat and milk products. SPI receives a protein quality score of 1, which is the highest possible score.

Introduction
Soy protein isolate (SPI) is a highly processed form of soy protein with a protein content of over 90% on a dry basis. It is made from soybeans by removing most of the fats and carbohydrates, resulting in a protein-rich product. Soy protein isolate is a type of soy protein processed to remove most non-protein components, such as carbohydrates and fats, leaving mostly protein. It is typically made from defatted soybean flakes that are dehulled and processed into a dry powder.

Soy protein is of the highest quality, providing approximately 35 to 38 percent of protein calories. Using the Protein Digestibility Corrected Amino Acid Score (PDCAAS) method, the protein quality rankings are determined by comparing the amino acid profile of the specific food protein against a standard amino acid profile with the highest possible score being a 1.0 and SPI receives a score of 1 i.e., the highest possible score, according to guidelines from the Food and Drug Administration (FDA) and the World Health Organization (WHO). It means the quality of soya protein is equal to that of meat and milk products. Soy protein isolate is used in various foods, such as baked goods, pasta, protein drinks, and dairy products. It offers multiple health benefits as well.

Difference between Soy protein vs. Soy protein isolate
Soyprotein: Soy protein is isolated from soybeans made from flaked and defatted soybeans and acts as a food additive consisting of a certain amount of carbohydrates, added sugars, and fiber.

How it is made
In soyprotein, all the constituent fat is removed from soybeans before extracting any water-soluble non-protein elements. This leaves a highly concentrated form of soy protein that contains carbohydrates and fiber as well.

Uses
Standard soya protein is typically used as a concentrate and texture, usually added to cereals,

beer, bakeries, meat substitute and infant formulas.

Benefits

- Cholesterol : free, low in saturated fat, and a great source of dietary protein that is easy to digest for the body. Research has suggested that soy protein can reduce bad cholesterol.
- Nutritional info per28 gram serving : 94 calories, 0.1 grams saturated fat, 16.5 grams protein, 8.8 grams carbohydrate and 1.6 grams fiber.

Soy protein isolate : The soya protein isolate is a complete plant protein source. It is the closest plant protein that is most similar to the amino acid profile of milk proteins and is a very popular non-dairy alternative. It is the highest-quality version of soy that is possible to source.

How it is made

Soy protein isolate is made by removing everything, including carbohydrates and fiber, from defatted soybeans, leaving only the protein results in a purer form of protein compared to its original form.

Uses

More refined and processed than standard soy protein, the isolate is highly biologically valuable (easily absorbed by the body and most of it is used) perfect for athletes and people who are active. Therefore, it is commonly found in supplements like protein bars and shakes, enriched dairy products and meat substitutes.

Benefits

Soy isolate is perfect for people who want to cut fat and generate lean muscle, it fits into a calorie-deficit diet plan easily as no carbohydrates and contributes to a lowering of levels of cholesterol. Soy is a complete protein with all nine essential amino acids, more than other plant proteins. It has lots of health benefits.

Nutritional profile and Benefits of Soy Protein Isolate

i. **Cholesterol** : Lowers the cholesterol levels, low-density lipoproteins i.e.; LDL (Bad cholesterol) and triglycerides.
ii. **Protein** : For vegetarian or vegan diet, soy protein is a healthy way to reach one's protein content goals. Typically contains over 90% protein by weight. **It is a source of complete protein** as it contains all essential amino acids necessary for human nutrition.
iii. **Low in Fat and Carbohydrates** : Virtually fat-free and low in carbs.
iv. **Gastrointestinal health** : Having fiber in soy, it is found to be great for gastrointestinal system. Adding fiber to the diet keeps stomach and lower intestines stress free and healthy.
v. **Vitamins and minerals** : Zinc, vitamin B, calcium, iron, and magnesium absorbed from soy isolate easily. They all together impart energy, allowing for better performance in sports. There are also plenty of antioxidants in soy.
vi. I**soflavones** :Isoflavones are chemicals present in soy protein that help prevent bone loss, which can occur after menopause and with certain cancers.
vii. **Cardiovascular health :** Eating soy protein isolate instead of animal proteins can help improve overall heart health.

Production Process

1. **Extraction**: Soybeans are cleaned, cracked, and then dehulled. The resulting soybean flakes are then processed to extract the oils using solvents or mechanical pressing.
2. **Precipitation**: The defatted soy flakes are mixed with water and an alkaline solution to extract the proteins. This mixture is then separated and the protein is precipitated out.
3. **Washing and Neutralization**: The precipitated protein is washed to remove residual chemicals and then neutralized to adjust the pH.
4. **Spray Drying**: The resulting protein solution is then spray-dried into a fine powder, resulting in soy protein isolate.

SOYPROTEIN ISOLATES IN FOOD

Role in baked goods & pasta

Soy protein isolate is utilized in baked and pasta products to enhance water absorption in the dough, strengthen gluten, and improve the flavor and nutritional value of the final product. Additionally, it can prolong shelf life, enhance nutritional content, prevent bread from getting stale, improve the crispness of biscuits, enhance bread crust color, improve cake texture, and create a fine honeycomb texture in cakes while preventing them from becoming dry or hard.

Role as dietary supplements and in protein drinks

Soy Protein Isolate is utilized in beverages to enhance their protein content. In the United States, over 12,000 types of soybean protein are incorporated into food and drinks because people enjoy the flavor and taste of soybeans when added to beverages. Soy protein is used to create protein drinks such as soy milk, soy cheese, fruit juice soy milk, coffee bean milk, etc., which have high nutritional value and a pleasant, sweet taste.

Role in meat products

In the production of meat products, soy protein isolate is used as a filler or functional ingredient. It can enhance flexibility, retain moisture and fat, prevent gravy separation, enhance flavor, and improve the overall quality of meat. Imported protein is utilized as a substitute for soy protein isolate in the processing of meat products. This modified protein has both gelling and solubility properties, which increases the yield and reduces the production cost of meat products. Adding 2% soy protein isolate can result in sausages gaining 10% more weight and varying degrees of flavor improvement. Incorporating soy protein isolate into high-quality meat products not only enhances their flavor and texture but also increases protein content and enhances vitamin levels.

Role in Dairy Products

Powdered infant formula milk and liquid milk can be produced using soy protein isolate, enhancing the milk's protein content and flavor by combining its advantages in amino acid content, ratio, and flavor. Soy protein isolate is stable, emulsifiable, soluble, and dispersible. With over 90% protein content, it is free from lactose and cholesterol, offering comprehensive nutrition. As a milk substitute, soy protein isolate can enhance ice cream emulsification and prevent lactose crystallization.

Soybean protein isolate in Ice-Cream

Researchers have been working on introducing soybean protein isolate in ice cream. It has been found that. An evenly distributed protein in the entire system improves the protein content and

nutritional value. Ice cream shows no negative changes in texture, no beany flavor, no roughness, and puffing rate. It does not contain any synthetic additives, making it suitable for people of all ages.

Conclusion

Soy protein isolate is a versatile ingredient that provides a concentrated source of high-quality protein with minimal fat and carbohydrates. Its use in various food products and dietary supplements makes it a popular choice for consumers looking to increase their protein intake or follow plant-based diets. However, individuals with soy allergies or specific dietary needs should consider alternatives or consult with a healthcare professional before consuming soy protein isolate products.

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AGNIHOTRA FARMING : HARNESSING ANCIENT WISDOM FOR SUSTAINABLE AGRICULTURE

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Abstract

Agnihotra farming, an ancient Vedic agricultural practice, leverages the power of a precisely timed fire ritual to enhance soil fertility and crop yield. This holistic approach integrates traditional wisdom with modern sustainability principles, offering a viable solution to contemporary agricultural challenges. By performing Agnihotra at sunrise and sunset, practitioners believe they can purify the atmosphere, enrich the soil, and promote plant health, leading to higher productivity without reliance on chemical inputs. Research indicates that Agnihotra ash possesses unique properties that can boost microbial activity in the soil, improve water retention, and enhance nutrient availability. This method aligns with the goals of sustainable agriculture by reducing environmental impact, preserving biodiversity, and fostering resilient farming systems. As the global demand for eco-friendly agricultural practices grows, Agnihotra farming presents a promising intersection of ancient knowledge and modern ecological sustainability, potentially revolutionizing the way we approach farming in the 21st century.

Keywords : Agnihotra ash, soil fertility, plant health, sustainable agriculture,

Introduction

In ancient times, traditional farming methods led to a prosperous "Golden Era" in the country, where the social fabric thrived. In India, agriculture was guided by the principle of "Jiva Jivasyajivanam/jiwajiwatjayate," meaning life sustains life, with organisms living off one another. Adherence to these principles resulted in record-high yields across various commodities, with paddy production reaching 7-8 tons per hectare in Tamil Nadu, according to available data (Claude, 2010). The emphasis on the green revolution has led to a neglect of crucial factors like soil biology, environmental ecology, local seed varieties, and traditional knowledge, which were once our main strengths. Consequently, we are now facing current crises in agriculture. The adverse impacts of intensive farming practices have prompted a reconsideration of alternative and sustainable agricultural systems. As a result, various organic farming approaches such as Biodynamic Farming, Rishi Krishi, Natural Farming, Panchagavya Krishi, Homa Organic Farming, and Jaivik Krishi have emerged in different regions of the country (Pathak, 2013). Out of different indigenous farming systems, Agnihotra farming, also known as homa farming, is a holistic agricultural approach that integrates ancient Vedic rituals with modern farming practices. It involves performing the sacred Agnihotra ritual-a fire ceremony-at specific times of sunrise and sunset, believed to purify the environment and invoke divine blessings. In Homa farming, Agnihotra, a gift to humanity from most ancient Vedic Sciences of bio energy, medicine, agriculture, and climate engineering, is a ritual designed to purify the atmosphere using fire within a copper pyramid synchronized with the biorhythms of sunrise and sunset. By harnessing the

radiative effects of specific astrological alignments and chanting mantras, this practice enhances the absorption of cosmic energies from the Sun and Moon, thereby restoring the planet's energy cycle to a state of natural harmony for the benefit of all living beings (Ram and Pathak, 2018).The ash collected from the Agnihotra fire is then used as a potent natural fertilizer in agriculture. Agnihotra farming aims to enhance soil fertility, promote plant growth, and create a harmonious relationship between humans, nature, and the cosmos. It combines traditional wisdom with sustainable farming techniques to cultivate crops in a manner that respects ecological balance and spiritual principles. Nowadays, organic farmers in South America and India are actively practicing it, with growing interest also seen in North America and Europe.

What is Agnihotra?

The term Agnihotra originates from Sanskrit, where "agni" means fire and "hotra" denotes healing. Therefore, Agnihotra is regarded as the science of healing the atmosphere using pyramid fires to eradicate pollution and contamination. This technique, passed down from the ancient Arharva Vedas, was revitalized in the mid-20th century by Parama Sadguru Shree Gajanan Maharaj and his disciple, Shree Vasant V. Paranjpe**.**

Why Agnihotra Farming is Necessary?

Agnihotra farming is essential for restoring ecological balance and promoting sustainable agriculture. It harnesses ancient Vedic wisdom, utilizing Agnihotra fire rituals to enhance soil fertility, improve crop yields, and mitigate environmental degradation, thereby ensuring long-term food security and ecosystem health.

Principles of Agnihotra Farming

The core principle of Agnihotra farming is the utilization of the Agnihotra fire to create an environment conducive to plant growth and soil health. The process involves the burning of specific organic materials, such as cow dung, ghee (clarified butter), and rice grains, in a copper pyramid-shaped vessel. The smoke and ash produced during the ritual are believed to contain nutrients and beneficial microorganisms that enhance soil fertility. Additionally, the positive vibrations and energies generated by the ritual are thought to promote plant growth and increase resistance to pests and diseases (Mahajan *et al*.,2021).

Materials Used in Agnihotra Farming

Agnihotra farming is a traditional Vedic agricultural practice that involves the performance of the Agnihotra ritual, a fire ceremony performed at sunrise and sunset. This ritual is believed to have various spiritual, ecological, and agricultural benefits. The materials used in Agnihotra farming are simple and primarily include:

1. **Cow Dung**: Cow dung is considered sacred in Hinduism and is a fundamental component of Agnihotra farming. It is used to prepare the fire pyramid or Agnihotra pot, which serves as the focal point of the ritual.
2. **Ghee (Clarified Butter)**: Ghee is a type of clarified butter made from cow's milk and holds significant importance in Vedic rituals. A small amount of ghee is placed in the Agnihotra pot as an offering to the fire during the ceremony.
3. **Rice**: Rice grains are used as offerings in the Agnihotra ritual. A specific quantity of uncooked, whole rice grains is offered into the fire as part of the ceremony.
4. **Agnihotra Copper Pyramid** : The Agnihotra copper pyramid, also known as the Agnihotra pot or Agnihotra kund, is a specially designed vessel used to perform the Agnihotra ritual. It

typically consists of a small copper pyramid-shaped container with a narrow opening at the top.

5. **Dried Cow Dung Cakes**: Dried cow dung cakes are used as fuel for the fire in the Agnihotra pot. These cakes are made from cow dung mixed with straw and dried in the sun, providing a clean and sustainable source of fuel for the ritual fire.
6. **Water**: Water is used to purify and cleanse the Agnihotra pot before and after each ritual. A small amount of water is sprinkled around the pot as part of the ceremonial purification process.

These materials are used in combination to perform the Agnihotra ritual, which is believed to create a harmonious and healing energy field beneficial for agricultural productivity, soil fertility, and overall well-being.

Preparation of Agnihotra Fire

1. **Select a Clean Location**: Choose a clean and quiet outdoor location for performing the Agnihotra ritual. It should be free from distractions and pollution.
2. **Set Up the Agnihotra Pyramid**: Place the Agnihotra copper pyramid (pot) on a stable surface, such as a small platform or the ground. Ensure that the pyramid is positioned facing east-west, with the opening at the top.
3. **Prepare the Fire**: Use dried cow dung cakes or dried wood sticks as fuel for the fire. Place a small amount of cow dung cakes or wood sticks inside the Agnihotra pot, leaving enough space for air circulation.
4. **Add Ghee and Rice**: Place a teaspoon of ghee (clarified butter) and a small quantity of uncooked, whole rice grains on top of the cow dung cakes or wood sticks inside the pot. These offerings symbolize gratitude and abundance.
5. **Light the Fire**: Use a matchstick or a lighter to ignite the fire inside the Agnihotra pot. Allow the flames to catch on to the fuel and ghee, ensuring that the fire burns steadily.
6. **Chant Mantras**: While the fire is burning, chant the Agnihotra mantra or other Vedic mantras associated with the ritual. Focus your intention on invoking positive energy and blessings for the land, crops, and environment. **At Sunrise,** Soory'ayaSw'ah'a, Soory'ayaIdam Na Mama /Praj'apatayeSw'ah'a, Praj'apatayeIdam Na Mama. **At Sunset,** AgnayaSw'ah'a, AgnayeIdam Na Mama/Praj'apatayeSw'ah'a, Praj'apatayeIdam Na Mama.
7. **Maintain the Fire**: Keep a watchful eye on the fire to ensure that it continues to burn steadily throughout the duration of the ritual. Add additional fuel if necessary to maintain the flames.

Collection of Agnihotra Ash

1. **Allow the Fire to Burn Out**: After the Agnihotra ritual is complete, allow the fire inside the Agnihotra pot to burn out naturally. Do not extinguish the fire artificially.
2. **Cooling Period**: Once the fire has burned out completely, allow the Agnihotra pot to cool down for some time. The ashes should be cool to the touch before proceeding with the collection.
3. **Collect the Ashes**: Carefully collect the ashes from the Agnihotra pot using a clean container, such as a small metal or ceramic bowl. Use a spoon or spatula to scrape the ashes from the bottom and sides of the pot.
4. **Storage**: Transfer the collected Agnihotra ash into a clean and dry container with a lid. Store the ash in a cool, dry place away from direct sunlight and moisture.

Effect of Agnihotra Ash in Agriculture

When Agnihotra is performed correctly with precise timings, pure ingredients, and proper pronunciation of mantras, the resulting ash is full of subtle energy (Sharma *et al.*, 2011). The ash produced from Homa farming is very crucial. It benefits all stages of farming operations, enhancing soil moisture retention and solubility of nutrient like phosphorus. Experiments in Russia confirmed that Ash is non-radioactive. Studies have shown that Agnihotra ash promotes rice seed germination (Heisnam *et al*., 2004), supports beneficial microorganisms, and suppresses pathogens (Ram *et al.,* 2016). Ash-treated moong seeds germinate faster (Abhang *et al.,* 2015), and rice seeds show improved growth (Devi *et al*., 2004). It also increases the nutritional value and yield of mushrooms (Indira *et al.,* 2010). Homa Farming, introduced globally by Shree Paranjpe, notably controlled Black Sigatoka in South American banana plantations (Garcia, 2009). Ash application on tomato foliage reduces fruit and shoot borer infestation (Punam *et al.,* 2011).In a study conducted by Heschl (2009) on soybean cultivation, it was observed that Homa organic farming yielded higher average seed weight per 1000 seeds (g), increased protein content percentage in seeds, elevated oil content percentage in seeds, and lower urease activity compared to Conventional Agriculture.

Applying methods of Agnihotra Ash

1. **Application to Soil**: Agnihotra ash is traditionally used as a potent organic fertilizer and soil amendment. It is rich in essential minerals and trace elements beneficial for plant growth and soil fertility. For fields irrigated before sowing, apply 5 kilograms of Agnihotra ash per acre, spreading it evenly across the fields.
2. **Foliar Application**: Agnihotra ash can be dissolved in water to create a nutrient-rich solution for foliar spraying or soil drenching. This helps in delivering nutrients directly to plants' roots and leaves.
3. **Composting**: Agnihotra ash can be incorporated into compost piles to enhance microbial activity and accelerate the decomposition process. It helps in producing nutrient-rich compost for enriching the soil.

Scientific Approach of Agnihotra farming

The profound influence of sound vibrations on energy fields has been recognized since ancient times and corroborated by modern science. Agnihotra, synchronized with the natural circadian

rhythm of sunrise and sunset, embodies the ancient Vedic science of bio-energy. Through the burning of specific substances and chanting of mantras, Agnihotra harnesses multidimensional effects with significant value. Its fumes, rich in formaldehyde, ethylene oxide, propylene oxide and other compounds, effectively inhibit the growth of pathogenic microbes, purifying the atmosphere and enhancing life energy (Prana). By aligning Prana and mind, Agnihotra mitigates pollution effects, utilizing the dual energies of heat from the fire and the sound of Vedic mantras. This harmonious blend yields physical, psychological, and spiritual benefits, fostering holistic well-being in its practitioners and the surrounding environment (Narang, 2009).

Benefits of Agnihotra Farming : The importance of Agnihotra farming include:

1. **Soil Fertility Enhancement**: Agnihotra ash, a byproduct of the ritual, is believed to be rich in nutrients like potassium and others micronutrients. When sprinkled on the soil, it is thought to improve soil fertility, enhance nutrient availability, and promote microbial activity, leading to healthier and more productive soils.
2. **Pest and Disease Management**: Agnihotra ash is also believed to possess pesticidal and fungicidal properties. When applied to crops or mixed with water and sprayed, it may help control pests and diseases, reducing the reliance on synthetic pesticides and fungicides.
3. **Stress Reduction and Crop Yield Improvement**: Proponents of Agnihotra farming claim that the positive vibrations generated by the ritual have a harmonizing effect on the environment, reducing stress in plants and promoting their growth and development. As a result, crops grown in Agnihotra-treated fields are said to exhibit increased vigor, resilience, and yield potential.
4. **Environmental Harmony**: Agnihotra farming emphasizes the importance of maintaining a harmonious relationship between humans, nature, and the cosmos. By performing the Agnihotra ritual regularly, practitioners seek to create a balanced and positive energy field that fosters ecological equilibrium, biodiversity conservation, and overall environmental well-being.
5. **Spiritual and Cultural Connection**: Beyond its agricultural benefits, Agnihotra farming holds spiritual and cultural significance for many practitioners. It is seen as a sacred ritual that honors ancient traditions, connects individuals with the rhythms of nature, and fosters a sense of reverence and gratitude towards the Earth and its resources.

Disadvantages of Agnihotra Farming : The disadvantages of Agnihotra farming include:

1. **Limited Scientific Evidence**: There is a lack of empirical scientific evidence to support the claimed benefits of Agnihotra farming, making it challenging to ascertain its effectiveness in improving soil fertility, pest control, or crop yield enhancement.
2. **Time and Labor Intensive**: Performing Agnihotra rituals requires regular dedication of time and effort, as it involves conducting fire ceremonies at specific times, typically at sunrise and sunset. This can be demanding for farmers with busy schedules or those managing large agricultural operations.
3. **Dependence on Traditional Knowledge**: Agnihotra farming relies heavily on traditional Vedic knowledge and practices, which may not always align with modern agricultural science and technology. This limits its adoption and scalability, especially among farmers who prioritize evidence-based practices.

4. **Resource Constraints**: Agnihotra farming requires specific organic materials, such as cow dung, ghee, and rice grains, for the fire ritual and ash production. Farmers may face challenges in sourcing these materials sustainably and affordably, particularly in urban or resource-constrained areas.
5. **Cultural and Religious Limitations**: Agnihotra farming is deeply rooted in Hindu spirituality and Vedic traditions, which may pose cultural or religious barriers to adoption among farmers from diverse backgrounds or communities with different belief systems. This limits its acceptance and implementation on a broader scale.

Conclusion

The escalating degradation of the environment, soil, and human health necessitates the adoption of Homa therapy due to its holistic benefits across the ecosystem. As an ancient practice, Homa organic farming emerges as a viable solution to contemporary challenges stemming from the indiscriminate use of chemicals. This eco-friendly approach aims to harmonize the relationship between living organisms and the natural world. Transitioning from chemical-intensive farming to organic practices is imperative for restoring soil and environmental health.

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