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PADDY CUM FISH CULTURE – A SUCCESSFUL INTEGRATED FARMING APPROACH FOR LIVELIHOOD IMPROVEMENT & INCOME GENERATION IN CHURACHANDPUR DISTRICT OF MANIPUR

Ningthoukhongjam Soranganba[1], Ch. Basudha[2] and Sanjay Kumar Das[3]
[1]ICAR-KVK Churachandpur, ICAR-RC for NEH Region, Manipur Centre
[2,]ICAR-RC for NEH Region, Manipur Centre, Lamphelpat, Imphal
[3]ICAR-RC for NEH Region, Umroi Road, Umiam, Meghalaya
Corresponding Email: adsoraning@gmail.com

Abstract
Production has been a challenging task for the marginal and resource poor farmers which become even prominent for upland and hilly region. Integrated approach of farming practice has certainly pave a new way for maximizing the production from limited land area and available resources without much input and modification in farming practice. After successful on farm trial by KVK Churachandpur, the integrated paddy cum fish culture has been demonstrated in frontline mode for horizontal spread and has benefitted hundreds of farmers covering more than 100 hectare of upland and paddy cultivable area of Churachandpur district of Manipur. This integrated farming module developed by ICAR-RC for NEH Region, Umaim with certain modification as per the local conditions, can be a game changer for the people of Churachandpur and Manipur state as a whole.

Challenges

Rice is the staple food of Manipur and similarly fish is one of the most preferred forms of animal protein. The demand of fish outweighs the supply both in valley and in hill populous of the state. Most of the paddy cultivations are confined in the valley and foothills of the region and so does the aquaculture practices where there is ample requirement of water for both the system. Farmers of the district residing at the plain and foothills are cultivating local paddy variety which usually gives low to average yield. Few of them have very small to medium pond sizes nearby their plots and/or agricultural land which they are not able to harness for aquaculture uses. Also, due to limited proper area for pond construction and perennial source of water, the aquaculture practice is not possible for most of them. The integration of both the farming system will act as a boon for the farmers of Churachandpur district, offering a diversified farming system and doubling their income from the same unit area. Proper technological knowhow and guidance could serve as a catalyst for boosting their income.

Initiatives

The potential offered by the food and feeding habit of the region along with limited land for paddy cultivation and similarly water for aquaculture gives a unique challenge to the subject experts of ICAR-KVK Churachandpur. After considering the baseline issues, it has been concluded that despite giving regular training on the line of paddy cum fish culture, an “On Farm Trial (OFT)” should be taken up to assessed the particular technology in the district. The paddy cum fish farming system was put up as an OFT in the annual Scientific Advisories Committee (SAC) meeting and after due deliberation and discussion, the committee approved the trial to be taken up for 3 years. Considering the regional suitability and proximity, the package and practices released by ICAR-RC for NEH Region, Barapani (2013) on "Integrated Paddy cum fish Farming technology" was tested on trial basis at different locations. After successful testing for three years, the same committee approved for wider dissemination through Frontline Demonstration (FLD) covering every potential area of the district. The technology demonstrated through this FLD programme can be summarized as:-

a) RC Maniphou -13 as the paddy variety
b) Advanced fingerling of Common carp as fish species
c) Stocking of fish fingerlings @ 5000/ha
d) Stocking after 21 days of paddy transplanting

The culture duration may differ from one location to another based upon the availability and water retention of the dugout trench (which constitute about 10% of the total area), it usually last for 4-5 months in the district.

Results

The paddy cum fish culture demonstration in Churachandpur district showed a good result in terms of overall production and percent change in income generation as compared to the traditional mono cropping of paddy alone. The average fish production is slightly lower @ 480kg/ha (avg. body weight of 150gm) in comparision to 683kg/ha on-station trial at ICAR Barapani (*Technology Inventory of Northeast India, Ch-10, Technology No. 7, Page no. 313-314*). Here one interesting aspect for difference in fish yield can be clearly observed due to the difference in duration of culture between the two locations (i.e. Barapani, Meghalaya and Churachandpur, Manipur). As reported from the research centre, about 237 days i.e. approximately 8 months of culture duration gives a yield of 683 kg where as in Churachandpur condition, the average yield of 480kg/ha was achieved from culture duration of 4-5 months.

Impact

The paddy production of 4320 kg/ha (RC Maniphou -13) was achieved in local condition. Difference in culture duration of 3-4 months may be considered as the reason for yield gap between the on-station and FLD results. For a unit area of 0.25ha (*one sangam in local unit area*) a gross income of Rs. 52,350/- and net income of 36,000/- can be earned by an individual farmer. The percent change in production cannot be calculated as the base production of fish was not there in case of mono cropping of paddy alone whereas the percent change in overall income from fish and paddy as compared to paddy alone gives an overwhelming increased in 471% income for the farmers. All the farmers implementing this IFS module are very happy and most of them expressed their desire to further expand the culture area and happy to spread the good news to their near and far relatives. They also introduce more farmer friends and approach our KVK for giving training and similar demonstration in their villages.

Table 1. Production and Income difference before and after intervention of KVK

Status of intervention	Area (ha)	Production (kg)	Gross Income (Rs.)	Net Income (Rs.)	% change in income
Before	0.25	1200kg (paddy)	31500	6300	471
After		1080kg (paddy 120 kg (fish)	52350	36000	

Please note that the price of fish in local market based upon the size is taken as Rs 200/kg

Lesson Learned

The paddy cum fish culture in Churachandpur is a huge success and gaining momentum in the district after the implementation of FLD programme. Few points which can be learned as an expert from the programme is that most of the farmers follows the golden nomenclature of “seeing is believing” i.e. they were reluctant to make any changes and renovate/dug trench for culturing fish in their paddy plot. This may be due to fear of venturing a new area of farming practice or lack of financial support. Whenever required and/or necessary for much needed beneficiaries, the critical inputs e.g. the paddy and fingerlings were provided by the KVK up to certain extend and the labour cost incurred for construction of trench were borne by the farmers themselves. The regular training, kishan gosthi and FLD programme help them to gain their confidence and let to wide spread implementation of this IFS module.

Supporting Quotes and Images

Mr. Haokhopao Kilong, 60 years old from Saiton Khunou; adhaar no. 757102839797, contact no. 8730925101 mentioned that “*although the paddy production was slightly lower from the earlier crops however due to the integration, there was a huge difference in income generation and expressed his willingness to continue and expand the farming area*”.

Mr. Thanggou, 23 years old from Siden village; contact no. 9862684463 expressed that “*integrated paddy cum fish farming will be a game changer for the marginal farmers of his area*”

Mr. Thongkhomang, 56 years old from Dampi village; contact 9436830944 also mentioned that “*scientific approach to integration with fish help them generate more income as compared to traditional monocropping of paddy alone*”

Plates 1: Demonstration of Paddy cum fish farming at Saiton Khunou

Plates 2: Fish harvest from paddy plot by Mr. Haokhopao Kilong

Plates 3: Demonstration of Paddy cum fish farming at KVK Churachandpur farm

Plates 4 & 5: Demonstration of Paddy cum fish farming at KVK Churachandpur

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BEE VENOM: AN OVERVIEW

Astha Bansal and Sneha Bag
Lovely Professional University, Phagwara, Punjab – 144001, India
Corresponding Email: aasthabansal242001@gmail.com

Abstract
Apitoxin, the name given to bee venom, has been utilised mostly in traditional medicine for millennia and is receiving more and more attention in contemporary studies. In-depth information about bee venom, including its chemical make-up, biological effects, health advantages, modes of action, and prospective therapeutic uses, is provided in this page. This article, which is based on a review of the scientific literature, intends to increase knowledge of the therapeutic benefits of bee venom while highlighting the need for more study to fully realise these benefits.

Introduction

Bee venom is produced by honeybees (*Apis mellifera*), has a long history of usage in folk medicine across the globe. Ancient cultures used it for a variety of maladies, such as arthritis, skin disorders, and pain relief, after realising its medicinal benefits. Modern scientific investigation is revealing the intricate makeup and potential medicinal uses of bee venom today. This article's goals are to thoroughly examine bee venom by going over its chemical components, biological impacts, health advantages, mechanisms of action, and prospective therapeutic uses. By doing this, it hopes to inspire additional study in this area and give a thorough overview of bee venom.

Composition of Bee Venom

A diverse mixture of bioactive chemicals, such as peptides, enzymes, and other elements, make up bee venom. These are the main elements of bee venom:

1.Melittin: The majority of the dry weight of bee venom, or about 50%, is made up of melittin. It is a potent antimicrobial peptide with broad-spectrum antibacterial, antifungal, and antiviral action. Melittin can alter immunological responses and has anti-inflammatory properties.
2. Apamin: A neurotoxic peptide called apamin is present in bee venom. It is a calcium-activated potassium channel (SK channel) blocker that has been investigated for its possible use in the treatment of pain and neurological diseases.
3.Adolapin: Bee venom contains the anti-inflammatory peptide adolapin. By preventing the formation of inflammatory mediators including prostaglandins and leukotrienes, it aids in the reduction of pain and inflammation.
4. Mast Cell Degranulating Peptide (MCDP): In bee venom, a peptide called MCDP triggers the release of histamine and other mediators that are involved in allergic reactions. It affects how the immune system reacts to venom and may help explain why bee venom has healing properties.
5. Phospholipase A2 (PLA2): The enzyme phospholipase A2 is present in bee venom and has a role in the inflammatory response. It causes the hydrolysis of phospholipids in cell membranes, which produces a range of inflammatory mediators. PLA2 demonstrates antibacterial properties as well.
6.Hyaluronidase: An important component of the extracellular matrix, hyaluronic acid, is broken down by the enzyme hyaluronidase found in bee venom. Hyaluronidase enhances the dispersion of other venom components and facilitates their activity by decomposing hyaluronic acid.

7. Other Bioactive Compounds: Other peptides, enzymes, and other components found in bee venom also contribute to its medicinal effects. Apamin-binding proteins, peptides having antibacterial action, and immunomodulatory enzymes are some of these ingredients.

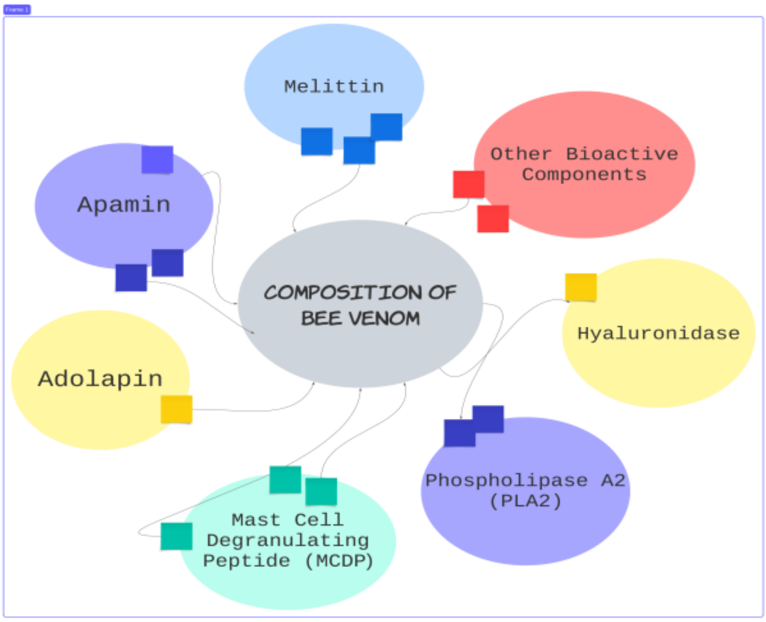

Fig. Composition of bee venom

Biological Effects of Bee Venom

There are several biological effects that are attached to bee venom and some of them are mentioned here to help one know about it.

1. Anti-inflammatory Effects : Bee venom effectively reduces inflammation by altering a number of signalling pathways. It prevents the synthesis of pro-inflammatory cytokines such interleukin-1 beta (IL-1) and tumour necrosis factor-alpha (TNF-). Additionally, nuclear factor-kappa B (NF-B), a crucial regulator of inflammation, is suppressed by bee venom.

2. Analgesic Effects : Since ancient times, bee venom has been utilised as a traditional painkiller. It can lessen pain by altering pain receptors such as transient receptor potential vanilloid 1 (TRPV1) and purinergic receptors. The analgesic effects of bee venom are also helped by its anti-inflammatory properties.

3.Immunomodulatory Effects : Bee venom has a variety of effects on the immune system. It has an impact on how immune cells work by encouraging the activation and growth of specific immune cells, like macrophages and natural killer cells. Interleukin-10 (IL-10), which aids in the regulation of immunological responses, is one of the immuno-modulatory cytokines that are produced as a result of bee venom.

4. Anticancer Properties : Many elements of bee venom have shown interesting anticancer properties. By causing apoptosis, repressing metastasis, and limiting tumour growth, melittin in particular demonstrates cytotoxic actions against different cancer cells. Conventional cancer therapies like chemotherapy and radiation therapy are made more effective by bee venom.

5. Antimicrobial Properties : The antibacterial properties of bee venom make it effective against a variety of diseases, such as bacteria, fungus, and viruses. Melittin and other antimicrobial peptides found in bee venom damage microbial cell membranes, which results in their demise. The antibacterial property of bee venom emphasises its potential to fight infectious disorders.

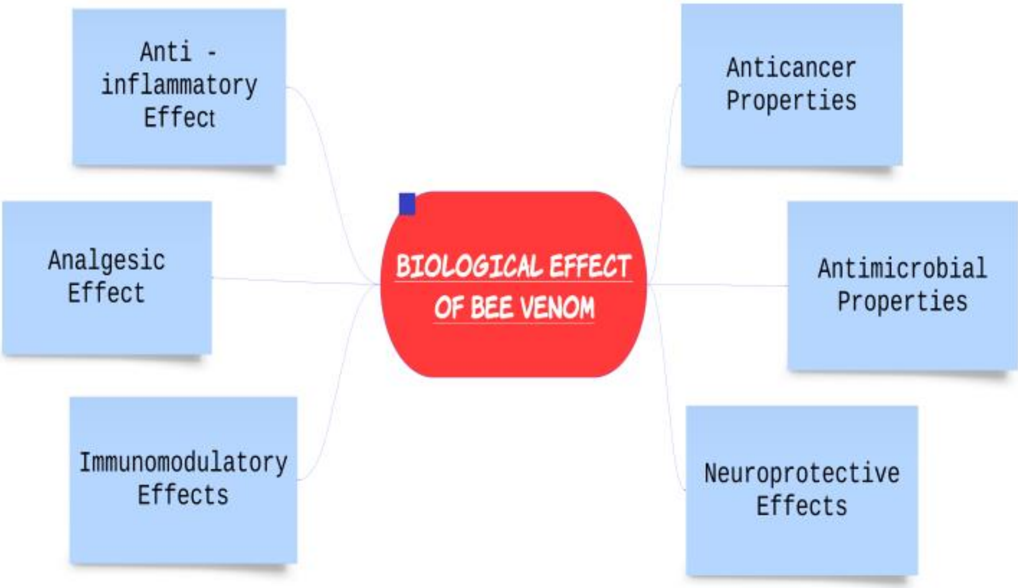

Fig. biological effects of bee venom

6.Neuroprotective Effects : Bee venom components have been shown to have neuroprotective benefits in a variety of neurological disorders. By preventing the activation of microglial cells and the release of inflammatory cytokines, they can lessen neuroinflammation. Bee venom also improves neurological outcomes in situations including Parkinson's disease, Alzheimer's disease, and stroke by promoting neuronal survival, boosting neurotrophic factors, and enhancing neurotrophic factors.

Health Benefits of Bee Venom

Bee venom is considered as the most useful thing that one can obtain from bees, as it has many health benefits that can help human beings in different ways. Some of the health benefits are mentioned here as well that can be healed using the venom obtained from bees.

1. Arthritis and Joint Diseases : A supplementary treatment for arthritis and other joint conditions is bee venom therapy (BVT). The anti-inflammatory and analgesic properties of bee venom can aid in easing joint discomfort, reducing inflammation, and enhancing joint function.

2. Multiple Sclerosis : Multiple sclerosis (MS) has showed potential in the treatment using bee venom. Improved neurological outcomes and quality of life for MS patients are a result of its modulation of immunological responses, reduction of neuroinflammation, and promotion of the repair of damaged myelin sheaths.

3. Skin Conditions: Eczema, psoriasis, and acne are just a few of the skin disorders that are treated with lotions and ointments made from bee venom. Bee venom's anti-inflammatory and antibacterial characteristics can aid in minimising skin inflammation, limiting microbial development, and accelerating skin healing.

4. Cancer Treatment: As a complementary therapy for cancer treatment, bee venom has promise. It can increase the cytotoxic effects of chemotherapeutic medications, trigger the death of cancer cells, stop the growth of tumours, and lessen metastasis. The best therapeutic approaches and potential combinations with current cancer therapies require further investigation.

Mechanisms of Action

Bee venom works through a variety of mechanisms including enzymatic activity, causing analgesia, having anti-inflammatory qualities, regulating the immunological system, and displaying antimicrobial activity. The bee venom contains substances including enzymes, peptides, and other bioactive compounds that help to modulate immunological responses, release inflammatory mediators, and activate immune cells. Although bee venom may have medicinal uses, due to the possibility of allergic reactions and other side effects, caution should be used.

1. Modulation of Inflammatory Pathways : By preventing the activation of pro-inflammatory signalling molecules like NF-B, bee venom regulates inflammatory pathways. Additionally, it increases the release of anti-inflammatory cytokines while inhibiting the synthesis of pro-inflammatory cytokines, resulting in a balanced immune response.

2. Immune System Modulation: Immune cells such as macrophages, lymphocytes, and dendritic cells all interact with bee venom. It can improve immune cell performance, increase the synthesis of immunomodulatory cytokines, and control immunological reactions. The medicinal properties of bee venom include immunological regulation.

3. Induction of Apoptosis: Melittin, one of the components of bee venom, has the ability to cause cancer cells to undergo apoptosis. While protecting healthy cells, they damage cellular membranes, turn on apoptotic pathways, and cause programmed cell death in cancer cells. This targeted cytotoxicity is useful in the therapy of cancer.

Conclusion

There has been a lot of interest in the fascinating and complex chemical known as bee venom because of its possible therapeutic uses. Bee venom has a variety of impacts on the human body because it contains a variety of different ingredients, including enzymes, peptides, and bioactive compounds. Bee venom shows potential for treating a range of medical diseases thanks to its analgesic and anti-inflammatory qualities, as well as its antibacterial and immunomodulatory activities. The treatment of pain has been one of the main applications of bee venom. Inflammatory joint diseases like rheumatoid arthritis and osteoarthritis have been studied for its analgesic qualities. Bee venom can aid in reducing pain and inflammation by focusing on pro-inflammatory pathways and altering the immune system. Due to its immunomodulatory qualities, bee venom is also useful for the treatment of inflammatory diseases. By blocking the activation of pro-inflammatory signalling molecules and increasing the production of anti-inflammatory cytokines, bee venom aids in the restoration of immunological balance and may have therapeutic benefits in diseases including multiple sclerosis and inflammatory bowel disease. Although bee venom's potential therapeutic uses are exciting, it is important to practise caution when using it. Bee venom allergies can cause serious reactions, hence careful administration by qualified doctors is required. The best methods, dosages, and safety profiles for bee venom therapy and bee venom-derived pharmaceuticals must also be determined through additional research.

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EDUCATIONAL AND CAREER ASPIRATIONS FOR STUDENTS

Martina Meinam[1*], Teresa Meinam[2], Huirem Bharati[3] and Venerability Dhar[1]

[1]College of Fisheries, CAU, Lembucherra, Tripura 799 210, India
[2]Manipur University, Imphal, Manipur 795 003, India
[3] ICAR Complex of NE Region, Tripura Centre, 799 210, India
*Corresponding Email: martinameinam3@gmail.com

Introduction

Career aspirations and educational aspirations are integral components of individuals' goal-setting and decision-making processes. They are essential components of students' goal-setting and decision-making processes. They represent the ambitions, dreams, and desired outcomes that individuals strive to achieve in their academic pursuits and future professional paths. Understanding and studying students' educational and career aspirations provide valuable insights into their motivations, interests, and potential trajectories. This knowledge is crucial for educators, policymakers, and researchers in developing effective strategies and interventions to support student's growth, success, and fulfillment. Understanding the factors that influence these aspirations is crucial for educators, policymakers, and researchers in promoting educational success and career development.

Educational and Career Aspirations

Educational aspirations encompass students' goals and expectations regarding their educational attainment. They reflect the level of education they aspire to achieve, such as completing high school, attending college or university, obtaining advanced degrees, or pursuing vocational training. Educational aspirations serve as a driving force for students' academic engagement, influencing their course selection, study habits, and overall educational trajectories. Career aspirations, on the other hand, encompass students' aspirations and goals related to their future careers and professional paths. These aspirations reflect their desired occupations, industries, and positions they aim to pursue upon completing their education. Career aspirations can range from specific career choices, such as becoming a doctor or an engineer, to broader career goals, such as making a positive impact in a particular field or achieving financial stability.

Studying students' educational and career aspirations provides valuable insights into their aspirations, societal influences, and environmental factors that shape their goals and decision-making processes. It helps identify the factors that contribute to or hinder the formation and achievement of these aspirations. Factors such as family background, socioeconomic status, cultural norms, access to resources, role models, and educational experiences can all play significant roles in shaping students' aspirations.

Moreover, understanding students' educational and career aspirations is crucial for guiding educational planning, career counseling, and policy-making. It helps educators tailor their teaching approaches, curriculum design, and career guidance services to align with students' interests, aspirations, and future goals. By providing support and resources that match students' aspirations, educators can enhance students' motivation, engagement, and success in their educational and career pursuits. Additionally, studying students' educational and career aspirations contributes to addressing achievement gaps and promoting equity in education. It highlights disparities that exist among different groups of students, such as those based on socioeconomic status, gender, ethnicity, or geographical location. By identifying and understanding these disparities, policymakers and educators can implement targeted interventions to provide equal opportunities and support to all students, regardless of their backgrounds.

Important of Educational and Career Aspirations Among Students

Understanding student motivation: By examining educational and career aspirations, researchers and educators can gain insights into the factors that drive students to set goals and pursue certain paths. This understanding is crucial for developing effective educational strategies and interventions that can enhance student motivation and engagement.

Guiding educational planning: Educational and career aspirations provide valuable information for educational planning at various levels. They help inform curriculum development, course offerings, and vocational training programs to align with the interests and goals of students. This ensures that educational institutions can adequately prepare students for their desired careers.

Addressing achievement gaps: Analyzing educational and career aspirations can reveal disparities among different groups of students. By identifying gaps in aspirations, such as those related to socioeconomic status, gender, or ethnicity, policymakers and educators can implement targeted interventions to address these inequities and promote equal opportunities for all students.

Career guidance and counseling: Educational and career aspirations serve as a foundation for career guidance and counseling services. Understanding students' aspirations allows counselors to provide tailored guidance and support, helping students explore various career options, make informed decisions, and develop the necessary skills and strategies to achieve their goals.

Informing policy and resource allocation: Knowledge of students' educational and career aspirations can inform policy decisions and resource allocation at the institutional, regional, and national levels. It helps policymakers understand the demand for specific educational programs, workforce development initiatives, and funding priorities to meet the needs of students and the labor market.

Enhancing student outcomes: When educational and career aspirations are aligned, students are more likely to have a sense of purpose, motivation, and direction. This alignment can positively impact their academic performance, persistence, and overall well-being. By studying aspirations, educators can design interventions to support students in setting realistic goals, building self-efficacy.

Factors influencing career aspirations

Numerous factors shape individuals' career aspirations. Research has identified personal attributes (e.g., self-efficacy, interests, values), family background (e.g., parental influence, socioeconomic status), educational experiences (e.g., academic achievement, exposure to career information), and social contexts (e.g., cultural norms, gender roles) as significant influencers. For instance, studies have found that parental expectations and support positively impact students' career aspirations, while gender stereotypes can influence occupational preferences.

Relationship between educational aspirations and career aspirations

Educational aspirations, referring to individuals' goals for their educational attainment, are closely linked to career aspirations. Research suggests that higher educational aspirations are associated with more ambitious career goals and better academic performance. Educational aspirations also serve as a predictor of college enrollment and completion rates. However, studies have highlighted the need to consider the influence of contextual factors, such as socioeconomic status and educational resources, in understanding the relationship between educational and career aspirations.

Impact of socioeconomic status

Shaping both educational and career aspirations. Students from lower SES backgrounds often have lower aspirations due to limited exposure to career options, financial constraints, and a lack of social networks. This disparity highlights the importance of providing career guidance, mentoring programs, and financial support to ensure equal opportunities for all students.

Influence of gender

Gender differences in career aspirations have been extensively studied. Research consistently shows that stereotypical gender roles can influence the career choices and aspirations of individuals. Efforts to promote gender equality in career aspirations involve encouraging girls' participation in STEM education, providing career information, and challenging gender norms.

Role of educational interventions

Studies have examined the effectiveness of educational interventions in shaping career and educational aspirations. Career development programs, mentoring initiatives, and experiential learning opportunities have shown positive effects on students' aspirations. Additionally, interventions targeting self-efficacy, goal-setting, and academic support have been found to enhance educational aspirations and achievement.

Cultural and contextual influences

Cultural and contextual factors significantly impact career and educational aspirations. Studies have explored variations across countries and cultures, revealing the influence of cultural values, societal expectations, and economic conditions on aspirations. For example, collectivist cultures may prioritize familial obligations over individual career aspirations, while individualistic cultures may emphasize personal achievement.

Conclusion

Studying educational and career aspirations among students provides valuable insights that can inform educational policies, improve career guidance services, and promote equitable opportunities, leading to better educational outcomes and increased success in students' future careers. Addressing socioeconomic disparities, challenging gender stereotypes, and providing supportive educational environments to foster students' aspirations is important. Future research should continue to explore the dynamic nature of aspirations and investigate innovative interventions to promote inclusive and equitable educational and career pathways for all individuals. The study of students' educational and career aspirations is of paramount importance. It sheds light on the motivations, interests, and goals that drive students' educational journeys and future career paths. By understanding these aspirations, educators, policymakers, and researchers can develop strategies and interventions to support students' growth, foster equitable opportunities, and empower them to achieve their educational and career aspirations and navigating their educational and career paths successfully.

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MUSA BULBASIANA COLLA (BHEEM KOL): NUTRIENTS AND ITS POTENTIAL IN HEALTH

Neha Maske[1] and Amita Beniwal [2]

[1]Dept. of Agricultural Biotechnology, Assam Agricultural University, Jorhat, Assam
[2]Dept. of Food Science and Nutrition, Assam Agricultural University, Jorhat, Assam
Corresponding Email: amita.beniwal.hdj19@aau.ac.in

Introduction

Musa bulbasiana Colla (*Bheem Kol)* is an indigenous banana variety of Assam, India. It is a very nutritious and inexpensive fruit, but it is highly overlooked and underutilized. All parts of the banana plant are extensively used in the assamese community of northeast India and locally it is known as 'bhimkol' or 'athiyakol'. It is called the store house of nutrients, e.g. carbohydrates, protein, phosphorus, calcium, potassium, phenols, flavonoids, polyphenols, and alkaloids (Bora and Das, 2017). In the fruit, roots, corm, inflorescence, flower, and seeds of Musa balbisiana, phytochemicals such as flavonoids, polyphenols, tannins, saponins, monoterpenoids, sesquiterpenoids, quinones, alkaloids, diterpenes, and triterpenes have been reported. A banana is a complete fruit that contains all the nutrients needed for energy and good health. Unripe bananas contain indigestible substances, resistant starch, and nutritional fibers. When ripe, the starchy fruit converts to fructose and sucrose, lowering its starch content. The fruit contains trace amounts of polyphenols, which act as antioxidants and make a significant contribution to the prevention of metabolic degenerative disorders. The banana pseudostem, a by-product of banana, is known to be rich in dietary fiber, comprising both insoluble fibers like cellulose and soluble fibres like pectin. (Tiroutchelvame *et al*., 2019). It is used in ayurveda and other traditional folklore medicine, to treat of urinary disorders, stomach difficulties like diarrhoea, dysentery, flatulence and it contains antiseptic, healing cough, hypolipidemic and hypoglycemic properties (Bhaskar *et al*., 2016). The resistant starch avoids digestion in the small intestine and travels to the large intestine instead. The rural populations of this region view the banana (Bhimkol) fruit as a good natural source of baby and children's food.

Super food or baby food

Due to its high energy content and easily digest called energy boost fruit. Musa 'Bhimkol' is a nutritious baby food. It is useful in gaining weight and improves immunity among kids. Rich in potassium and iron, it also helps in building a strong body, which is very important for growth development.

Bheem kol consumed mainly due to its high nutritional content. The most commonly consumed parts are fruit, flower, stem and seed. The nutrient content of these parts are mentioned in the table below:

Nutrients Content

Nutrients (%)	Flower	Seed
Protein	17.26	8.81
Fat	0.76	1.39
Fiber	2.06	4.31
Total minerals	3.66	5.04
Total carbohydrate	64.42	69.3
Total sugar	8.14	6.39
Energy	333	324

The banana, flower, seed, stem are rich source of macro and micro nutrients. The potassium and magnesium is highly conc. in ripe fruit reverse of raw fruit which contain calcium and selenium. It contains high percentage of amino acid essential and non essential amino acid than commercial bananas. Mostly aspartic acid, glutamic acid and leucine were in major conc. form.

Uses or products

The banana are being currently used to product development e.g. dehydrated powder, baby food powder, Jam, jelly, instant squash, beverage powder, extruded products, bakery products, bread, as a mix for cereals or millets based breakfast products, ready to eat foods, baby weaning foods, etc. which are of benefits to human health and improves the macro or micro nutrients level in humans.

Tribes of Assam and their unique utilisation of banana in recipes

The basic preparation of each dish involving the use of banana or any of its edible plant part varies from tribe to tribe within the state of Assam. The tradition of preparing ethnic foods not only garners creativity but it is also a bridge that connects the socio-cultural, spiritual, economic and way of life of the concerned communities. Banana has been an integral part of Assamese nutritional diet charts for as long as one can remember. The traditional recipes are prepared with bheem kol are : **Kolakhar** (prepared from ashes of peel), **Kol posola** (stem cooked as vegetable), **Koldil bhaji** (fried banana flower), **Koldil mangxho** (non- vegetarian preparation), **Kaskol bhaji/bor** (fried vegetable), **Kaskol dia maas** (raw banana-based fish curry), **Kaskol pitika** (side dish, ingredients added in raw banana), **Patot dia maas** (fish steamed in banana leaves), **Kol pitha** (sweet dish), **Jolpan** (assamese breakfast) etc. (Sarma *et al.,* 2020).

Bioactive compounds and their health benefits

A lot of valuable bioactive compounds have been present in musa bulbasiana colla which role in health promotions and treatments of diseases e.g. antigyycemic effect, hepatoprotective effect, prevention of muscular contractions due to its vitamins, potassium and magnesium, regulation in blood pressure, managing glycoprotein abnormalities.

Carotenoids—β-carotene, α-carotene, lutein, violaxanthin, neoxanthin, auroxanthin, isolutein, β-cryptoxanthin and α-cryptoxanthin act as antioxidants, especially in scavenging singlet oxygen, decreases the risk of certain cancers, heart problems and eye diseases; improves immunity.

Phenolic compounds—catechin, gallic acid, epicatechin, tannins and anthocyanins, gallocatechin, quercetin, epigallocatechin, ferulic, myricetin, kaempferol, sinapic, salicylic, gallic, p-hydroxybenzoic, syringic, vanillic, gentisic and p-coumaric acids act as protective scavengers against oxygenderived free radicals and reactive oxygen species responsible for ageing and various diseases.

Biogenic amines— dopamine, serotonin and norepinephrine reduce the plasma oxidative stress and enhance the resistance to oxidative modification of low density lipoproteins; contributes towards the feelings of well-being and happiness; plays an important role in the human brain and body as a neurotransmitter with great impact on our mood, ability to concentrate and emotional stability.

Phytosterols— cycloeucalenol, cycloeucalenone, stigmasterol, cycloartenol, campesterol and b-sitosterol lowers cholesterol level in the blood and reduce its absorption in the intestine; act as immune system modulators and also have anticancer properties (Rinah *et al.,* 2019).

Conclusion

Bheem Kol and its by products (seeds, stem, flower) are rich source of macro or micro nutrients and can be included in diet as a healthy food source because of therapeutic and nutritional properties. It is renewed interest and focus of indigenous crop varieties and novel food products which are rich in nutritional and antioxi- dant sources. There are a lot of beneficial bioactives in bananas that are necessary for health and disease prevention. Bananas' bioactive compounds especially phenolics, biogenic amines, and phytosterols may be enhanced through genetic engineering while bio-fortified cultivars are developed to enhance micronutrient content. Value-added Musa balbisiana products will not only increase public awareness of the existence of this nutrient-dense fruit but also promote widespread consumption of it as a healthier alternative to processed foods. More studies are required for large scale production of banana products to explore the indigenous varieties for their health and economic gain.

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ECOFRIENDLY INTEGRATED PADDY STRAW MANAGEMENT

H.A. Archana[1]* and J.P. Mathiguru[2]

[1]Department of Crop Management, SRM College of Agricultural Sciences, Chengalpattu (District), Tamil Nadu- 603 201,
[2]IV Year, B.Sc. (Hons.) Agriculture, SRM College of Agricultural Sciences, Chengalpattu (District), Tamil Nadu 603 201.
*Corresponding Email: archanah@srmist.edu.in

Introduction

In India, rice is a staple grain produced on almost 50 million ha of land with a productivity of roughly 2390 kg/ha. It thrives in a variety of climatic and soil environments. Particularly in the irrigated and mechanised rice-wheat system, a significant amount of the paddy straw is burned on the farm to clear the field for the succeeding crop. After harvest, 84 Mt (23.86%) of the stubble is burned on the field yearly. It is a substantial producer of particulate matter (PM10 and PM2.5), carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NOx), sulphur oxides (SO_x), methane (CH_4), and other gaseous pollutants that have a severe negative impact on the environment and human health (Silvia C, 2020). 3.4 Mt of CO, 0.1 Mt of NOx, 91 Mt of CO_2, 0.6 Mt of CH_4, and 1.2 Mt of PM (Abdurrahman *et al.*, 2020) were reported to be released into the atmosphere by burning 63 Mt of crop stubble. Due to its timing (October–November), the devastating cloud over India during the winter season has been connected to stubble burning. In addition to polluting the air, burning paddy straw depletes soil organic matter and vital nutrients, limiting microbial activity and increasing the likelihood of soil erosion. Burning the leftovers pollutes the air and increases the risk of soil erosion on the property.

Reason for burning the residue

Crop productivity, cropping frequency, and crop type all affect how much crop residue is produced. Cereals (rice, wheat, maise, millets) account for almost 70% of all crop residues, with the rice-wheat system making up almost one-fourth of the total. In India, 136.5 million tonnes of rice were produced annually as of 2019. Around 1.1–1.5 kg of straw is produced for every kg of harvested grain. Thus, it is predicted that between 136.5 and 150 million tonnes of paddy straw are generated each year. The state of Uttar Pradesh in India produces the most crop residues (60 MT), followed by Punjab (51 MT) and Maharashtra (46 MT) (NPMCR, 2014).

One of the most prevalent lignocellulosic wastes on the planet is paddy straw. The management of paddy straw is a significant issue in paddy-based agricultural systems, and following combined harvesting, farmers frequently engage in the illegal practice of burning paddy straw in their fields (Fig. 1)). The lack of more affordable, suitable machinery to manage the enormous amount of loose straw, which impedes sowing operations and leads to poor crop stand, in the farmers' eyes, presents a simple answer. Additionally, its poor palatability, low protein content (2–7%), low digestibility, and high silica concentration renders it nutritionally inert in nature and abrasive in the cattle's gastrointestinal tract. The wide C:N ratio (80:1) and high silica (12–16%) and lignin (6-7%) of rice residue slow down *in situ* breakdown and cause nitrogen immobilisation in soil which makes nitrogen unavailable to plants.

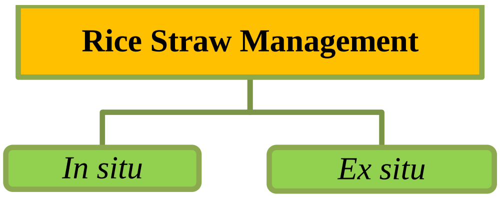
Fig. 1 Burning of Paddy Straw and Residues

Problems due to burning

Direct burning considerably raises soil temperature in rice fields, reaching up to 38 to 42 °C, especially in the top 3 cm of the soil. This kills microbes and lowers soil ammonium levels, soil phosphorus availability, and readily assimilated carbon sources for bacteria. Burning also slows the rate of organic matter breakdown and microbial biomass, CO_2-C respiration, microbial quotient, and total FAME concentration. In addition to having a quantitative impact, fire alters the species makeup of soil microbes. The effect on microbial activities varies depending on the harvesting technique or quantity of burned straw, type of soil, and soil moisture level. After burning paddy straw, the soil's original moisture level, which was 14.84 per cent, dropped to 8.72 per cent. Soon after burning paddy straw, the soil's temperature rose to 55 °C. Compared to the unburnt field (7.91), the pH of the soil improved significantly after burning (8.16). After burning straw in the field, the soil's EC value dramatically rose (0.09 dS/m).

Integrated Paddy Straw Management

We can control the paddy straw burning in several ways. In general, it can be divided into in situ and ex-situ methods. *In situ* means "in the original place". Using in situ approaches, we can control the paddy straw burning on-site, such as in the field. It is less expensive, has a vast capacity, and requires less effort overall. *Ex situ* means "Outside the original place". *Ex situ* methods performed off-site. It is more expensive, requires equipment, and requires much labour. Integrated paddy straw management combines two or three environmentally beneficial techniques for controlling paddy straw burning.



***In situ* management**

High C: N ratio crop wastes are assimilated into the soil, plant nutrients are momentarily immobilised, and phytotoxic compounds are created in the initial stages of decomposition. Using either aerobic decomposition in piles or soil absorption, rice stubble can be successfully composted in place (Fig. 2). Because it increases the soil's ability to store water, crop residue decomposition is crucial for soil health. A faster degradation rate is achieved by adding straw, adding 25 kg more nitrogen per hectare as a base, and adding biomineralizer like 2 kg/t of rice bran and slurry made from cow dung at a 5% concentration. As a result, it makes more nitrogen, phosphorus, and potassium in the soil available for use. Individual applications of 25 kg more N produce results superior to those of bio mineralisers and cow dung slurry. This might be primarily owing to the possibility that 25 kg of extra nitrogen could have replaced the nitrogen need that might have become immobilised due to the development of the organic complex while also providing energy to the bacteria. Crop residue is a vital natural resource for protecting and maintaining the soil's production. Crop residues serve as the principal source of organic matter replenishment, and after they have mineralised, they provide essential plant nutrients. The soil's physical and biological characteristics can also be improved by residue absorption, halting soil deterioration. It might result from a culmination of all contributions that enhance the soil's biological, chemical, and physical characteristics.

Management of Former Situations

Fig. 2 *In situ* Paddy Straw Management

***Ex-situ* management**

Trash can be disposed of economically and environmentally via composting. Composting organic wastes recycled for agriculture adds much-needed organic matter to the soil, enhancing its fertility and productivity. Paddy straw composting emerges as a safe choice that allows the nutrients present in all the leftovers to be reused. Therefore, managing paddy straw through composting will decrease nutrient and organic matter loss and air pollution brought on by residue burning. Uncut Paddy straw should be gathered from the field, soaked in a 0.1% urea solution for three minutes in a drum with a capacity of 200 litres, and then piled in windrows that are 1 m tall by 1 m wide by 2 m long. It is wrapped with a thick polythene covering to keep the moisture in (Fig. 3). The varied in ocula should be mixed with the urea solution at a 1.0% dry weight basis, together with the cattle manure and biogas slurry. 100 kg of new material is placed on top of the previously treated layer and is then sprayed with urea. A stack is created by repeating this method. A little stick offers two benefits. First off, the ammonification process is more effective. Second, there are fewer opportunities for mould growth, resulting in straw deterioration. Using this urea solution, biomineralizer, and cow dung slurry, paddy straw could be converted into high-quality compost in about three months.

Fig. 3 *Ex situ* Paddy Straw Management

Conclusion

Using one method alone takes time to decompose the paddy straw. Integrating one or two methods increases the decomposition rate. Thus, eco-friendly integrated paddy straw management will avoid air pollution caused by residue burning and loss of nutrients.

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EMBRACING SUSTAINABLE AGRICULTURE: CULTIVATING A GREENER FUTURE

Sunil Kinge[1*] and Aishwarya Rathod[2]

[1]Ph.D.Scholar, Department of Agronomy,
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.
[2]Ph.D. Scholar, Department of Agronomy,
Mahatma Phule Krishi Vidyapeeth, Rahuri.
Corresponding Email: sunilkinge40@gmail.com

Introduction

Sustainable agriculture is an increasingly vital practice that promotes the harmonious coexistence of agriculture and the environment. It seeks to meet the world's food needs while preserving natural resources, protecting biodiversity, and mitigating climate change. As global challenges like population growth and climate instability intensify, adopting sustainable agricultural practices becomes crucial. This article delves into the significance of sustainable agriculture and explores key principles and practices that pave the way toward a greener and more resilient future.

Sustainable Agriculture

Sustainable agriculture refers to a set of farming practices that aim to optimize productivity while minimizing the negative impact on the environment, preserving natural resources, and supporting rural communities. It involves holistic approaches that integrate ecological principles, such as soil conservation, water management, biodiversity preservation, and the use of renewable resources.

1. Preserving Soil Health

Healthy soil forms the foundation of sustainable agriculture. By implementing soil conservation techniques such as crop rotation, cover cropping, and minimal tillage, farmers can prevent soil erosion, enhance nutrient cycling, and improve soil structure. Practices like composting and organic fertilization reduce the reliance on synthetic inputs, fostering soil health and promoting long-term productivity.

2. Water Management and Conservation

Efficient water management is crucial for sustainable agriculture, particularly in regions facing water scarcity. Employing techniques such as drip irrigation, precision farming, and water recycling minimizes water wastage and optimizes resource use. Moreover, utilizing drought-resistant crop varieties and implementing water-sensitive farming practices contribute to resilience against changing climate patterns. In many regions, water scarcity poses a significant challenge to agricultural production. Sustainable agriculture emphasizes efficient water management strategies, such as precision irrigation systems, drip irrigation, and rainwater harvesting. By reducing water waste and optimizing irrigation practices, farmers can conserve water resources and mitigate the ecological impact of water extraction.

3. Biodiversity Conservation

Preserving biodiversity within agricultural ecosystems is essential for sustainable food production. By adopting agroforestry practices, creating wildlife habitats, and incorporating natural pest control methods, farmers can reduce their reliance on chemical pesticides and create balanced ecosystems. Encouraging pollinator populations through the establishment of flowering borders and the conservation of native plant species promotes natural pollination, leading to higher crop yields.

Sustainable agriculture encourages the preservation and enhancement of biodiversity on and around farms. Farmers are encouraged to create wildlife habitats, plant native vegetation, and incorporate natural pest control methods like biological pest control and integrated pest management. By promoting biodiversity, farmers can reduce reliance on chemical pesticides, improve pollination, and create resilient ecosystems.

4. Organic Farming and Reduced Chemical Inputs

Transitioning to organic farming practices plays a pivotal role in sustainable agriculture. By avoiding synthetic fertilizers, pesticides, and genetically modified organisms (GMOs), organic farmers prioritize environmental and human health. Organic farming practices also promote soil fertility, enhance biodiversity, and improve water quality. Consumers' increasing demand for organic produce further incentivizes farmers to adopt sustainable farming methods.

5. Climate-Smart Agriculture

Addressing climate change challenges is a fundamental aspect of sustainable agriculture. Climate-smart agricultural practices involve adopting strategies that mitigate greenhouse gas emissions, enhance carbon sequestration, and build resilience against extreme weather events. These strategies include agroforestry, conservation tillage, integrated pest management, and precision agriculture, among others. By harnessing innovative technologies and knowledge-sharing platforms, farmers can adapt to climate change while reducing their environmental footprint.

6. Local Food Systems and Food Security

Promoting local food systems strengthens the connection between consumers and farmers, reduces food miles, and enhances food security. By supporting small-scale farmers, agroecology, and community-supported agriculture, sustainable agriculture ensures a diverse and resilient food supply. Local food systems also foster economic development, social cohesion, and cultural preservation.

7.Agroforestry and Permaculture:

Agroforestry and permaculture are innovative approaches that blend agriculture and forestry, aiming to maximize land use efficiency and ecological harmony. Agroforestry systems integrate trees, crops, and livestock in a mutually beneficial manner, providing multiple sources of income and ecosystem services. Permaculture principles focus on designing sustainable and self-sufficient farming systems that mimic natural ecosystems, resulting in increased productivity and reduced environmental impact.

8. Supporting Rural Communities:

Sustainable agriculture is not only concerned with ecological sustainability but also with the social and economic well-being of farmers and rural communities. It promotes fair trade practices, encourages local food systems, and provides training and resources for small-scale farmers. By fostering strong local economies and preserving traditional farming knowledge, sustainable agriculture contributes to rural development and food security.

Conclusion

Sustainable agriculture provides a pathway towards a greener, more equitable, and resilient future. By embracing practices that prioritize soil health, water conservation, biodiversity, reduced chemical inputs, climate adaptation, and local food systems, we can revolutionize our approach to food production. Governments, farmers, consumers, and policymakers all play crucial roles in supporting and promoting sustainable agricultural practices. By investing in sustainable agriculture today, we can secure a bountiful and sustainable food supply for generations to come while safeguarding the planet's resources. Sustainable agriculture is a paradigm shift in the way we approach food production. By embracing ecological principles and prioritizing long-term sustainability, we can mitigate the environmental impacts of conventional agriculture and build resilient food systems. Governments, farmers, consumers, and businesses all have a role to play in supporting sustainable agriculture initiatives. By working together, we can cultivate a greener future, where agriculture nourishes both people and the planet.

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DISEASES IN LITCHI AGRO-ECOSYSTEM AND ITS INTEGRATED MANAGEMENT

Garima[1*], Kumud Jarial[2], Deepak Kumari[1] and Niharika Sheoran[1]

[1]Ph.D. Scholar, CCS Haryana Agricultural University, Hisar, Haryana
[2]Associate Professor, College of Horticulture and Forestry, Neri, Hamirpur, H.P.
*Corresponding Email: garima.ahuja007@gmail.com

Litchi is a delicious fruit belonging to family *Sapindaceae* and originated from China. India is the second largest producer of litchi after China. In India, Bihar has the maximum area. The food value of litchi mainly lies in its sugar content which varies from variety to variety. The fruit rich in Vitamin B_1, Riboflavin and Vitamin C apart from proteins (0.7%), fats (0.3%), carbohydrates (9.4%), minerals (0.7%), fibrous matter (2.25%), calcium (0.21%), phosphorus (0.31%), iron (0.03%) and carotene. Litchi makes an excellent canned fruit. Like other fruit trees, litchi is prone to various biotic and abiotic stresses. Among biotic stresses, diseases are one of the constraints in the production of litchi as they directly or indirectly reduce the yield and quality of fruit. Litchi is attacked by leaf blight, anthracnose, algal leaf spot, twig blight and fruit rot.

Leaf, Panicle and Fruit Blight (*Alternaria alternata*)

The disease is more important in the nursery of litchi. The symptoms of disease starts from the tip of litchi leaves as dark brown necrotic lesions which at advanced stages lead to complete necrosis. Initially, the symptoms are similar to potassium deficiency but later drying of affected plant parts can be seen clearly.

Management

- Follow crop rotation for two years.
- Spray of copper oxychloride (0.1%)

Anthracnose (*Colletotrichum gloeosporioides*)

The disease infects at the time of blossoming till when it is half grown. The pathogen attack fruits that exhibit brown lesions. In case of leaves, spots appear as grey lesions or irregular brown patches leading to development of white mycelial mat on the skin. Acervuli soon rupture that release conidia and appear pink in colour.

Management

- Avoid overcrowding of trees
- Pruning of infected plant parts
- Spray copper oxychloride @ 3g/l or Carbendazim @1g/l

Algal leaf spot

The infections are also referred to as red rust but caused by a parasitic algae *Cephaleurosvirescens.* The disease is abundant at the time of frequent rains from June to October. The harmful effects of the algal presence are attributed to (a) depletion of water and mineral nutrients from the host tissues (b) secretion of harmful algal metabolites (c) loss of photosynthetic area due to the necrosis of the green tissue. This algal disease can cause economic injury to plant leaves, fruits and stem. The symptoms are more prevalent on older leaves and in the lower foliage of the trees. In severe infections, leaf drop and stem die back occurs. No lesions are observed on fruits. The disease first appears on the young unfolded tender branches. On the infected young leaves, small lesions of velvety white growth appear on the lower surface. On the upper surface, just the opposite site of the lesion, chlorotic patches occur. As the leaves unfold and increase in size, the velvety growth becomes more prominent and dense. Later, larger areas of leaves are affected with this growth. Old and thick leaves show various types of malformation. The velvety growth turns light brown to brick-red. The disease is also accompanied by curling of leaves due to presence of mites.

Management

- Spray copper oxychloride @0.3%

Fruit Rot (*Peronophythora litchi*)

Also known as downy blight. Attack mostly on leaves, panicle and fruit. This disease is serious after harvesting on injured portion of fruits. Water soaked lesions with depressed decayed area are developed on fruits which at later stages emit odour of fermentation.

Management

Low temperature storage is the most successful means of slowing rot development. For instance, fruit stored at 22°C rotted three times more quickly than fruit stored at 5°C.

- Prevent any type of injury on fruits.
- Spray of Carbendazim @1g/l before 15-20 days of harvesting.

Wilt (*Fusariumsolani*)

It can appear as slow decline or a sudden death of tree. Internal red discolouration of roots can occur but there is no leaf shed.

Management

- Application of castor or neem cake as manure integrated with bioagents like *Trichoderma harzianum.*
- Do not plant trees on low-lying field or waterlogged soil.

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WHY LARGE-SCALE FARMING IS SHIFTING TO ORGANIC AGRICULTURE

Katta Sravan Naga Parimala Kumar* and Abhishek Pathak

Research Scholar
Department of Agricultural Communication,
G.B. Pant University ofAgriculture &Technology,
*Corresponding Email: KSNPkumar@gmail.com

Abstract

Large-scale farming is increasingly adopting organic agriculture due to consumer demand, environmental concerns, and economic viability. Organic farming prioritizes soil health, biodiversity conservation, and the elimination of synthetic chemicals, resulting in improved fertility, reduced pollution, and enhanced carbon sequestration. It also offers health benefits by minimizing chemical exposure and promoting nutrient-dense produce. While transitioning to large-scale organic farming presents challenges, it provides opportunities for market growth, rural development, and a more sustainable food system.

Introduction

Organic farming is an agricultural approach that emphasizes sustainable practices, biodiversity conservation, and the elimination of synthetic chemicals. It is gaining popularity worldwide as consumers and farmers alike recognize its benefits for human health, the environment, and long-term agricultural sustainability. This article provides an overview of organic farming, its principles, key practices, and its positive impact on various aspects of agriculture and society.

Organic agriculture has gained significant traction in recent years, attracting not only small-scale farmers but also large-scale farming operations. The shift towards organic farming on a larger scale is driven by various factors, including consumer demand, environmental concerns, and the potential for long-term sustainability.

Reasons behind the transition from large-scale farming to organic agriculture

I. Growing Consumer Demand for Organic Products (Willer, H and Lernoud, J. 2020).

- Introduction to the increasing consumer preference for organic products
- Shift in consumer awareness towards health and environmental sustainability
- Increasing market demand for organic produce and processed goods
- Market demand for organic produce and processed goods

II. Environmental Benefits and Sustainable Practices (Reganold, J. P and Wachter, J. M. 2016)

- Overview of the environmental impact of conventional farming practices
- Preservation of soil health and fertility through organic practices
- Reduction in chemical inputs and their impact on water and soil quality
- Biodiversity conservation on organic farms
- Introduction to organic farming methods and their positive environmental effects
- promotes soil conservation, and biodiversity preservation

III. Long-Term Economic Viability and Market Opportunities (Dimitri, C. and Greene, C. 2002)

- Analysis of the economic advantages of organic agriculture

- Cost savings in chemical inputs, energy, and water usage
- Case study: Opportunities for market growth and premium prices for organic products

IV. Government Support and Policy Initiatives (Lampkin, N. H., Foster, C, and Padel, S. 2015

- Overview of government support and policies promoting organic agriculture
- Subsidies, grants, and financial incentives for transitioning to organic farming
- Policy frameworks supporting organic certification and market access
- Many countries with robust organic agriculture policies

V. Challenges and Considerations for Large-Scale Organic Farming (Ponisio, L. C., et al. 2015)

- Discussion on the challenges faced in scaling up organic farming operations
- Transition period, certification requirements, and infrastructure needs
- Infrastructure and logistics for organic farming operations
- Successful examples of large-scale organic farming enterprises

Conclusion

The shift of large-scale farming towards organic agriculture is driven by increasing consumer demand for organic products, environmental concerns, economic viability, and government support. As consumers become more conscious of their health and the environmental impact of conventional farming, the organic sector offers a sustainable and profitable alternative. However, challenges remain in scaling up organic farming operations. Nonetheless, with continued innovation and support, large-scale organic agriculture has the potential to transform the industry, promoting a more sustainable and ecologically friendly approach to food production.

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AGROTOURISM IN INDIA : AN AGRIBUSINESS ANALYSIS

Pooja Singh[1], Kamesh Singh Chauhan[1], Abhishek Singh Chauhan[2*] and Ramkumar[3]

[1]Department of Agronomy, Banda University of Agriculture & Technology Banda
[2]Department of Agronomy, CCS University Meerut Uttar Pradesh
[3]Department of Entomology, Banda University of Agriculture & Technology Banda
[4]Department of Entomology and Agricultural Zoology,
Institute of Agricultural sciences, Banaras Hindu University, Varanasi, India
*Corresponding Email: achauhanbuat@gmail.com

Abstract

Agrotourism, the convergence of agriculture and tourism, has emerged as a popular travel trend worldwide. This article explores the concept of agrotourism in India and provides an in-depth analysis of its potential as an agribusiness opportunity. India, with its diverse agricultural landscape and rich cultural heritage, presents a promising environment for agrotourism to thrive.

Introduction

Agrotourism, the fusion of agriculture and tourism, has gained significant popularity in recent years as a unique and immersive travel experience. India, with its diverse agricultural landscape and rich cultural heritage, offers tremendous potential for agrotourism. This article delves into the concept of agrotourism in India, exploring its various facets and analyzing its potential as an agribusiness opportunity.

1. Understanding Agrotourism

Agrotourism refers to the practice of attracting tourists to rural areas to engage in agricultural activities, experience farm life, and learn about the local culture and traditions. It involves a range of activities such as farm visits, organic farming workshops, culinary tours, rural handicraft demonstrations, and eco-lodging.

2. The Significance of Agrotourism in India

2.1 Agricultural Diversity: India's vast agricultural diversity, encompassing varied climatic zones and agro-ecological regions, provides a unique opportunity for agrotourism. From the verdant tea gardens of Assam to the expansive wheat fields of Punjab, each region has its own distinct agricultural practices and products that can captivate tourists.

2.2 Cultural Heritage: Agrotourism in India not only offers insights into agricultural practices but also provides a glimpse into the country's rich cultural heritage. Rural communities often showcase traditional arts, crafts, music, and dance forms, allowing tourists to immerse themselves in the local traditions and rituals.

2.3 Socio-economic Development: Agrotourism can contribute significantly to the socio-economic development of rural areas in India. By promoting tourism, it generates additional income for farmers and rural communities, creates employment opportunities, and helps in the preservation of indigenous practices and traditions.

3. Agribusiness Potential of Agrotourism:

3.1 Diversification of Income Sources: Agrotourism provides an avenue for farmers to diversify their income sources. By opening their farms to tourists, farmers can supplement their agricultural earnings and reduce dependency on seasonal crop yields.

3.2 Value Addition and Branding: Agrotourism allows farmers to showcase their agricultural products and value-added goods directly to consumers. By establishing farm shops, farmers can sell organic produce, dairy products, honey, handicrafts, and other locally made items, thus creating a distinct brand for their farm.

3.3 Agri-Entrepreneurship Opportunities: Agrotourism fosters the growth of agri-entrepreneurship. It encourages the establishment of farm stays, organic cafes, rural spas, and adventure activities, which can attract both domestic and international tourists. This diversification of services can lead to increased revenue and job creation in rural areas.

4. Challenges and the Way Forward

4.1 Infrastructure Development: Developing adequate infrastructure such as accommodation facilities, transportation, and tourist-friendly amenities in rural areas is crucial to support the growth of agrotourism. Government initiatives and private sector investments are essential in this regard.

4.2 Awareness and Marketing: Creating awareness about agrotourism among potential tourists and marketing it effectively is essential. Collaborations between tourism boards, agriculture departments, and tour operators can help promote agrotourism destinations and experiences.

4.3 Skill Development: Providing training and capacity-building programs to farmers and rural communities in hospitality, customer service, and sustainable farming practices can enhance the quality of agrotourism offerings.

Key reasons why agrotourism is important for India

Economic Development: Agrotourism offers a pathway for economic development, particularly in rural areas where agriculture is a primary source of livelihood. By attracting tourists to these regions, agrotourism generates additional income for farmers, agri-entrepreneurs, and rural communities. This diversification of income sources can contribute to poverty reduction, employment generation, and overall economic growth in these regions.

Rural Empowerment: Agrotourism plays a crucial role in empowering rural communities. By showcasing their agricultural practices, cultural heritage, and traditional craftsmanship, rural communities can actively participate in tourism activities. This involvement not only enhances their economic status but also instills a sense of pride and self-worth, preserving their way of life and preventing migration to urban areas.

Agricultural Sustainability: Agrotourism promotes sustainable agricultural practices by creating awareness among tourists about the importance of sustainable farming, organic production, and environmental conservation. It encourages farmers to adopt eco-friendly methods, reduce chemical inputs, and preserve biodiversity. This focus on sustainable agriculture ensures the long-term viability of the sector and safeguards natural resources for future generations.

Cultural Preservation: India is renowned for its rich cultural heritage and diverse traditions. Agrotourism provides a platform to showcase and preserve this cultural wealth. Visitors can learn about traditional arts, crafts, music, and dance forms, fostering an appreciation for the country's cultural heritage. This exposure also encourages the transmission of traditional knowledge and skills from one generation to the next, preventing cultural erosion.

Tourism Diversification: Agrotourism diversifies India's tourism offerings, moving beyond the typical attractions of historical sites and natural landscapes. It taps into the growing demand for unique and immersive experiences, allowing tourists to engage directly with local communities, participate in farming activities, and experience rural life. This diversification enhances India's tourism industry, attracts new segments of travelers, and increases the length of stay and spending in rural areas.

Environmental Conservation: Agrotourism promotes environmental conservation by highlighting the importance of sustainable farming practices and ecological balance. It creates opportunities for visitors to experience the natural beauty of rural landscapes, forests, and water bodies.

Knowledge Exchange and Education: Agrotourism facilitates knowledge exchange between farmers, tourists, and researchers. This exchange of knowledge enhances agricultural productivity, encourages innovation, and promotes collaborative learning.

Conclusion

Agrotourism in India presents an exciting agribusiness opportunity, combining agriculture, tourism, and rural development. With its rich agricultural diversity and cultural heritage, India has the potential to become a global hub for agrotourism. Agrotourism is important for India as it drives economic development, empowers rural communities, promotes sustainable agriculture, preserves cultural heritage, diversifies the tourism sector, supports environmental conservation, and facilitates knowledge exchange. By harnessing the potential of agrotourism, India can achieve inclusive and sustainable development while celebrating its agricultural heritage and natural beauty.

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ROLE OF GPS IN PRECISION FARMING

Abdullah Zaid[1*],Shivani Dubey[2] and Shivam Chaurasia[1]

[1]Department of Fruit Science, College of Horticulture,
Banda University of Agriculture and Technology, Banda Uttar Pradesh
[2]Department of Seed Science and Technology, College of Agriculture, SHUATS
*Corresponding Email:abdullahzaid265@gmail.com

Abstract
The growing food demands due to ever-rising human population has forced world farmers to adopt resource-intensive and sustainable practices that increased both economic and environmental costs. Developing countries farming systems represent both obstacles and opportunities for adoption of precision agriculture. Tailoring soil and crop management to match varying conditions (soil texture, moisture, nutrient status and pest distribution) within a field is not entirely new to farmers. The growers traditionally noted yield variability in space, time and changed farm practices depending on site conditions to optimize soil resources and external inputs. This was possible because most developing countries farms were relatively small and farmers were familiar with spatial and temporal variation. However, the precision farming in terms of using technologies such as Global Positioning Systems (GPS), Geographic Information Systems (GIS) remote sensing, yield monitors, guidance systems for variable rate application to manage within-field variation is still in its infancy in almost all developing countries including India. Precision agriculture is an integrated crop management system that attempts to match the kind and amount of inputs with the actual crop needs for small areas within a farm field. Precision agriculture is often referred to as GPS (Global Positioning System) based agriculture, variable-rate farming, prescription farming, site-specific farming etc.

Keywords: Population, Precision agriculture, GPS, GIS, Remote sensing

Global Positioning System (GPS)
The global positioning system (GPS) has made it possible to record the in-field variability as geographically encoded data. It is also use to determine the position continuously. This technology focuses on agricultural fields in detail and a huge database is available for the user. The accurate field data can be obtained only in the points where GPS position recording has happened. The global positioning system (GPS) has made it possible to record the in-field variability as geographically encoded data. It is also use to determine the position continuously. This technology focuses on agricultural fields in detail and a huge database is available for the user. The GPS consists of 24 satellites that circle the earth in six orbital planes having four satellites in each plane and associated ground stations. These satellites are distributed in a unique manner to ensure the coverage of the entire globe. GPS allows farmers to accurately navigate to specific locations in the field, year after year, to collect soil samples or monitor farm conditions. These satellites, known as NAVSTAR (Navigation by Satellite Timing and Ranging), have been launched and maintained by the Department of Defence (DOD) U.S to provide all weather ranging 24 hours a day anywhere on the surface of the earth. Crop advisors use rugged data collection devices with GPS for accurate positioning to map pest, insect, and weed infestations in the field.

Pest problem areas in crops can be pinpointed and mapped for future management decisions and input recommendations. The same field data can also be used by aircraft sprayers, enabling accurate swathing of fields without use of human "flaggers" to guide them. Crop dusters equipped with GPS are able to fly accurate swaths over the field, applying chemicals only where needed, minimizing chemical drift, reducing the amount of chemicals needed, thereby benefiting the environment.

The need for Global Positioning System (GPS)

Global positioning system has revolutionized positioning concept, though it started primarily as a navigation system. Today, the Global Positioning System (GPS) has become an international utility. In addition to its ease of use and worldwide all-weather operation, GPS owes its popularity to the dependable high accuracy with which position, time and direction can be determined. As a tool of precision Agriculture, Global Positioning System satellites broadcast signals that allow GPS receivers to calculate their position. This information is provided in real time, meaning that continuous position information is provided while in motion. Having precise location information at any time allows crop, soil and water measurements to be mapped. GPS receivers, either carry to the field or mounted on implements allow users to return to specific locations to sample or treat those areas according to the need.

Precision Farming

Precision agriculture, sometimes called site-specific management, is an emerging technology that allows for adjustments to address within-field variability in characteristics such as soil fertility, soil moisture, weed intensity and insect-pest infestation. The technology has the potential to reduce production costs through more efficient and effective application of crop inputs. It also reduces environmental degradation by allowing farmers to apply agricultural inputs at appropriate rates at places where these are needed. Spatial, temporal and predictive aspects of soil and crop variability are the vital elements of precision agriculture. It involves the sampling, mapping, analysis, and management of specific areas within a field in recognition with spatial and temporal variability with respect to soil fertility, moisture availability, crop characteristics and insect-pest population. Large-scale variability has long been encountered with different cropping practices in different regions. However, precision agriculture responds to spatial variability within individual fields or orchards. Precision agriculture practices lead to a more cost-effective and environment friendly agriculture by:

- Increasing agricultural productivity
- Optimizing the use of restricted natural resources such as land and water and other crop inputs such as seeds, fertilizers, herbicides and other chemicals
- Reducing environmental degradation
- Engaging the efficient capabilities of intelligent farm machinery
- Improving the performance of farm management
- Prevents soil degradation in cultivable land
- Reduction of chemical use in crop production
- Efficient use of water resources

GPS role in Precision Farming

Precision Agriculture is doing the right thing, at the right place, and at the right time. Knowing the right thing to do may involve all kinds of high tech equipment's and fancy statistics or other analysis. Doing the right thing however starts with good managers and good operators doing a good job of using common tools such as planters, fertilizer applicators, harvesters and whatever else might be needed. In this context, GPS becomes part and parcel of precision agriculture. For analysis and processing of remote Sensed images requires ground truth information, collected in the field, at a variety of sites and often at various times throughout the crop production season. Conventionally this data has been manually recorded on field sheets, air photos or paper maps and considerable time and effort is required to convert it to digital format for use in remote sensing or GIS. For image analysis the ground data must be digitized in order to create a mask for training the software to recognize different conditions and classify the remote sensing imagery. We have developed an interactive, portable system to record field data directly into a digital database consisting of yield, soil, road, water and contour maps overlain on air photos or remote sensing imagery. A GPS receiver is linked to a note book computer displaying appropriate, pre-loaded information layers, and a software package then combines incoming GPS signals with the displayed data to allow the user to see where they are with respect to the map components as shown in Fig.1 The various layers of information can be easily edited and modified in the field and new data can be added as point or polygon layers and attribute tables. The system also allows the user to save GPS data to view and track field activity at a later date. Data recorded in the field, such as the location of weed patches, field boundaries and crop condition noted can be moved easily to other GIS. Spreadsheet and image processing systems to enhance datasets and improve analysis. The image classification process in particular can be improved with the accurate and easily accessible ground-truth data.

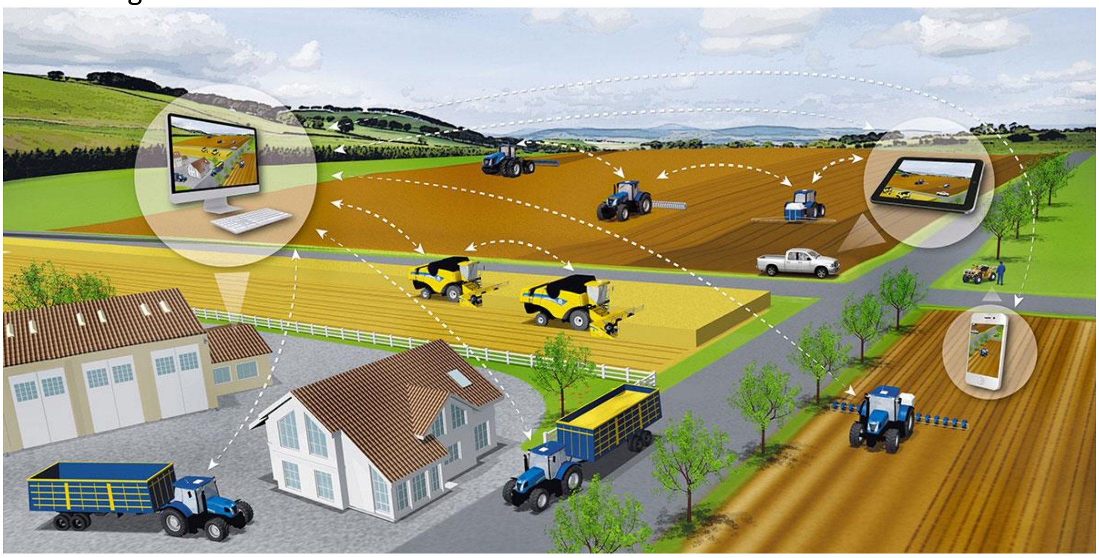

Fig.1

Indian Scenario

Precision Agriculture has been mostly confined to developed countries. Reasons of limitations of its implementation in developing countries like India are Small holdings, Heterogeneity of cropping systems and market imperfections, Lack of technical expertise knowledge and technology and High cost. In India major problem is the small field size. More than 58 percent of operational holdings in the country have size less than 1ha. Only in the states of Punjab, Rajasthan, Haryana and Gujarat more than 20 per cent of agricultural lands have operational holding size of more than 4 ha. There is a scope of implementing precision Agriculture for crops like, rice and wheat especially in the states of Punjab and Haryana. Commercial as well as Horticultural crops shows a wider scope for precision Agriculture. Adoption of precision agriculture needs combined efforts on behalf as scientists, farmers and government. The following strategies may help in the successful adoption of precision agriculture in the country are Creation of multidisciplinary teams involving agricultural scientists in various fields, engineers, manufacturers and economists to study the overall scope of precision agriculture, Formation of farmer's co-operatives since many of the precision agriculture tools are costly (GIS, GPS, RS), Government legislation restraining farmer using indiscriminate farm inputs and thereby causing ecological/environmental imbalance would induce the farmer to go for alternative approach, Pilot study should be conducted on farmer's field to show the results of precision agriculture implementation.

Conclusion

The use of GPS technology is an efficient and effective method of providing location data for precision agriculture applications. Farmers and agriculture service providers can expect even further improvements as GPS continues to modernize. The use of GPS in Agriculture is limited but it is fair to expect wide spread use of GPS in future. Recently a GPS based crop duster (precision GPS Helicopter), which can spray an area as small as 4 X 4 m is attracting great attention. Some progressive farmers are now beginning to use GPS for recording observations. Such as weed growth, unusual plant stress, coloring and growth conditions, which can then be mapped with a GIS programmers. In the years to come, GPS system role in precision agriculture may help the Indian farmers to harvest the fruits of frontier technologies without compromising the quality of land and produce.

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CLASSIFICATION OF COTTON INSECT PESTS AND THEIR MANAGEMENT

Pooja Singh*, Kamesh Singh Chauhan, Abhishek Singh Chauhan and Pushpendra

Department of Agronomy, Banda University of Agriculture & Technology Banda
Department of Agronomy, CCS University Meerut Uttar Pradesh
Department of Entomology, Banda University of Agriculture & Technology Banda
Junior Research Assistant, Banda University of Agriculture & Technology, Banda
*Corresponding email: psinghbuat@gmail.com

Abstract

Cotton, being one of the most important commercial crops worldwide, is susceptible to various insect pests that can cause significant damage to yields and quality. Effective classification and management of cotton insect pests are crucial for sustainable cotton production. This abstract provides an overview of the classification of cotton insect pests and highlights important management strategies employed to minimize their impact.

Introduction

Cotton, one of the most important cash crops worldwide, faces a constant threat from various insect pests that can cause significant damage to the crop. Effective management of these pests is crucial for maintaining cotton yields and ensuring the economic viability of cotton production. In this article, we will explore the classification of cotton insect pests and discuss strategies for their effective management.

The classification of cotton insect pests encompasses a wide range of species belonging to different orders, including Lepidoptera (moths), Hemiptera (bugs), Thysanoptera (thrips), Coleoptera (beetles), and Diptera (flies). These pests exhibit diverse feeding habits and life cycles, making their identification and classification essential for appropriate control measures.

Major Insect

- **Bollworms :** Bollworms, including the notorious pink bollworm (*Pectinophora gossypiella*) and the cotton bollworm (*Helicoverpa armigera*) are among the most damaging pests of cotton. These pests primarily attack the cotton bolls, causing yield loss and quality deterioration. Integrated Pest Management (IPM) techniques, such as monitoring and early detection, use of resistant varieties, cultural practices, biological control agents, and judicious use of insecticides, are key strategies for managing bollworm infestations.
- **Whiteflies :** Whiteflies, notably the cotton whitefly (*Bemisia tabaci*), are sap-feeding insects that pose a significant threat to cotton crops. They damage the plants by sucking sap and excreting honeydew, which promotes the growth of sooty mold and reduces photosynthesis. Effective management of whiteflies involves the use of insecticidal sprays, deployment of yellow sticky traps for monitoring, cultural practices like weed control, and the implementation of biological control methods, such as the use of natural enemies like parasitic wasps.

- **Aphids :** Aphids (*Aphis gossypii*) are small, soft-bodied insects that infest cotton plants by sucking sap from leaves, stems, and buds. They reproduce rapidly and can cause stunting, leaf curling, and the transmission of viral diseases. Management strategies for aphids include the use of insecticidal soaps and oils, biological control agents like ladybugs and lacewings, and cultural practices such as intercropping and proper plant nutrition.
- **Thrips :** Thrips are tiny insects that feed on developing cotton buds, flowers, and leaves. They cause damage by rasping the plant tissue and spreading viral diseases. To manage thrips infestations, farmers can employ techniques such as early planting, using resistant varieties, employing reflective mulches, and applying insecticides targeted at specific growth stages.
- **Armyworms :** Armyworms, including the cotton armyworm (*Spodoptera litura*), can cause extensive damage to cotton crops by devouring leaves, bolls, and squares. Effective management of armyworms involves early detection through scouting, cultural practices such as crop rotation, biological control using natural enemies like parasitic wasps and predators, and judicious use of insecticides.

Management

Management of cotton insect pests involves integrated pest management (IPM) strategies that integrate multiple approaches to minimize pesticide use while ensuring effective pest control. These strategies include cultural practices, biological control, host plant resistance, and chemical control.

Integrated Pest Management (IMP): The following components and strategies can be incorporated into an IPM program for cotton insect pest management:

Monitoring and Identification

Regular monitoring of cotton fields is essential to identify and assess pest populations accurately. Various monitoring techniques such as pheromone traps, sticky traps, visual inspections, and scouting can be employed to detect pest presence and determine population levels.

Economic Thresholds

Establishing economic thresholds helps determine when pest populations have reached a level that justifies intervention. Economic thresholds consider factors such as crop growth stage, pest density, and potential yield loss, ensuring that control measures are only implemented when economically justified.

Cultural Practices

Cultural practices play a crucial role in pest management by creating unfavorable conditions for pests or disrupting their life cycles. These practices include crop rotation, planting date manipulation, tillage, and removal of crop residues. By altering the crop environment, cultural practices can reduce pest populations and limit the spread of pests between seasons.

Biological Control

Biological control involves the use of natural enemies to suppress pest populations. Predatory insects, parasitic wasps, spiders, and beneficial nematodes can be introduced into cotton fields to prey on or parasitize pest insects. Conservation and augmentation of natural enemies through habitat manipulation and provision of alternative food sources can also enhance biological control.

Host Plant Resistance

Breeding cotton varieties with inherent resistance or tolerance to specific insect pests is an effective long-term strategy. By incorporating traits such as antibiosis (toxicity to pests), antixenosis (reducing pest preference), and tolerance (maintaining yield despite pest feeding), resistant varieties can reduce the need for chemical control measures.

Chemical Control

When pest populations exceed economic thresholds, judicious use of insecticides becomes necessary. In an IPM program, selective insecticides with minimal impact on beneficial organisms are preferred. Insecticide application is timed based on pest life cycles and weather conditions to maximize effectiveness. Application rates and methods should follow label instructions and minimize non-target exposure.

Record Keeping and Evaluation

Maintaining detailed records of pest populations, control measures, and their outcomes helps evaluate the effectiveness of IPM strategies over time. This information enables farmers to make informed decisions regarding pest management and implement necessary adjustments to optimize pest control methods.

Conclusion

Managing insect pests is essential for ensuring healthy cotton crops and maximizing yields. By understanding the classification of cotton insect pests and implementing integrated pest management strategies, farmers can effectively control infestations while minimizing the use of chemical insecticides. Continuous monitoring, early detection, use of resistant varieties, cultural practices, biological control methods, and targeted insecticide applications are all key components of a successful pest management program in cotton cultivation. With a comprehensive approach, farmers can mitigate the impact of insect pests and maintain the sustainability and profitability of cotton production.

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SPATIAL ANALYSIS OF IRRIGATION, MULCHING, AND DROUGHT RISK USING REMOTE SENSING AND GIS

S. H. Parmar, D. D. Vadalia, P. A. Pandya and G. V. Prajapati

Centre of Excellence on Soil and Water Management,
Office of Research Scientist (Agril. Engg.), Junagadh Agriculture University, Junagadh, India
Corresponding Email: sanjayparmar5151@gmail.com

Abstract

Irrigation, mulching, and drought risk are crucial factors in agricultural water management. Remote sensing and Geographic Information Systems (GIS) have emerged as powerful tools for spatial analysis in these areas. This article provides a comprehensive overview of the application of remote sensing and GIS in the spatial analysis of irrigation, mulching, and drought risk. It explores the use of remote sensing data for estimating evapotranspiration, optimizing irrigation practices, mapping and monitoring mulching techniques, and assessing drought vulnerability. The integration of remote sensing and GIS enables a holistic approach to water resource management, aiding decision-making processes and improving agricultural sustainability.

Introduction

Water management is a crucial aspect of sustainable agriculture as it directly influences crop productivity, resource efficiency, and environmental sustainability. With the increasing global population and growing demand for food, efficient water management practices are essential to meet these challenges. Water is a main constraint in arid and semi- arid regions for intensive irrigation (Pandya and Rank, 2014).In this context, the utilization of remote sensing and GIS technologies has emerged as a valuable approach to analyze and optimize irrigation, mulching, and drought risk in agricultural systems. One of the key reasons why water management is important in agriculture is the limited availability of freshwater resources. Prajapati and Subbaiah, (2019) emphasized the overestimation of seasonal crop evapotranspiration when using adjusted FAO Kc values, highlighting the importance of verification before their blind application. The development of Kc curves for Bt. cotton was pursued due to its simplicity and minimal data requirements, enabling effective irrigation scheduling and water management. Vadalia*et al*. (2022) observed that BBF yielded lower Kc values as compared to flatland. Overestimated adjusted FAO-Kc values caused a loss of precious water for wheat. Agriculture accounts for a significant portion of global water consumption, and inefficient irrigation practices can lead to water scarcity and depletion of aquifers. By implementing proper water management techniques, farmers can maximize the use of available water resources while minimizing wastage. This ensures that water is utilized efficiently and sustainably, benefiting both the farmers and the environment.

Remote sensing, in combination with GIS, offers a powerful toolset for analyzing and monitoring water-related parameters in agricultural landscapes. Remote sensing involves the use of satellite imagery and other sensors to collect data on various aspects such as vegetation health, evapotranspiration rates, and soil moisture content. Remote sensing and Geographic Information Systems (GIS) are powerful tools for agricultural analysis and management. They allow for the collection, integration, and analysis of spatial data from multiple sources, including satellite imagery and ground-based measurements. This technology has revolutionized the way we understand and manage our natural resources, including water use in agriculture (Zhao*et al*. 2023). These data can be processed and integrated into GIS platforms, allowing for the spatial analysis of irrigation, mulching, and drought risk. Parmar *et. al* (2019) demonstrated the potential of using MODIS satellite imagery, specifically the LST_Night_1km band, along with regression equations to simulate maximum and minimum temperatures at the CAET, Godhra, and Kakanpur gauge stations in Gujarat. The results showed promising agreement between the MODIS imagery and ground-measured temperatures, indicating the applicability of remote sensing for temperature estimation in the region. When it comes to irrigation, remote sensing provides valuable information on crop water requirements and helps determine the optimal timing and amount of irrigation needed. By analyzing satellite imagery and vegetation indices, such as the normalized difference vegetation index (NDVI), farmers can identify areas with water stress and adjust their irrigation schedules accordingly. This targeted irrigation approach improves water use efficiency, reduces water wastage, and minimizes the risk of over- or under-irrigation.

Mulching is another important component of water management in agriculture. Mulch materials, such as plastic films or organic residues, are used to cover the soil surface around plants, conserving soil moisture, reducing evaporation, and suppressing weed growth. Prajapati and Subbaiah, (2018) revealed the use of silver black plastic mulch with drip irrigation scheduled at 0.8ETc resulted in superior performance in terms of morphological variables, yield attributes, and water use efficiency compared to wheat straw mulch, drip irrigation without mulch, and furrow irrigation. Vadalia and Prajapati, (2022) revealed that adjusted FAO Kc predicts higher value than sensor based Kc values at both irrigation levels. Remote sensing and GIS can aid in assessing the effectiveness of mulching practices by analyzing the temperature of the soil surface and monitoring changes in vegetation health. This information can guide farmers in selecting the most suitable mulch materials and optimizing their application for maximum water conservation. Drought risk analysis is crucial for anticipating and mitigating the impacts of drought events in agricultural regions. Remote sensing plays a vital role in early detection and monitoring of drought conditions. Drought indices, such as the normalized difference vegetation index (NDVI) or the vegetation condition index (VCI), derived from satellite imagery can provide valuable insights into the severity and spatial extent of drought. By integrating these data into GIS platforms, drought risk maps can be generated, highlighting areas at high risk of water scarcity and guiding decision-making regarding crop selection, water allocation, and emergency response measures.

The integration of remote sensing and GIS in analyzing irrigation, mulching, and drought risk brings several benefits to water management in agriculture. Spatial analysis of irrigation using remote sensing and GIS is a crucial aspect of precision agriculture. The use of remote sensing data and GIS tools can help to identify the areas that require irrigation, monitor the water usage, and optimize the irrigation process (Mujere and Kanji, 2015). Firstly, it allows for a comprehensive understanding of the spatial variability of water-related parameters, enabling targeted interventions and efficient resource allocation. Secondly, it provides timely and up-to-date information, facilitating real-time decision-making and adaptive management strategies. Finally, it supports evidence-based policy formulation by providing accurate assessments of water availability and identifying areas prone to drought risks.

Role of GIS in Water Resource Management

GIS plays a crucial role in water resource management by enabling the integration of various data layers, such as topography, hydrology, climate, and land use. It allows for the creation of comprehensive digital maps that represent the spatial distribution of these factors, aiding in the identification of water sources, watershed delineation, and hydrological modelling. Parmar and Tiwari, (2020) revealed that remote sensing-based data exhibited comparable performance to point estimations from field studies in accurately estimating ET_0.GIS facilitates the analysis of water availability, water quality, and water demand, supporting decision-making processes related to irrigation planning, water allocation, and water conservation strategies.

Application of Remote Sensing in Agriculture

Remote sensing technology provides a unique perspective by capturing detailed information about the Earth's surface from a distance. In agriculture, remote sensing offers valuable insights into crop health, vegetation dynamics, soil moisture, and other important agricultural parameters. Satellite imagery, acquired at regular intervals, allows for monitoring changes in vegetation cover, identifying areas of stress or disease, and assessing crop growth patterns.

The Benefits of Remote Sensing and GIS Integration

Spatial Analysis: The integration of remote sensing and GIS enables spatial analysis by overlaying and analyzing different data layers. This integration allows for the identification of patterns, trends, and spatial relationships, facilitating informed decision-making in agriculture. For example, by combining satellite imagery with GIS data, farmers can delineate zones with varying soil moisture levels and apply irrigation resources accordingly.

Precision Agriculture: Remote sensing and GIS technologies support precision agriculture practices by providing detailed information about field variability. Farmers can use this information to tailor their management practices, such as variable-rate irrigation or fertilization, to specific areas within a field. This targeted approach optimizes resource allocation, minimizes input waste, and maximizes crop productivity.

Crop Monitoring and Yield Estimation: Remote sensing-based monitoring of crops allows for early detection of anomalies, such as disease outbreaks or nutrient deficiencies. By utilizing satellite imagery and GIS tools, farmers can identify and respond to such issues promptly, preventing yield losses. Additionally, remote sensing can aid in yield estimation and crop forecasting, supporting market analysis and decision-making for farmers and policymakers.

Environmental Impact Assessment: Remote sensing and GIS facilitate the assessment of the environmental impact of agricultural practices. By monitoring land use changes, deforestation, soil erosion, and water quality, these technologies contribute to sustainable land management and conservation efforts. This information can guide policymakers in implementing effective environmental regulations and conservation strategies.

Mulching Techniques and Remote Sensing

Mulching is a widely recognized agricultural practice that involves covering the soil surface with a layer of organic or synthetic materials. This technique offers several benefits, such as moisture conservation, weed suppression, soil temperature moderation, and improved nutrient cycling. Prajapati and Subbaiah, (2015) revealed the drip irrigated silver plastic mulch enhanced the yield by 13.69%, biodegradable plastic mulch 23.94%, wheat straw mulch 28.74%, drip without mulch 52.43% and furrow irrigation at 0.8 ETc. Remote sensing, in conjunction with mulching techniques, can provide valuable insights and support decision-making processes in agriculture. This section explores the application of remote sensing in assessing mulching effectiveness, monitoring mulch distribution, and optimizing mulch management.

Assessing Mulching Effectiveness

Remote sensing can be utilized to assess the effectiveness of mulching techniques in conserving soil moisture and regulating soil temperature. By analyzing satellite imagery, researchers and farmers can evaluate the impact of mulch on soil moisture levels over time. The images can capture differences in vegetation health and vigor between mulched and non-mulched areas, providing an indication of the efficacy of the mulching practice. This information enables farmers to make informed decisions regarding the selection of appropriate mulch materials and thickness for different crops and environmental conditions.

Monitoring Mulch Distribution

Remote sensing techniques, including aerial photography and satellite imagery, can be used to monitor the distribution and coverage of mulch materials across agricultural fields. High-resolution imagery can capture detailed information about the spatial variability of mulch distribution, highlighting areas with inadequate coverage or potential erosion risks. By identifying these areas, farmers can take corrective measures, such as redistributing mulch materials or applying additional mulch layers, to ensure uniform coverage and maximize the benefits of mulching.

Optimizing Mulch Management

Remote sensing, in combination with GIS, offers the potential to optimize mulch management practices. Through the integration of remote sensing data with other geospatial information, such as soil characteristics, topography, and climate data, farmers can identify optimal locations for mulching and tailor their mulch application strategies accordingly. Mulching is a practice that involves covering the soil with materials such as straw, leaves, or plastic to retain moisture, suppress weeds, and improve soil fertility. This information can be used to assess the effectiveness of mulching in conserving water resources and reducing drought risk. Additionally, spatial analysis of mulching using remote sensing and GIS can aid in identifying areas where this practice can be implemented for maximum benefit (Hoque *et al*. 2021). Furthermore, remote sensing can aid in monitoring the degradation of mulch materials over time. By regularly analyzing satellite imagery, farmers can assess the rate of mulch decomposition and plan for timely reapplication or replacement of mulch. This ensures the continuous effectiveness of mulching in weed suppression, soil moisture retention, and temperature regulation.

Drought Monitoring and Risk Assessment

Integration of Integration of remote sensing data and GIS allows for the development of early warning systems for drought. By combining historical climate data, satellite imagery, and hydrological models, it is possible to forecast and anticipate drought conditions. Pandya *et al*. (2022) developed the composite drought index using a linear combination with PCA based weights of three parameters including meteorological drought index, vegetation drought index and inverse of maximum consecutive dry days. These early warning systems provide valuable information to decision-makers and stakeholders, allowing them to take proactive measures to mitigate the impacts of drought. GIS-based decision support systems play a crucial role in disseminating this information in a spatially explicit manner, enabling efficient resource allocation and drought preparedness strategies.

GIS offers powerful spatial interpolation and extrapolation techniques that facilitate the integration of meteorological data with irrigation, mulching, and drought risk analysis. By incorporating multiple layers of information, such as soil moisture levels, crop water requirements, and drought indices, a comprehensive picture of water management can be achieved. This integration enables the identification of optimal irrigation and mulching practices while considering drought risk factors. Geospatial models provide a holistic approach to water management by simulating and analyzing the interactions between irrigation, mulching, and drought risk. Pandya and Gontia, (2023) demonstrated the methodology for developing DSDF curves to identify drought proneness in terms of drought severity and duration. The most promising drought index of the semi-arid region, i.e. SPEI, was used to construct the drought severity time series of 1–4 months duration and severities for 2–100 years return periods were estimated by testing various probability distributions. These models consider various parameters, including soil characteristics, topography, climate data, and vegetation indices derived from remote sensing. By combining these technologies, farmers can optimize resource use, reduce crop damage from drought or pests, and ultimately increase yields. Additionally, the use of remote sensing and GIS can help promote sustainable agriculture practices by reducing water usage and chemical inputs. Overall, the integration of these technologies is a valuable tool for modern agriculture management (Hazaymeh and Hassan, 2016).

Conclusion

The application of remote sensing and GIS in the spatial analysis of irrigation, mulching, and drought risk plays a vital role in water resource management and agricultural sustainability. These technologies offer numerous benefits, including improved water use efficiency, optimized resource allocation, and enhanced decision-making processes. Remote sensing enables the estimation of evapotranspiration rates and the identification of areas experiencing water stress, allowing for targeted irrigation practices. By integrating remote sensing data with GIS, farmers can make informed decisions regarding irrigation timing and quantity, reducing water wastage and maximizing crop productivity. Similarly, remote sensing and GIS facilitate the assessment of mulching effectiveness by monitoring soil moisture levels and vegetation health. This information guides farmers in selecting suitable mulch materials and optimizing their application to conserve water and enhance crop performance. Moreover, the integration of remote sensing and GIS in drought risk analysis enables the development of early warning systems and decision support tools. These systems provide stakeholders with timely information about drought conditions, enabling proactive measures to mitigate its impacts.

By considering multiple layers of geospatial information, such as soil characteristics, climate data, and vegetation indices, GIS facilitates a holistic approach to water management. Geospatial models allow decision-makers to simulate and analyze the interactions between irrigation, mulching, and drought risk, optimizing resource allocation and promoting sustainable agricultural practices. Overall, remote sensing and GIS technologies offer valuable insights into water management in agriculture, supporting efficient resource utilization, improved crop productivity, and resilient farming systems. The integration of these technologies holds great potential for addressing water scarcity challenges and ensuring the long-term sustainability of agricultural practices.

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RUST DISEASE OF PEANUT

R. Yonzone[1*] and M. Soniya Devi[2]

[1]College of Agriculture (Extended Campus), UBKV, West Bengal
[2]Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh
*Corresponding Email: rakeshyonzone.com@gmail.com

Peanut rust caused by *Puccinia arachidis* Speg. is one of the most important disease causing upto 57% of economical losses to the crop production. This pathogen has been constantly coevolving with the host in south America ever since it first report form Surinam in 1827. Prior 1969 this disease was largely confined to South and Central America but now the pathogen has spread widely and established in many countries including Asia. It is now one of the most economically important disease in almost all groundnut growing areas. The losses caused by *Puccinia arachidis* have been substantial, however if the disease is accompanied by two leaf spot disease *Cercospora arachidicola* and *Cercospora personata* the damage is even more higher.

The disease symptoms begins to appears 7-10 days after infection which appears as whitish flecks initially on the abaxial surface. Later it turns into orange red or brown colored with yellow flecks on upper surface of the leaves (Fig 1 and 2). The lower surfaces contain pustules (uredinia) which are mostly circular to elliptical, raised and measures about 0.3 to 2.0 mm in diameter. In the advance stage the pustules ruptures and exposes circular or oval uredospores which are dark orange in color at the initial stage but soon turns brown color. The surrounding areas of pustules may turn necrotic which soon coalesce and lead to defoliation. Beside leaves the symptoms may develop on petioles stems. The disease is highly favored by wet and warm weather.

Fig 1 & 2: Symptoms of Peanut rust disease on the lower surface and upper surface of leaves

In pea nut urediospores are most common which are 24.96×21.22 µm in diameter, with spore walls brown in colour, thick, finely echinulate with 2-4 germpores and measures 1.22 µm. The Urediospores are present in Uredinia which are mostly hypophyllus, subepidermal, ellipsoidal or oblong in shape, and become dark cinnamon brown color when mature (Fig 3). Each uredosorus contains numerous pedicillate uredospores. Pedicel of the uredospore is short, fragile, and hyaline. the telialstage is not so common and was only reported from Central America, Florida, and Brazil in wild peanut leaves. It was also observed very recently from cultivated peanut field at Gadag, Karnataka, India. Telia are chiefly hypophyllus, 0.2 mm in diameter, contain numerous teliospores. Teliospores are oblong, obovate, and ellipsoidal to ovate in shape, with round to acute and thickened apex, constricted in the middle. Teliospores are smoot walled and light yellow, golden yellow, or chestnut brown, predominantly two celled. Basidium and basidiospores are not still known for *P. arachidis*.

Fig 3: Uredinospores of *Puccinia arachidis*

In this disease uredospores are the only repetating spores and have practical significance. They are mostly air borne and may also be present on outer pod/seed surface but are not internally seed borne. The disease is favoured by warm temperatures 20-30 °C) with wet weather or high humidity (>78 %). study in Karnataka, India confirmed that the uredospores were viable up to 20 days under field conditions (25–28 °C) and optimum temperature of 25 °C was found congenial for the maximum germination of spores. The uredospores on self-sown/voluntary peanut plants play an important role in survival and viability of the pathogen from season to season which help in perpetuation and carryover of rust.

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FERTILIZER ASSOCIATION OF INDIA (FAI): FUNCTIONS, SOLUTIONS AND VALUE PROPOSITION

Ankit[1*], Dhram Prakash[2], Sunita Sheoran[3] and Manju Kumari[4]

[1,2,3]Department of Soil Science, CCSHAU, Hisar, Haryana-125004
[4]Division of Soil Science and Agricultural Chemistry, IARI, New Delhi - 110012
[*]Corresponding email: ankityadamal@hau.ac.in

Introduction

The Fertiliser Association of India (FAI) is a non-profit organisation that primarily represents input suppliers, equipment manufacturers, distributors, importers and manufacturers of fertilizer. The Association was set up in 1955 with the goal of bringing together all parties involved in the creation, distribution and application of fertilizers. All Indian fertilizer manufacturer's profiles, performance, capacity utilisation, energy consumption, energy conservation measures implemented and their effects, obstacles to further implementation of energy conservation measures, technology licensors and equipment suppliers are all available to FAI, in part as publicly available data and partly as confidential information.

The Fertiliser Association of India (FAI) is a body that represents the fertiliser industry and works to improve fertiliser distribution and production. The board of directors, which represents the various interests of the constituent member units, oversees FAI. The board currently has 32 members, the majority of whom are the CEOs of the member companies. Technical, environment safety, marketing, statistics, information, communication, economics, agricultural sciences, documentation, accounts, administration and public relations are some of the functional divisions/departments that carry out FAI's activities. Four regional offices of the FAI are situated in Mumbai, Chennai, Kolkata and Delhi. The regional offices primarily concentrate on regional issues and maintain constant communication with the regional fertiliser producers, the state governments and other local authorities.

Functions of FAI

- Monitoring the performance of fertilizer plants in relation to various operational parameters, such as energy consumption, water consumption, plant downtime causes and other causes as well as the concentration of pollutants in emissions and effluents. The preparation, presentation and publication of status papers. Periodically, benchmarking exercises are also performed.
- Through a variety of group discussions, workshops, seminars and symposia, FAI promotes the exchange of knowledge on all topics pertaining to fertiliser production. Additionally, FAI publishes a monthly journal called "Indian Journal of Fertilisers" that gives readers the chance to share their experiences with various facets of fertiliser production, distribution, and use.
- Working with the Bureau of Energy Efficiency (BEE) as the sector expert agency for the implementation of the perform achieve transfer scheme. Under this programme, 29 designated consumers (DCs) have already been identified. FAI helped BEE to achieve its goals for reducing energy consumption.

Challenge that FAI is trying to solve

There are many difficulties facing the local suppliers and producers of fertiliser, including the fact that India uses less fertiliser than nation like China and does not provide subsidies to them.

Solutions by FAI

Through its activities, the Fertiliser Association of India (FAI) is a body that represents the fertiliser industry which acts as a bridge for all parties involved in the production, marketing and use of fertilisers with the goal of:

- Acting as a bridge for all stakeholders concerned with the production, marketing and use of fertilisers.
- Aiding the industry in improving its operational efficiency.
- Address the issues that the agricultural sector and fertiliser industry are facing.
- Encourage the efficient and balanced use of fertilisers.

  The Association's main goal is to ensure food security by using plant nutrients effectively and in a balanced ways. Nearly 973 members, including active, associate, overseas associate, technical and professional members make up FAI which offers the assistance required to meet the challenges the industry is facing.

The four membership categories provided by the Indian Fertiliser Association are as follows:

1) Active membership
2) Associate membership
3) Overseas Associate membership
4) Technical/Professional membership

Technology

An energy assessment toolkit called Assessment to Action (A2A), created by IIP and ICF Marbek was initially designed for Chinese plants before being modified and improved for the Indian fertilizer industry. Each improvement strategy in the toolkit's library has undergone a careful examination. For each of the identified technological options, FAI offers accurate information on costs, energy savings and cost-benefit analyses. After that, two plants were visited in order to validate and further test the modified toolkit in the field.

Value Proposition and Key Differentiator of FAI

- The FAI serves as a focal point for resolving industry problems by bringing up concerns with the concerned agencies and ministries.
- The FAI acts as a bridge between industry and government by maintaining close contact and rapport with concerned ministries and agencies. It compiles information on various business issues. FAI is represented in all government committees and panels that deal with fertiliser and agriculture.
- FAI maintains close liaison with international bodies like: Food and Agriculture Organization of the United Nations (FAO), United Nations Industrial Development Organization (UNIDO), International Fertilizer Industry Association (IFA), IMPHOS (World Phosphate Institute), The Sulphur Institute (TSI), International Potash Institute (IPI), International Zinc Association (IZA), Potash & Phosphate Institute of Canada(PPIC), Fertilizer Advisory Development and Information Network for Asia and the Pacific

(FADINAP), International Rice Research Institute (IRRI), National Fertilizer & Environmental Research Centre, USA and World Bank.

- The FAI is present in a number of international fora where their representatives are invited to present papers on subjects related to fertiliser and agriculture that are significant to developing countries. The FAI has occasionally conducted studies that were funded by international organisations and a few developing nations.
- Through group discussions, workshops, think tank meetings and seminars at the regional, national and international levels, the FAI offers a forum for the exchange of views and cross-fertilization of ideas to those concerned with fertilisers in various disciplines.
- The FAI also conducts related studies on particular subjects like energy conservation, downtime analysis, safety and pollution abatement that are funded by the FAO. For national planning, FAI also forecasts fertilizer supply and demand.
- The FAI maintains a sizable and up-to-date library and documentation centre that serves as a clearinghouse for technical, agricultural, marketing, statistical and other information pertaining to the industry.
- The FAI also offers training programmes at all levels that cover all of the industry's disciplines.
- The FAI has established a number of annual awards in an effort to encourage healthy competition and recognise exceptional work.
- Additionally, the FAI established the PPIC-FAI award for the best research on management and balanced use of inputs in achieving maximum yield, the IMPHOS-FAI award for research that best demonstrates the impact of phosphorus on crop yield and quality and the IPI-FAI award for outstanding M.Sc. research in balanced and integrated fertiliser usage with a focus on potassium.
- Regular updates on developments and issues relating to fertilizers, agriculture and related fields are provided by the FAI to the national press, international organisations and government agencies as well as professional and specialised publications in India and abroad. Press conferences are held to draw attention to problems or issues facing the fertilizer industry.
- Internationally recognised as reliable sources of reference information, FAI publications. Every month, FAI publishes journals like Fertiliser Marketing News (English), Khad Patrika (Hindi) *etc*.
- The FAI website, www.faidelhi.org.in is an effective resource that offers a wealth of information on fertiliser, agriculture and related topics at both the macro and micro levels.

Conclusion

The FAI is a body that represents the fertilizer industry and works to improve fertilizer distribution, production, input suppliers, equipment manufacturers, distributors and importers. The FAI aim to keep advancing fertilizer production, use and distribution in India. Through a lineup of creative programmes and initiatives, they hope to achieve.

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IoT- FUTURE OF AGRICULTURE

Rajesh G M*, Sharanbasava and Siddharam

Kelappaji College of Agricultural Engineering and Technology,
Kerala Agricultural University, Kerala, India-679573.
Corresponding Email: rajeshgm7991@gmail.com

Abstract

Agriculture is essential to the development of nations economy, and it provides food for the entire population. There are significant issues that need to be resolved, including the increase in food demand, climate change, extreme weather conditions, and environmental effects. IoT is a network of a physical objects things embedded with sensors, software, and other technologies for connecting and sharing data with other devices and systems over the internet. IoT is used in so many applications such as self-driven cars, farming, traffic management, telehealth, industrial internet, water, and waste management. In farming, it includes data collection on temperature, humidity, rainfall, windspeed, pest infestation, and soil compaction. Additionally, information gathered concerning various environmental characteristics is sent to the user via message alerts or trigger alerts that convey recommendations to authorities. Users will be able to remotely monitor the production environment and process with the IoT-based system's capacity to connect real things on the farm and make them accessible through the Internet. With the help of this technology, customers may reduce expenses, save on inputs, and monitor every step of the farming process. For IoT solutions to be affordable for most farmers, especially small- and medium-scale farm owners, there are still a few issues that need to be resolved.

Keywords : IoT, Precision Farming, AI, Sensors, UAV, GPS & GIS

Introduction

Agriculture is important to the development of nations economy, and it provides food for the whole population. A nation is seen as socially and economically prosperous if it's a significant agriculture. The agro-industry must adopt IoT so as to feed this enormous population. There are significant issues that require to be resolved, including the rise in food demand, global climate change, extreme weather, and environmental effects.

Internet of Things (IoT) may be a system of interrelated computing devices, mechanical and digital machines, objects, animals, or folks that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT may be a network of a physical objects things embedded with sensors, software, and other technologies for connecting and sharing data with other devices and systems over the web. IoT is employed in so many applications such as self-driven cars, farming, traffic management, telehealth, industrial internet, water, and waste management. In farming, it includes data collection on temperature, humidity, rainfall, windspeed, pest infestation, and soil compaction. By using this data, it's possible to automate agricultural procedures, make informed choices which will improve quality and quantity while lowering risk and waste, and streamline crop management tasks. For instance, farmers may now use IoT data for precise water and

fertiliser applications and remotely monitor soil temperature and moisture. Sensor analysis can help a farmer know much about his farm, enhance farm productivity, and save costs all directly.
Precision farming, livestock, and greenhouses are the three main IoT applications in agriculture, which are organised into various monitoring domains. Wireless sensor networks (WSNs), which assist farmers in gathering pertinent data through sensing devices, are wont to monitor all these applications with the assistance of various IoT-based sensors and devices. An IoT management is proposed therein monitors the elements such as wind, soil, atmosphere, and water over an outsized area.

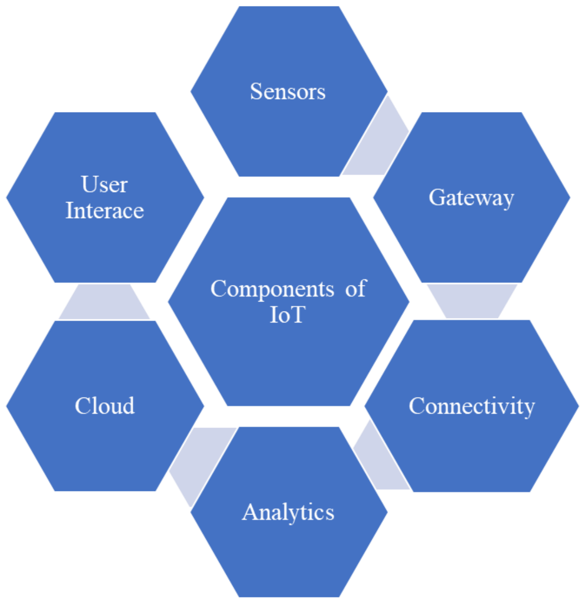
Major components of IoT

Here are the most components based on which an internet of things ecosystem works on.

Things or Devices : Things or Devices are the first physical things being tracked. Smart sensors are attached to different objects or devices, continuing to collect data from the object or device and sending it to the next layer, which is that the portal or alternatively known as the gateway. Because of recent developments in microelectronics, small smart sensors are now practical for a variety of applications. Some commonly used sensors are:

- Temperature sensors and thermostats
- Pressure sensors
- Humidity level
- Light intensity detectors
- Moisture sensors
- Proximity detection
- RFID tags

Connectivity : A medium is required for the transportation of the data from sensors to the cloud infrastructure. Several communication and transport methods, including as cellular networks, satellite networks, Wi-Fi, wide-area networks (WAN), low power wide-area networks (LoRAWAN), ZigBee, Bluetooth, Z-wave, and others, are often used to connect sensors to the cloud.



IoT components

Gateway: For the sensors' incoming, unprocessed data to succeed in the cloud, gateways are required. Network protocols are translated by gateways, enabling seamless communication between all devices within the network. In essence, this turns the gateways into a critical communication hub and makes it possible to simply regulate data flow.

Cloud: Data that has been gathered from various objects or devices is stored within the cloud. Simply described, cloud computing may be a network of linked servers that run continuously over the Internet.

Analytics: After receiving the information or data in the cloud, that data is processed. Data is analysed here with the assistance of various algorithms like machine learning and all. Analytics is that the conversion of analogue information via connected sensors and devices into actionable insights that can be processed, interpreted, and analysed thorough. Analysis of data or information for further processing is a prerequisite for the monitoring and enhancement of the Internet of things (IoT).

User Interface: User interface also termed as UI is nothing but a user-facing program that allows the user to monitor and manipulate data. The interface (UI) is the visible, tangible portion of the IoT device that folks can interact with. Developers must provide a well-designed interface that requires the least amount of effort from users and promotes additional interactions.

Applications of IoT in Agriculture

A few IoT applications for agriculture have been introduced in recent years. Counting on their intended usage, these applications are divided into categories like monitoring, tracking, and traceability, also as greenhouse production. The detailed results are presented within the following.

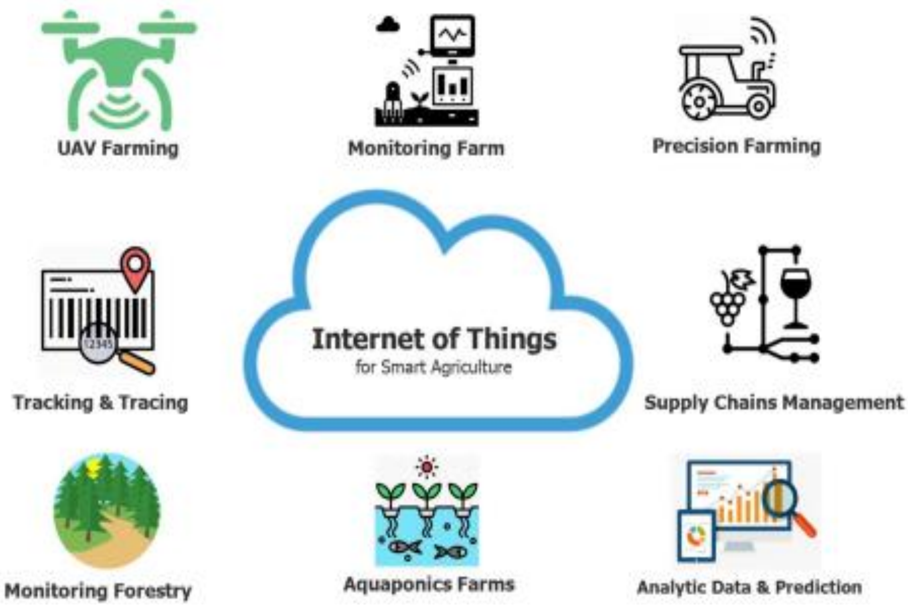
Monitoring: In the agricultural sector, parameters impacting the farming and production process like soil moisture, air humidity, temperature, pH level, etc., are often monitored and analyzed (Villa-Henriksen *et al.,* 2020).

Crop Farming : Significant factors including in this sector are air temperature, precipitation, air humidity, soil moisture, salinity, solar radiation, pest activity, soil nutrient composition, etc., have a significant impact on farming practises and production efficiency.

Aquaponics : It’s an integration of aquaculture and hydroponics. Aquaponics is a farming technique where fish waste becomes a source of nutrients needed by plants. The important issues in farms are constantly monitoring water quality, water level, temperature, salinity, pH, sunlight, etc. IoT system to monitor water temperature and pH for aquaponics farms. Additionally, this technique has a water metric management system to maintain the stability of the fish habitat and an automated fish feeding function to enhance fish productivity.

Livestock Monitoring : Large farm owners use wireless IoT apps to determines the location, health, and well-being of their livestock. This information enables them to identify sick animals and, from then on, segregate them from the herd, to care them, and to prevent the spreading sickness to other animals (). It is also help to reduce labour expenses since owners may locate their animals using IoT-based sensors.

Smart Precision Farming: The advent of the GPS (global positioning system) has created breakthrough advances in many fields of science and technology. Emerging technologies like remote sensing, global positioning systems (GPS), geographic information systems (GIS), Internet of Things (IoT), Big Data analysis, and artificial intelligence (AI) are capable tools being utilized to optimize agricultural operations and inputs aimed to enhance production and reduce inputs and yield losses (Sishodia*et al.,* 2020). The GPS provides the foremost important parameters for locating a device like location and time. GPS systems are successfully deployed in many fields, such as smartphones, vehicles, and IoT ecosystems. Precision farming is one among the most well-known IoT applications in the agriculture industry, and used by different organizations across the world.



Application of IoT in Agriculture (Quy *et al.,* 2022*)*

Unmanned Aerial Vehicles : Drones, also called unmanned aerial vehicles are wont to help optimize agriculture operations, monitor crop health, and help for sustainable farming (Cerro *et al*., 2021). Drones are fitted with different sensors that can generate real time information on crop status or livestock movement, leading to more efficient and precise decision-making agricultural operations and management (Mogili*et al.,* 2019). A variety of sensors fitted for digital imagining capabilities, like multi spectral, high resolution image sensors and actuators, for field surveys, crop scouting, spraying, and spreading operations, and livestock and fishery monitoring (Mohan *et al.,* 2021). Farmers can exactly calculate their field sizes, categorise crop types and varieties, generate soil maps with pest control, and appropriately plan the harvesting of their crops using data analytics.

Greenhouses: In a greenhouse, plants are grown in a controlled and precise environment, including precise controlling of moisture, nutrient ingredients of the soil, light, temperature, etc. Consequently, greenhouse technology makes it possible for humans to grow any plant, at any time, by providing suitable environmental control. In a smart greenhouse, several sensors are employed to evaluate environmental conditions and analyse their appropriateness for plants.

Conclusion

IoT in the field of agriculture and thorough discussion on how to encourage IoT application in the agricultural industry on a number of different ways. Users are going to be able to remotely monitor the production environment and process with the IoT-based system's capacity to connect real things on the farm and make them accessible through the Internet. With the assistance of this technology, customers may reduce expenses, save on inputs, and monitor every step of the farming process. For IoT solutions to be affordable for the majority of farmers, especially small- and medium-scale farm owners, there are still some issues that need to be resolved.

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DRIVING SUSTAINABLE GROWTH IN INDIA'S AQUACULTURE INDUSTRY: THE ROLE OF TECHNICAL EDUCATION AND PMMSY

Shivam Pandey[1*], Gajender Singh[2], S.K. Mahajan[3], Sona Dubey[3], Ashutosh Lowanshi[4], Shiv Mohan Singh[5]and Prateek Tiwari[5]

[1 *& 2]Department of Aquatic Animal Health Management,
College of Fisheries Science, CCS Haryana Agricultural University, Hisar, Haryana
[3]Department of Aquaculture, College of Fisheries Science,
Nanaji Deshmukh Veterinary Science University, Jabalpur (M.P.)
[4]Department of Aquaculture, College of Fisheries Science,
CCS Haryana Agricultural University, Hisar, Haryana
[5]College of Fisheries Science, Nanaji Deshmukh Veterinary Science University,
Jabalpur (M.P.)
***Corresponding Email:** karateshivam97@gmail.com

Introduction

India, with its vast coastline, abundant water resources, and rich aquatic biodiversity, has witnessed a remarkable surge in its aquaculture industry. Aquaculture, the farming of aquatic organisms, including fish, mollusks, crustaceans, and aquatic plants, has emerged as a crucial sector contributing to food security, economic growth, and employment opportunities in the country. India is the 3rd largest fish producing and 2nd largest aquaculture nation in the world after China. The inland fisheries and aquaculture have grown in absolute terms, the development in terms of its potential is yet to be realized. The unutilized and underutilized vast and varied resources, in the form of 191,024 km of rivers and canals, 1.2 million Ha of floodplain lakes, 2.36 million Ha of ponds and tanks, 3.54 million Ha of reservoirs and 1.24 million Ha of brackish water resources offer great opportunities for enhanced production along with livelihood development and ushering economic prosperity.

Expanding Horizons

Over the past decade, India's aquaculture industry has witnessed a phenomenal expansion, transforming it into one of the fastest-growing sectors of the economy. According to the Marine Products Export Development Authority (MPEDA), India's seafood exports reached a record value of $7 billion in the fiscal year 2021-22. Aquaculture contributes a substantial portion to this export value, and the industry continues to demonstrate remarkable potential for further growth.

Factors Driving Growth

1. Technological Advancements: The aquaculture industry in India has embraced modern technologies and scientific advancements to enhance productivity and sustainability. Practices such as pond management, improved feed formulations, water quality monitoring, disease control, and genetic improvement of aquatic species have revolutionized the sector.

2. Government Initiatives: The Indian government has played a pivotal role in promoting the growth of the aquaculture industry. Various schemes, subsidies, and incentives have been introduced to support aquafarmers, encourage scientific research, and ensure sustainable practices. The National Fisheries Development Board (NFDB) has been actively involved in the development and promotion of the sector.

3. Diversification of Species: Indian aquafarmers have diversified their production by cultivating a wide range of species. Traditional favorites like shrimp, catfish, and carp continue to dominate, while newer species like tilapia, seabass, and ornamental fish have gained popularity.

4. Rising Domestic Demand: The growing population and increasing disposable incomes have fueled the demand for seafood in India. Consumers are becoming more health-conscious and recognizing the nutritional benefits of fish and seafood. This rising domestic demand has encouraged aquafarmers to increase production to meet the market needs.

5. Export Opportunities: India's seafood exports have witnessed significant growth, driven by increasing global demand for sustainably produced seafood. The country has established itself as a reliable supplier of high-quality seafood to international markets, including the United States, Europe, Southeast Asia, and the Middle East.

Sustainable Practices

Recognizing the importance of sustainability, Indian aquafarmers have adopted responsible practices to minimize environmental impact and ensure long-term viability. These practices include:

1. Disease Management: Aquaculture farmers focus on disease prevention through improved farm management, regular health monitoring, vaccination programs, and the use of probiotics to enhance the immune system of aquatic organisms.

2. Water and Waste Management: Proper water quality management, efficient use of water resources, and waste treatment systems are integral to sustainable aquaculture. Farmers employ techniques like recirculating aquaculture systems (RAS), biofloc technology, and sedimentation ponds to reduce water consumption and minimize environmental pollution.

3. Certification and Traceability: Many Indian aquaculture farms have obtained internationally recognized certifications such as the Aquaculture Stewardship Council (ASC) and Best Aquaculture Practices (BAP). These certifications ensure adherence to stringent environmental and social standards, providing consumers with confidence in the sustainability of the seafood they consume.

Pradhan Mantri Matsya Sampada Yojana (PMMSY)

The PMMSY initiative, launched by the Prime Minister on September 10, 2020, represents the largest-ever investment in the fisheries sector. It aims to promote sustainable and responsible development while ensuring the socio-economic well-being of fishers, fish farmers, and fish workers. The program was implemented over a five-year period from FY 2020-21 to FY 2024-25 in all States and Union Territories. The PMMSY has set ambitious targets for FY 2025, including increasing fish production by 70 lakh MT, raising aquaculture productivity from 3 tons to 5 tons per Ha, doubling exports from Rs. 46,589 crores to Rs. 1,00,000 crores, creating 55 lakh additional employment opportunities, and doubling the incomes of fishers and fish farmers.

The Pradhan Mantri Matsya Sampada Yojana (PMMSY) offers several benefits for the development of India's fisheries sector. It aims to increase fish production to meet the growing demand for nutritious food. The scheme generates employment opportunities for fishermen and fish farmers, improves infrastructure, and promotes modern and sustainable fishing practices. It also boosts fish and fish product exports, supports the expansion of aquaculture, enhances value addition and processing, and promotes sustainable development by encouraging responsible fishing practices. Overall, PMMSY provides a comprehensive framework for the sector's development, benefiting stakeholders while increasing productivity, employment, and export potential.

Role of technical education in fisheries field

Technical education plays a crucial role in the fisheries field by providing the necessary knowledge, skills, and training to individuals pursuing careers in this sector. The fisheries industry encompasses various aspects, including fish farming, fishery management, seafood processing, aquaculture technology, and fisheries research. Here are some key roles of technical education in the fisheries field:

Skill Development: Technical education programs in fisheries offer hands-on training that equips individuals with practical skills. Students learn about fish biology, aquaculture techniques, water quality management, disease control, feed formulation, breeding and genetics, and sustainable fishing practices. These skills are essential for successfully managing fisheries operations and ensuring optimal production.

Technology Adoption: Technical education provides students with knowledge about the latest advancements in aquaculture technology, equipment, and machinery. This enables them to understand and adopt innovative practices such as recirculating aquaculture systems (RAS), biofloc technology, automated feeding systems, water quality monitoring devices, and fish health diagnostics.

Research and Development: Technical education institutions in the fisheries field often engage in research and development activities. This includes studying fish behavior, breeding techniques, nutrition requirements, disease management, and environmental impact assessment. Research-driven education programs contribute to the advancement of scientific knowledge and promote sustainable practices in the fisheries industry.

Entrepreneurship and Industry Engagement: Technical education in fisheries instils an entrepreneurial mindset in students, enabling them to identify business opportunities and start their own ventures. Programs often include courses on business management, marketing, and financial planning tailored to the fisheries sector. Additionally, technical education institutions establish partnerships and collaborations with industry stakeholders, ensuring that students have exposure to real-world challenges and opportunities.

Policy and Regulation: Fisheries management and conservation are essential for the long-term sustainability of the industry. Technical education equips individuals with a deep understanding of fisheries policies, regulations, and governance frameworks. This knowledge enables them to contribute to policy development, sustainable resource management, and environmental conservation efforts.

Employment Opportunities: Technical education in fisheries opens up a wide range of career opportunities. Graduates can pursue careers as aquaculture farmers, fishery managers, seafood processors, hatchery operators, fisheries researchers, fish health specialists, fisheries extension officers, or consultants. The industry demands skilled professionals who can address challenges related to production, environmental sustainability, disease control, and market demand.

Conclusion

India's aquaculture industry has experienced significant growth, making substantial contributions to the economy, food security, and employment generation. The industry's success is attributed to the adoption of sustainable practices, technological advancements, and government support, establishing it as a responsible and resilient sector. Technical education plays a crucial role in the fisheries field by equipping students with essential skills, knowledge, and practical training necessary for success. It promotes skill development, technology adoption, research, entrepreneurship, industry engagement, and understanding of policies and regulations, thereby fostering growth, sustainability, and success in the fisheries sector.

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CELEBRATING THE INTERNATIONAL YEAR OF MILLETS : A SUSTAINABLE SUPER FOOD FOR A HEALTHIER PLANET

Kamesh Singh Chauhan*, Pooja Singh and Abhishek Singh Chauhan

Department of Agronomy, CCS University Meerut Uttar Pradesh
Department of Agronomy, Banda University of Agriculture & Technology Banda
Department of Entomology, Banda University of Agriculture & Technology Banda
Corresponding Email: achauhanbuat@gmail.com

Abstract

The International Year of Millets (IYM) is a global initiative aimed at raising awareness about the significance of millets in addressing various global challenges, including hunger, malnutrition, and environmental sustainability. Millets are a group of small-seeded grasses that have been cultivated for centuries and are known for their resilience, nutritional value, and adaptability to diverse agro-ecologies. The IYM serves as a platform to promote the production, consumption, and utilization of millets worldwide. By highlighting their nutritional benefits, climate resilience, and role in achieving food security, the initiative aims to encourage policymakers, farmers, consumers, and other stakeholders to recognize and embrace millets as a key component of sustainable food systems.

Introduction

The year 2023 celebrated as the International Year of Millets by the United Nations, highlighting the importance of these small but mighty grains in promoting sustainable agriculture, improving nutrition, and addressing global food security. Millets have been an integral part of human diets for thousands of years ago, especially in regions with arid and semi-arid climates. With their incredible nutritional profile and resilience to climate change, millets are emerging as a key solution to many of the world's pressing challenges.

A Brief Introduction to Millets

Millets are a group of small-seeded grasses that belong to the Poaceae family. They are highly diverse, with several varieties, including pearl millet, finger millet, sorghum, foxtail millet, and many more. These ancient grains have been cultivated for centuries, primarily in Asia and Africa, and are known for their adaptability to harsh environments, low water requirements, and short growing crop.

Nutritional Powerhouses

Millets are often referred to as "nutri-cereals" due to their exceptional nutritional composition. They are rich in complex carbohydrates, dietary fiber, proteins, vitamins, and minerals. Millets are gluten-free and have a low glycemic index, making them an excellent choice for individuals with gluten sensitivities or diabetes. Their high fiber content aids digestion, reduces the risk of chronic diseases, and promotes satiety.

Climate Resilient and Sustainable Agriculture

In the face of climate change, millets have become a valuable crop due to their adaptability and resilience. These grains require significantly less water than major cereals like wheat and rice, making them ideal for regions prone to drought and water scarcity. Millets are also pest-resistant and can grow well in poor soil conditions, reducing synthetic fertilizers and pesticides. Their short growing cycles enable farmers to cope with unpredictable weather patterns and crop failures, providing a reliable source of food and income.

Supporting Food Security and Sustainable Development

Millets have the potential to address global food security challenges by diversifying agricultural systems and reducing dependency on a few staple crops. They can play a crucial role in combating malnutrition, especially in vulnerable populations, as they are rich in micronutrients. Encouraging the cultivation and consumption of millets can enhance dietary diversity and improve the health and well-being of communities worldwide.

Empowering Small-Scale Farmers and Rural Communities

Promoting millet farming can empower small-scale farmers and rural communities by enhancing their livelihoods and income opportunities. Millets are often grown using traditional farming practices, which can help preserve indigenous knowledge and cultural heritage. Additionally, the cultivation of millets can promote sustainable farming practices, preserve biodiversity, and contribute to the conservation of natural resources.

Culinary Delights and Culinary Innovation

Millets offer a wide range of culinary possibilities, from porridges, flatbreads, and savory dishes to baked goods and desserts. They have a unique texture and flavor, which adds variety to meals and delights the taste buds. The International Year of Millets provides an opportunity to explore and promote innovative millet-based recipes and products, encouraging culinary creativity and fostering a vibrant food culture.

Conclusion

As we celebrate the International Year of Millets, it is essential to recognize the immense potential of these ancient grains in promoting sustainable agriculture, improving nutrition, and ensuring food security. By harnessing the power of millets, we can create a more resilient and environmentally friendly food system while addressing some of the world's most pressing challenges. Let us embrace millets as a sustainable super food and work towards a healthier planet for present and future generations.

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DRONE TECHNOLOGY IN AGRICULTURE : BENEFITS AND CHALLENGES IN AGRICULTURE

Pooja Singh, Kamesh Singh Chauhan, Abhishek Singh Chauhan and Ramkumar

Department of Agronomy, Banda University of Agriculture & Technology Banda
Department of Agronomy, CCS University Meerut Uttar Pradesh
Department of Entomology, Banda University of Agriculture & Technology Banda
Department of Entomology and Agricultural Zoology, Institute of Agricultural sciences, Banaras Hindu University, Varanasi, India
Corresponding email: achauhanbuat@gmail.com

Abstract

Drone technology has emerged as a powerful tool in modern agriculture, offering numerous benefits and presenting unique challenges. Drones have revolutionized the agricultural industry by enhancing efficiency, productivity, and sustainability. They offer a range of benefits, including precision agriculture, crop monitoring, and automation of various tasks. With the aid of sensors and imaging technology, drones can collect high-resolution data on crop health, soil conditions, and irrigation needs. This data enables farmers to make informed decisions regarding resource allocation, optimizing the use of fertilizers, water, and pesticides, thereby reducing costs and minimizing environmental impact.

Introduction

In recent years, the agricultural industry has witnessed a remarkable transformation through the integration of advanced technologies. One such groundbreaking innovation is the utilization of drone technology. Drones, also known as unmanned aerial vehicles (UAVs), have emerged as valuable tools in modern agriculture, offering numerous benefits while also presenting unique challenges. This article delves into the advantages of employing drone technology in agriculture and explores the challenges that farmers and stakeholders face in adopting and implementing this revolutionary solution.

Benefits of Drone Technology in Agriculture

Precision Crop Monitoring

Drones equipped with high-resolution cameras and sensors enable precise crop monitoring. Farmers can capture aerial images and collect data on plant health, growth patterns, and nutrient deficiencies. This information empowers them to make data-driven decisions regarding irrigation, fertilization, and pest management, leading to improved crop yields and resource optimization.

Efficient Crop Spraying

Traditional crop spraying methods are labor-intensive and often result in uneven distribution of pesticides or fertilizers. Drones equipped with spraying systems offer a more efficient and precise alternative. By delivering targeted treatments to specific areas, drones minimize chemical wastage, reduce human exposure to harmful substances, and ensure better coverage of the crops.

Plant Health Assessment

Drones equipped with multispectral or thermal cameras can detect early signs of plant stress, diseases, or infestations. By analyzing the collected data, farmers can swiftly identify problem areas within large fields and take timely action, such as targeted treatment or removal of infected plants. This proactive approach helps prevent the spread of diseases and minimizes crop losses.

Time and Cost Savings

The implementation of drone technology in agriculture significantly reduces labor requirements and operational costs. Drones can cover large areas in a fraction of the time it would take for manual inspections, enabling farmers to allocate resources more efficiently. Moreover, drones can access remote or inaccessible areas, eliminating the need for physical infrastructure, such as ladders or scaffolding.

Challenges in Implementing Drone Technology in Agriculture

Regulatory Frameworks

One of the key challenges in adopting drone technology in agriculture is navigating the complex regulatory environment. Laws and regulations regarding drone operations, flight restrictions, and data privacy vary across jurisdictions. Farmers and stakeholders must comply with these regulations, obtain necessary permits, and stay updated with evolving policies, which can be time-consuming and require additional investments.

Technical Expertise

Operating drones and harnessing their full potential requires technical expertise. Farmers need to acquire knowledge about drone piloting, data analysis, and equipment maintenance. Integrating drone technology into existing farming practices may necessitate training programs or hiring skilled personnel, posing a challenge for small-scale farmers with limited resources.

Data Management and Interpretation

Drones generate vast amounts of data during flights. Effectively managing, analyzing, and interpreting this data can be overwhelming for farmers. It requires specialized software tools and data analytics capabilities to extract meaningful insights and make informed decisions. Farmers must invest in data management systems or collaborate with experts to effectively utilize the collected information.

Weather Conditions and Flight Limitations

Unfavorable weather conditions, such as strong winds, rain, or low visibility, can restrict drone operations. Agricultural drone flights are also subject to altitude restrictions and flight permits in certain areas. These limitations may hinder the seamless integration of drones into day-to-day farming activities, particularly in regions with unpredictable weather patterns.

Conclusion

Drone technology offers significant benefits to the agricultural sector, revolutionizing farming practices and improving efficiency. However, challenges related to regulations, costs, data management, and environmental factors need to be addressed for wider adoption and integration of drones in agriculture. Overcoming these obstacles will unlock the full potential of drones, enabling farmers to achieve higher yields, reduce environmental impact, and promote sustainable farming practices. As technology continues to advance, collaboration between stakeholders, governments, and agricultural communities becomes crucial to harness the full potential of drones in transforming the future of agriculture.

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NATURAL FARMING: AN ECOLOGICAL AGRICULTURAL PRACTICES

Pretty Rani [1] and R. Geetha Reddy [2]

[1]Teaching Associate, Department of Extension Education and Communication Management, PJTSAU, Hyderabad
[2]Professor and University Head, Department of Extension Education and Communication Management, PJTSAU, Hyderabad
*Corresponding Email: prettyrani2510@gmail.com

Natural farming, often known as traditional farming, uses no chemicals. It is regarded as an agro ecology-based, varied farming system that incorporates plants, animals, and trees as well as functional biodiversity.

The use of chemical pesticides, artificial fertilizers, and growth regulators is a major component of modern agricultural practices, which have greatly increased agricultural production at the expense of resource depletion, environmental degradation, and loss of crop diversity. It was then realized that modern agriculture with the expenses of deterioting climatic condition cannot go to long run; hence the concept of sustainable agriculture emerged. The emphasis of sustainable agriculture is on conservation of natural resources and to maintain the quality of the environment. According to FAO (2017), sustainable agriculture is at the heart of the 2030 agenda, and the first fundamental step to secure zero hunger.

Natural farming is low input based, climate resilient, and low cost agricultural method, hence decreasing the usage of artificial fertilizers and industrial pesticides.

Natural farming is a chemical-free farming method based on Indian heritage and enhanced by contemporary ecological knowledge, resource recycling, and resource optimisation on the farm. It is regarded as an agroecology-based, varied farming system that incorporates plants, animals, and trees as well as functional biodiversity. It is mostly centred on the recycling of biomass inside the farm, with a particular focus on biomass mulching, the use of cow dung and urine formulations within the farm, maintaining soil aeration, and excluding any synthetic chemical inputs. Natural farming is anticipated to lessen reliance on input purchases. It is regarded as a productive farming method with potential to boost employment and rural development

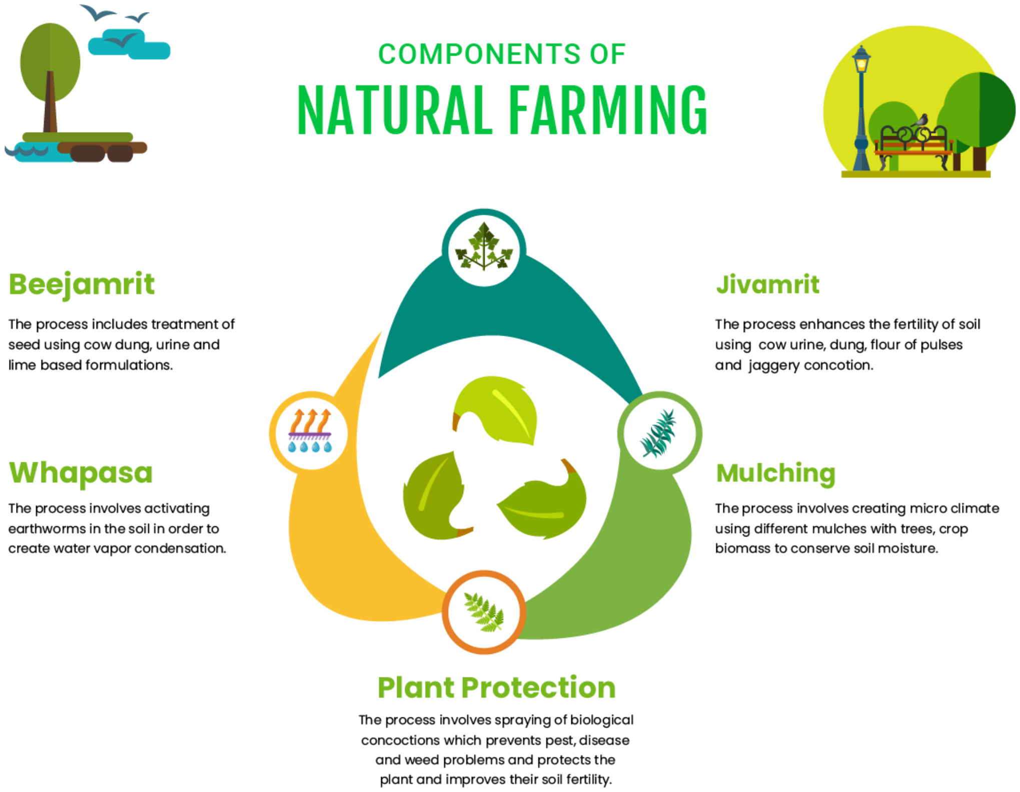

Fig1: Components of Natural farming (source: National mission on natural farming management and knowledge portal)

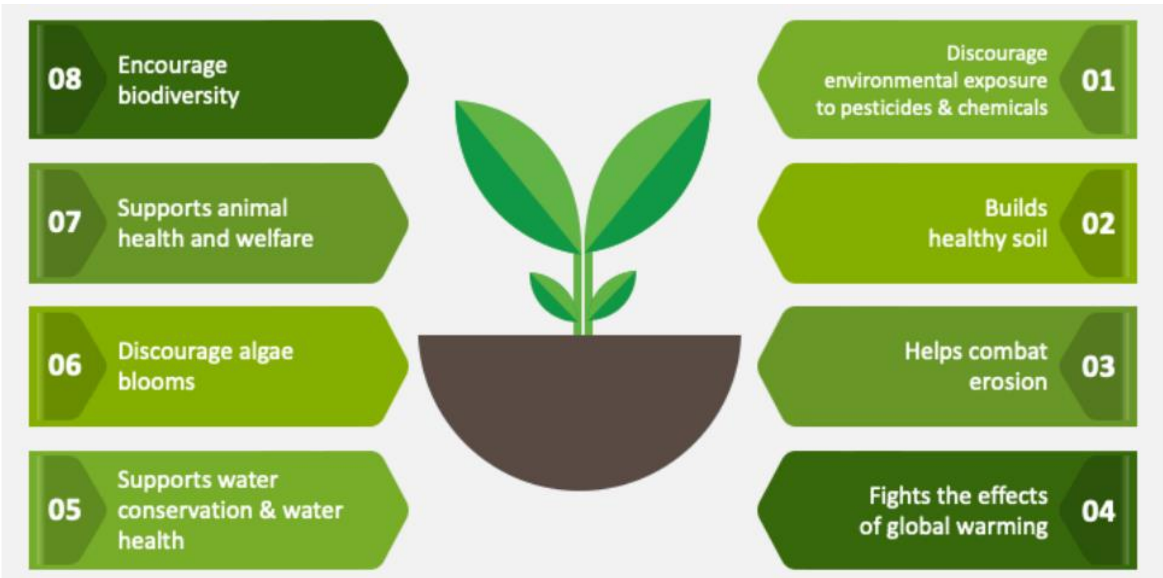

Fig2: Benefits of Natural farming (source: National mission on natural farming management and knowledge portal)

Kumar *et al.* (2023) pointed out the benefits as perceived by NF farmers are manifold, ranging from a lower cost of cultivation, better quality and taste to a premium price. The practice seems to be good for human health as well as environmental health.

Principles of Natural Farming

Based on philosophy and application factors, cause and effect relationship, natural farming has following four principles

a. Principle of improved natural resource efficiency
b. Principle of self-sustainability/no dependency
c. Principle of resilience d. Principle of social equity/responsibility

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FORENSIC BOTANY: UNVEILING THE SECRETS OF PLANTS IN CRIME INVESTIGATION

Shailja Singh

Assistant Professor, Department of Forensic Science,
ITM University Gwalior, M.P.
Corresponding mail- shailjasingh235@gmail.com

Abstract
Forensic botany is a specialized branch of forensic science that utilizes plant evidence to assist in the investigation of crimes. This article explores the applications of forensic botany in crime investigation, highlighting its potential as a valuable tool in solving complex criminal cases. It provides an overview of plant evidence, collection methods, preservation techniques, and its significance in forensic analysis. Furthermore, the article discusses case studies that demonstrate the successful utilization of plant evidence in criminal investigations. The aim is to emphasize the importance of forensic botany as a complementary discipline to traditional forensic sciences, showcasing its potential to unravel hidden truths in crime scenes.

Introduction
Forensic science encompasses various disciplines that aid in the investigation of crimes. Forensic botany has emerged as a valuable tool in crime investigation, offering unique insights into different aspects of criminal cases. Forensic botany can provide crucial information about crime scene locations, timing, and associations by examining plant evidence. This article provides an in-depth exploration of forensic botany and its applications in unraveling the mysteries surrounding plant evidence.

Plant Evidence
Types and Significance Plants leave behind a wide range of trace evidence at crime scenes, including pollen, seeds, leaves, flowers, and wood fragments. Each type of plant evidence carries its own significance and can provide valuable information to investigators. For example, pollen analysis can help determine the geographical origin of a suspect or victim, while seed and plant material may indicate the presence of a specific ecosystem at the crime scene. Understanding the importance of plant evidence is fundamental to its effective utilization in forensic analysis.

Collection and Preservation of Plant Evidence
Proper collection and preservation of plant evidence are critical to maintaining its integrity and ensuring accurate analysis. This section discusses the methods and techniques employed for the collection, documentation, and preservation of botanical samples. It emphasizes the importance of following standardized protocols to prevent contamination and degradation. Techniques such as air-drying, freeze-drying, and chemical preservation are employed based on the nature of the plant material.

Analytical Techniques in Forensic Botany
Various analytical techniques are utilized in forensic botany to examine plant evidence. This section explores commonly used methods, such as microscopy, DNA analysis, palynology,

dendrochronology, and stable isotope analysis. Microscopy allows for the identification and comparison of plant structures, while DNA analysis can establish species identification and genetic relationships. Palynology involves the study of pollen grains, providing information about the plant species present at a crime scene. Dendrochronology uses the growth rings of trees to determine the age of wood samples, aiding in dating and establishing timelines. Stable isotope analysis helps determine the origin of plant material by examining isotopic ratios.

Case Studies

Successful Applications of Forensic Botany This section presents case studies that demonstrate the successful application of forensic botany in real criminal investigations. Each case study highlights the role of plant evidence in establishing links between suspects, victims, and crime scenes, ultimately aiding in the conviction or exoneration of individuals. These examples showcase the practical utility of forensic botany in solving complex criminal cases, including homicides, burglaries, and clandestine burials.

Future Directions and Challenges As forensic botany continues to evolve, it is essential to identify future directions and address the challenges faced by this discipline. This section explores potential advancements, including the integration of new technologies and methodologies, standardization of protocols, and increased collaboration among forensic scientists and botanists. Overcoming these challenges will enhance the efficacy of forensic botany in crime investigation.

Conclusion

Forensic botany plays a vital role in crime investigation, offering valuable insights into the circumstances surrounding criminal activities. By unraveling the secrets of plants, forensic botany complements traditional forensic sciences, aiding in the identification of suspects, determining the time of death, locating burial sites, and establishing associations between individuals and crime scenes. This article underscores the significance of forensic botany and highlights its potential for future advancements in the field of forensic science.

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APPLICATIONS OF HERBAL REMEDIES IN AQUACULTURE

Arita M. Rathod[1]*, Rajesh V. Chudasama[1] and Sandhya S. Chak[1]

[1]PG Scholler, Department of Aquaculture,
College of Fisheries Science, Kamdhenu University, Veraval (Gujarat), India
*Corresponding email: rathodarita280@gmail.com

Abstract
Herbal remedies have gained attention in aquaculture as alternative solutions for disease management, growth promotion, immunostimulant, antiviral activity, and control of fungal pathogens. These remedies offer antimicrobial properties, influenced by bioactive compounds such as phenolics, flavonoids, polysaccharides, and proteoglycans. They act as growth promoters by enhancing feeding behaviour and flavour, improving growth performance. Herbal immunostimulants boost immune response, phagocytic activity, and antibody production in fish. Moreover, they exhibit antiviral effects against various fish pathogens. Herbal extracts and derivatives serve as effective fungicides for managing fungal diseases in finfish and shellfish. The application of herbal remedies in aquaculture presents eco-friendly, cost-effective, and sustainable approaches for disease prevention and overall improvement of aquatic organism health.

Keyword : Aquaculture, Disease management, Growth promotion, Herbal remedies

Introduction
Aquaculture, the fastest-growing industry, faces disease challenges and bans on chemical treatments. Herbal remedies offer natural alternatives, boosting fish immunity, growth, and antimicrobial properties. They mitigate financial losses and the risks associated with excessive drug use. Embracing herbal remedies is a promising approach for disease management in aquaculture (Elumalai *et al.,* 2020). Herbal medicine provides an eco-friendly alternative to control diseases in aquaculture. Different medicinal herbs offer unique components that combat pathogens. Studies confirm their successful use in fish diets and diverse applications in aquaculture. By adopting herbal remedies, aquaculture can enhance disease prevention while promoting eco-friendly practices for healthier fish stocks (Harikrishnan *et al.,* 2010).

Growth Promoter
Herbal plants are being studied as natural alternatives to chemical agents for promoting the growth of cultured fish. These plants influence feeding patterns, enhance flavour, and increase total feed intake. Research suggests that Chinese herbs can improve fish growth by boosting metabolism, protein synthesis, and activating digestive enzymes. Harnessing the unique properties of herbal plants offers a promising approach to enhancing fish growth in aquaculture (Ma *et al.,* 2009).

Table 1. Growth promoter herbal plants

Sr. No.	Scientific Name	Common Name
1	*Andrographis paniculata*	Maha tita, king of bitters
2	*Crataegi fructus*	Hawthorne

Sr. No.	Scientific Name	Common Name
3	*Picrorhiza kurooa*	Guduchi
4	*Tridax procumbens*	Coat buttons
5	*Tephrosia purpurea*	Sharpunkha Fish Poison, Wild Indigo
6	*Zingiber officinalis*	Ginger

Antimicrobial

Herbs have shown remarkable antimicrobial potential in aquaculture. Extracts such as essential oils or crude preparations possess excellent antimicrobial properties, inhibiting various pathogens. Bioactive compounds like phenolics, proteoglycans, polysaccharides, and flavonoids found in herbs play a vital role in controlling infectious microbes. Utilizing herbs as alternative biomedicine holds great promise for disease control in aquaculture (Chakraborty and Hancz, 2011).

Table 2. Antimicrobial properties of herbal remedies plant

Sr. No.	Scientific Name	Common Name
1	*Curcuma longa*	Haldi
2	*Mastocarpus stellatus*	Carrageen moss
3	*Ocimum sanctum*	Tulsi
4	*Ricinus communis*	Castor oil plan
5	*Eclipta erecta*	Bhringraj

Antiviral

Certain herbal plants have shown promise as antiviral agents against fish-related pathogens. These plants, both terrestrial and marine, possess immunostimulant properties and have been studied for their effectiveness against viruses such as SVCV, CyHV, WSSV, GIV, and GCRV. Extracts from these plants contain bioactive compounds that inhibit viral replication, block viral mRNA synthesis, and enhance non-specific immunity. Utilizing herbal plants as antiviral agents holds potential for managing fish diseases effectively (Chakraborty and Hancz, 2011).

Table 3. Antiviral properties of herbal remedies plant

Sr. No.	Scientific Name	Common Name
1	*Cassia alata*	Candle bush
2	*Phyllanthus acidus*	Star gooseberry
3	*Calophyllum*	indian doomba oil
4	*Cynodon dactylon*	Bermuda grass
5	*Tinospora cordifolia*	Heart leaved moonseed

Immunostimulants

Herbal medicines act as immunostimulants, enhancing the immune response and disease resistance in fish and shrimp. They are safe, biodegradable, and cost-effective. Herbal immunostimulants improve phagocytic cell activity, lymphocyte activation, lysozyme activity, and antibody production. Administered through injection, bathing, or oral methods, herbal immunostimulants offer a natural and sustainable alternative to reduce the use of hazardous chemicals in fish culture (Anderson,1992).

Table 4. Immunostimulant properties of herbal remedies plant

Sr. No.	Scientific Name	Common Name
1	*G. glabra*	Liquorice
2	*Astragalus*	Milkvetch
3	*Lonicera japonica*	Japanese honeysuckle
4	*Ocimum sanctum*	Tulsi
5	*Azadirachta indica*	Neem

Antistressor

Herbal medicine contains biochemical components that inhibit the generation of oxygen anions and scavenge free radicals, effectively reducing stress (Citarasu *et al*., 1998).

Table 5. Antistressor properties of herbal remedies plant

Sr. No.	Scientific Name	Common Name
1	*Picrorhiza kurroa*	Picrorhiza, katuka
2	*Toona sinensi*	Rutin
3	*Astragalus membranaceus*	Qompsel
4	*A. membranaceus*	Mongolian milkvetch

Antiprotozoal

Protozoan parasites pose a significant threat during the early life cycle of fish, from eggs to fry and fingerling stages, as well as infecting adult animals. Currently, the primary technique to address these parasites involves removing attached stages through various bath treatments using herbal plants (Raman, 2017).

Table 6. Antiprotozoal properties of herbal remedies plant

Sr. No.	Scientific Name	Common Name
1	*Allium sativum*	Garlic
2	*Melia azadirach*	Chinaberry

Antifungal

In recent years, medicinal plants have been utilized as fungicides to combat fungal pathogens in both finfish and shellfish. Plant derivatives offer the advantages of low cost and no side effects on fish and the environment. The aqueous extract of herbs is commonly used to address fungal diseases (Raman, 2017).

Table 7. Antifungal properties of herbal remedies plant

Sr. No.	Scientific Name	Common Name
1	*Cnidium monnieri*	Conidium fruit
2	*Asparagopsis taxiformis*	Limu kohu
3	*Magnolia officinalis*	Magnolia bar

Conclusion

Herbal remedies offer diverse applications in aquaculture, including growth promotion, antimicrobial activity, immunostimulation, antiviral properties, stress reduction, and control of fungal pathogens. These remedies provide natural and eco-friendly alternatives with minimal environmental impact and cost-effectiveness. By reducing reliance on chemical treatments and antibiotics, herbal remedies promote sustainable disease management practices in aquaculture. However, further research is needed to optimize their usage for different species and disease conditions. Overall, herbal remedies hold great potential for enhancing fish health and productivity while ensuring the sustainability of the aquaculture industry.

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NANOFERTILIZERS FOR SUSTAINABLE AGRICULTURE: CURRENT AND FUTURE PERSPECTIVES

K. N. Tiwari[1*] and Yogendra Kumar[2]

[1] Consultant, Indian Farmers Fertilizer Cooperative Limited
IFFCO Bhawan, 8, Gokhale Marg, Lucknow 226001
[2] Marketing Director, Indian Farmers Fertilizer Cooperative Limited,
IFFCO Sadan, C-1, District Centre, Saket Place, Saket, New Delhi 110017
*Corresponding email: kashinathtiwari730@gmail.com

Abstract

Traditional fertilizers need to be applied in large amounts, as they have low uptake efficiencies. The two main challenges for phosphorus- and nitrogen-based fertilizers are low nutrient uptake efficiency and rapid change into chemical forms that cannot be utilised by plants. This has had a negative impact on the soil and the environment, as the emission of dangerous greenhouse gases and eutrophication have increased. Nanofertilizers gradually release nutrients, which may aid in improving nutrient use efficiency without any related adverse effects.

Introduction

The widespread use of fertilizers is a result of the increased global demand for food. The commonly used chemical fertilizers may increase plant growth and output, but they have deleterious effects on the soil, the environment, and even human health. Due to several factors such as volatilization, leaching, degradation, insolubility, and decomposition, the availability of nutrients applied through conventional fertilizers (CFs) is insufficient for plants and leads to lower crop yields. It has been reported that macronutrient elements, namely, N, P, and K applied to the soil get lost ca. 40–70%, 80–90%, and 50–90%, respectively with water toxicity. Nitrogen is largely inaccessible as it forms NH_3, emissions of N_2O, or NO_3 in runoff (Kumar et al. 2020a and 2020b). Similarly, an excess of P is fixed in soil, where it forms chemical bonds with other elements, such as Ca, Mg, Al, Fe, and Zn, and becomes unavailable for plant uptake. In fact, most of the applied CFs dissipate into the atmosphere or surface water bodies where they cause serious environmental issues. Hence, farmers resort to the excessive and repeated applications of these fertilizers to achieve desired yields, which in turn decrease soil health/fertility with the accumulation of salt concentrations in the rhizosphere with impaired plant/crop growth, performance, and productivity. Approximately, 80–90% of P and 40–70% of N applied to farmlands are either lost to the environment and do not reach plants, which causes unsustainable and economic losses **(Fig. 1**). Thus, there is an urgent need to optimize the use of chemical fertilization to fulfil the crop nutrient requirements and to minimize the risk of environmental pollution. This paper addresses the potential benefits of NFs to agriculture, synthesis, mode of entry, mechanisms of action, development of resistance to biotic and abiotic stresses, safety issues and the fate of Nanofertilizers in soil.

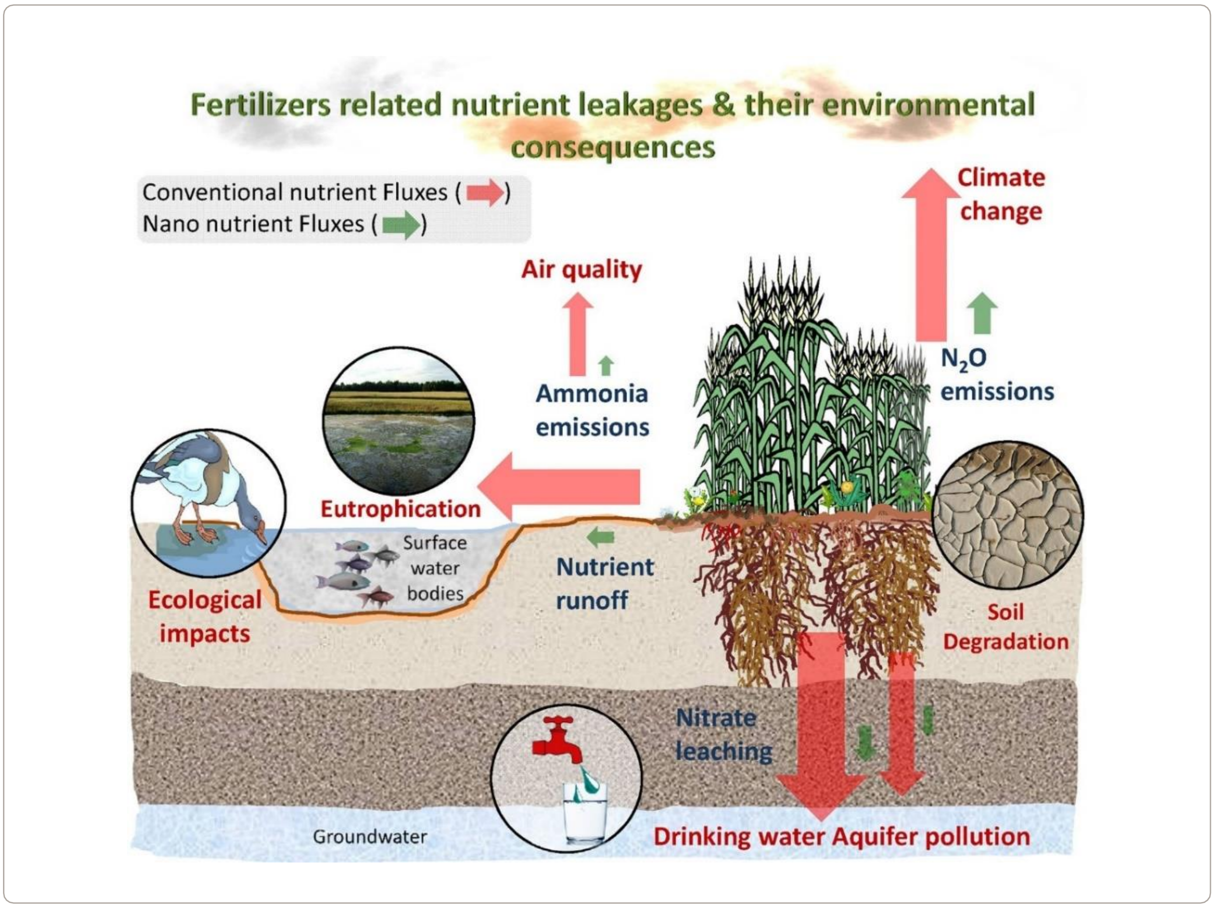

Fig.1. Fertilizers related nutrient leakages and their environmental consequences

Source: Bhardwaj et al. (2022)

Considering these facts, the large-scale application of chemical fertilizers to increase the crop productivity is not an acceptable option for sustainability. Although the conventional fertilizers increase the crop production, they disturb the soil mineral balance and decrease the soil fertility, especially in a long-term perspective. In addition to the irreparable damage that the excess use of chemical fertilizers causes to the soil structure and mineral cycles, it spoils the soil microflora, plants, and consequently, the food chains across ecosystems, leading to heritable mutations in future generations of consumers.

Nanofertilizers

The Nanofertilizers (NFs) are materials in the size range of 1–100 nm that support the nutrition of the plants. NFs in agriculture have drawn attention for their unique features, such as ultra-high absorption, increased production, and increased photosynthesis due to leaf surface coverage. The main benefit of the use of NFs in agriculture is the greater efficiency of plants to absorb them, minimizing the amount of fertilizers and consequently reducing the toxicity to the soil environment. It is a novel way to optimize the nutrient supply, either alone or in combination have come up as a better and seemingly sustainable solution to meet production targets as well as maintaining the environmental quality by use of less quantity of raw materials and active ingredients, increased nutrient use-efficiency by plants, and decreased environmental losses of nutrients.

NFs are made up of nutrients and micronutrients and may act as carriers for nutrients. These engineered materials are composed of nanoparticles containing macro and micronutrients that are delivered to the plant rhizosphere in a regulated manner. In nanofertilizers, the essential minerals and nutrients (such as N, P, K, Fe, and Mn) are bonded alone or in combination with nano-dimensional adsorbents. Although nano-coated materials manage to penetrate through the stomata with a size exclusion limit greater than 10 nm, the nanoparticles appear to be able to make holes and enter the vascular system. The nanocarriers deliver the nutrients to the right place, reducing the additional amount of active chemicals deposited in the plant, besides a slow release. NFs are one of the most promising solutions or substitutes and are an economical alternative to ordinary chemical fertilizers (CFs) that can increase global food production in a sustainable way. The application of different NFs in various crops was reported to have a considerable increase in crop yield. NFs have many benefits in promoting more sustainable agriculture, which is shown in **Figure 2.**

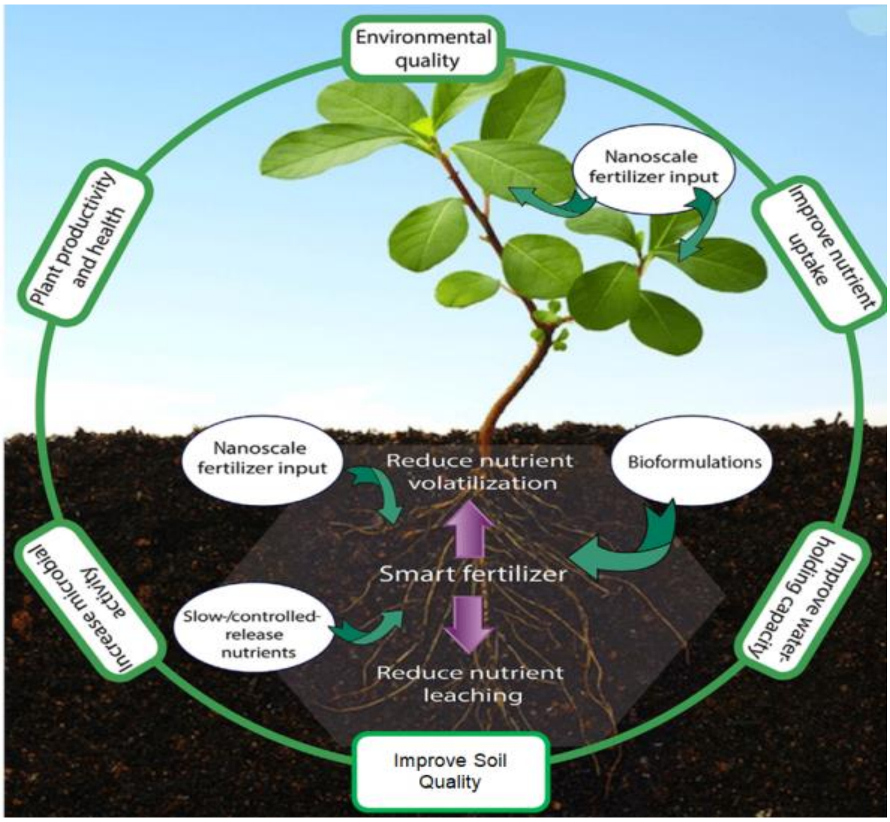

Figure 2. Potential effects of nanofertilizers in soil-plant system
Source: Calabi-Floody et al., (2017)

Classification of NFS

NFs are usually classified into three types, which mainly include nanoscale fertilizers, nanoscale additives, and nanoscale coatings. Among these, nanoscale fertilizers are composed of nanoparticles that contain nutrients. It is well known that the application of nano-scale fertilizers has attracted considerable attention and hence, several nano-based fertilizers have been developed and their industrial-scale production has also been started.

Benefits of NFS over chemical fertilizers (CFS)

The CFs are indispensable for improving crop productivity, extensively applied through various approaches but they are not sustainable for multiple reasons, including high delivery and usage inefficiency, considerable energy, and water inputs with adverse impact on the agroecosystem. Mineral nutrients if applied to crops in the form of NFs hold potential to offer numerous benefits for making the crop production more sustainable and eco-friendly. NFs advantages over conventional mineral fertilizers are summarized below:

a) The miniature size, higher surface-to-volume ratio of nanoparticles and high reactivity of NFs increase the bioavailability of nutrients.
b) NFs ensure slow, targeted, efficient release in a controlled manner to ensure higher efficiency of nutrient uptake matching the uptake pattern of crop in contradiction to rapid and spontaneous release of nutrients from CFs. For example, nutrients can be released over 40-50 days in a slow release fashion rather than the 4-10 days by the CFs. As a result, synthetic fertilizers, particularly N-urea, can rapidly lose more than 50% of nutrient contents after field application through leaching and volatilization.
c) Research has shown that NFs release nutrients as much as 12 times slower than synthetic fertilizers, and they can significantly increase the yields and quality traits of crops.
d) NFs prevent undesirable nutrient losses to soil, water and air via direct internalization by crops, and avoiding the interaction of nutrients with soil, microorganisms, water, and air that enhance the nutrient use efficiency and reduce the costs of environmental protection.
e) NFs because of increased fertilizer efficiency and uptake ratio of the soil nutrients, save fertilizer resource. As the utilization efficiency of NFs is high, and the application scale is very lo so instead of 50 kg, one can apply only a few grams and as such application doses reduce by 100 to 200 times, thus it reduces the burden on the farmers, fertilizer industry and the Government.
f) NFs impact the supply chain in a positive manner. When 50 kg gets replaced by a few grams, the import and procurement of raw materials for fertilizers will also be proportionately reduced. The fuel required for transportation will also come down. Instead of 50 kg, we only need to spend the energy required for a few grams. Similarly, instead of 20 trucks to transport CFs, probably one truck or a smaller vehicle would be enough.
g) NFs facilitate beneficial functions for the nitrogen cycle, enhancing enzyme activities and stimulating soil plant-friendly microbes.
h) NFs as a result of their unique properties, influence metabolic activities of the plant to different degrees compared to conventional materials and have the potential to mobilize native nutrients in the rhizosphere.
i) NFs minimize over accumulation of salt in soil as they are required in small amount.
j) NFs also reduce the crop cycle period and increase crop yield. For example, the amendment of nanoparticles carrying NPK (nitrogen, phosphorus, and potassium) to wheat showed an increase in grain yield and reduced the crop cycle of wheat by 40 days. Similar results were obtained in many other cropping systems.
k) The evidence shows that in some cases, the utilization-efficiency of nano-fertilizer goes up to 95%, or even 100%.

l) Small-sized nanomaterials impart a quantum effect or say, they act as additional reaction centres in plant leaves and help plants in increasing their photosynthetic rate.
m) Providing balanced nutrition, NFs facilitate the crop plants to fight various biotic and abiotic stresses and crop lodging.
n) The foliar application of NFs is much better and preferred than the soil application of NFs due to its significant enhancements in the growth, physiological and biochemical traits, yield, and quality of crops-particularly in smart agriculture.
o) Foliar application of NFs arrests nutrient supply and growth of weeds.
p) The higher surface-to-volume ratio of nanoparticles has unique capabilities as an efficient water transporter in soil thus these particles could contribute to solving drought problems and the lack of water. NFs are useful for mitigating the chronic problem of moisture retention in arid soils and enhancing crop production by increasing the availability of nutrients in the rhizosphere.
q) NFs required in small amount which reduce the cost of transportation and field application.

These facts support the statement that fertilizers based on nanotechnology have the potential to surpass conventional fertilizers following several important indices as shown in **Table 1**.

Table 1. The difference between conventional fertilizers and nanofertilizers

Properties	Nanofertilizer	Conventional fertilizer
Rate of nutrient loss	Low loss of fertilizer nutrients	High loss rate *via* drifting, leaching, run-off
Controlled release	Rate of release and release pattern precisely controlled	Excess release of nutrients lead to high toxicity and soil imbalance
Solubility	High	Low
Bioavailability	High	Low
Dispersion of mineral nutrients	Improved dispersion of insoluble nutrients	Lower solubility due to large size particle
Effective duration of release	Effective and extended duration	Used by the plant at the site and time of application; the rest is converted into an insoluble form
Controlled release	Release rate and pattern precisely controlled	Excess release leading to toxicity and soil imbalance.
Loss rate	Reduced loss of fertilizer nutrients	High loss rate due to volatilization, leaching, drifting, run-off etc.
The efficiency of nutrients uptake	Enhanced uptake ratio and saves fertilizer resource	It is not available to roots and the efficiency of nutrients uptake is low
Soil adsorption and fixation	Reduced	High

Source: Aadapted and modified from Thavaseelan and Priyadarshana (2021).

The effects of Nanofertilizers on plant health, growth performance and physiological parameters and an overview of the benefits of NFs to enhance mitigating abilities of plants under environmental stress conditions are presented in **Fig. 3** and an overview of benefits of NFs to enhance mitigating abilities of plants under environmental stress conditions in **Fig. 4**, respectively.

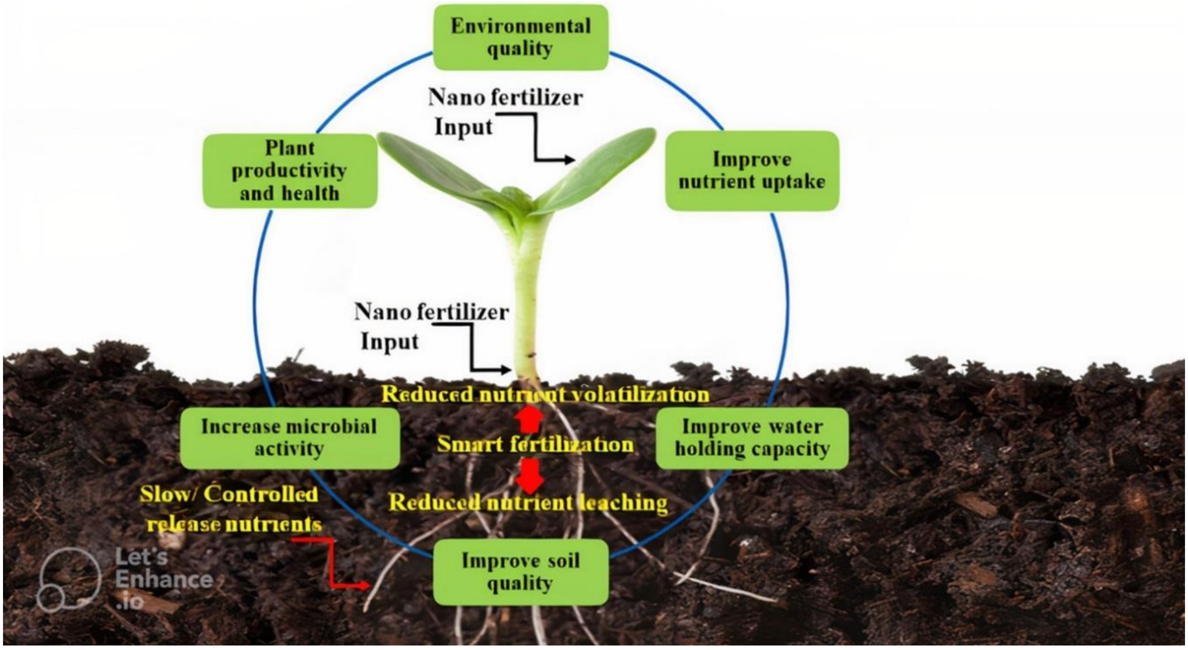

Fig. 3. Effects of nanoparticles on soil health and environmental quality.
Source: Ali, Murad Jakhar et al. (2022).

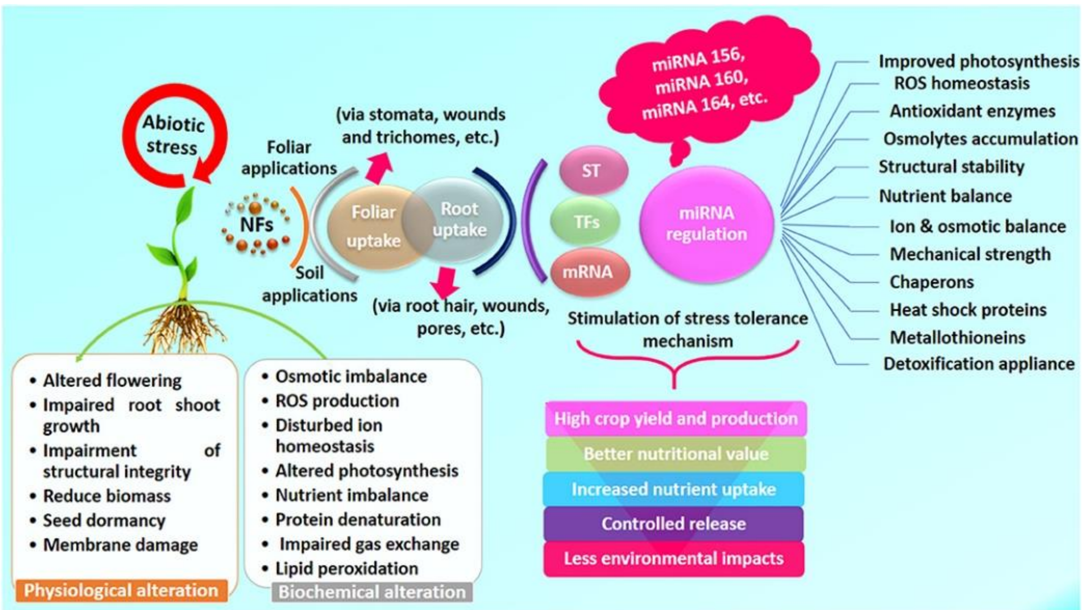

Fig. 4. An overview of benefits of NFs to enhance mitigating abilities of plants under environmental stress conditions.
Source: Verma et al. (2022).

Role of Nanofertilizers in mitigating the effects of climate change on agriculture

It is expected that earth's temperature will increase by 3–5°C in the coming 50–100 years. The intergovernmental panel on climate change (2021) has mentioned that human activity has warmed the atmosphere, ocean and land without a doubt. They have also warned that unless efforts are in place to reduce emissions of carbon dioxide and other greenhouse gases (GHGs), global warming of 1.5 °C and 2 °C will be exceeded during the 21st century. As we see, in the modern era of civilization, the changing climatic scenario has altered the natural balance of the global environment. The agriculture sector has become one of the major contributors to GHG emissions leading to climate change. GHG emission from agriculture mainly comes from the fertilizer industry. When conventional fertilizers are made a lot of fuel and energy are invested in its synthesis and transportation. Also, these fertilizers are required in large amounts due to low use efficiency (20-40% for N, P and K). Nutrient imbalances in plants have a significant impact on their performance, such as growth pattern, antioxidant defense mechanisms, and tolerance to biotic and abiotic stresses. Under these circumstances, plants encounter more frequently, concurrently both biotic and abiotic stresses (drought, temperature variations, soil salinity, soil alkalinity and heavy metal stresses) can have overwhelming impacts on the growth and productivity of crops under different agricultural ecosystems, which may develop constraints to food security worldwide. Unless responsive mechanisms are not developed against biotic and abiotic stresses, the plants will continuously subjected to such stresses and ultimately will prove a great threat to world agriculture. Contrarily, due to their very high-use efficiency, nanofertilizers are required in very small amounts as compared to the conventional fertilizers (1/100 times lesser). By reducing the application rate by 100 times, nanofertilizers can reduce GHG emissions at the source itself. The world's leaders committed to a number of agreed-upon aspects when they signed the historic "Glasgow Climate Pact" in November 2021. Some of these decisions include greater efforts to strengthen climate change resilience, reduce greenhouse gas emissions, and provide the necessary funding for both.

Nanofertilizers are eco-friendly and safe for health or crops

IFFCO NFs (Nano urea, Liquid and Nano DAP, Liquid went through all levels of clearance for safety assessments as suggested in the guidelines by the Department of Biotechnology (DBT), and FCO order 2021, Government of India and were declared safe for health and crops.

Nanofertilizers for mitigating biotic and abiotic stresses

Numerous studies have shown that the use of nanofertilizers (NFs) or nanoparticles (NPs) can effectively decrease the adverse effects resulting from different environmental stresses by increasing the levels of plant antioxidant compounds. The Nanofertilizers overcome nutritional deficiencies, increase enzymatic activities and help in adhesion of plant growth promoting bacteria to plant roots under abiotic stresses and in these diverse ways, improved the tolerance of crops to stresses. The initial reports are quite promising and have opened a new area of utilizing nanofertilizers for increasing crop productivity under stressful environmental conditions.

Epilogue

Sustainable global food security seems to be a big issue in times to come. Therefore, innovative/appropriate agricultural practices may be explored to acquire the target of food production under changing climate variables, rising population, and loss of arable land. After the green revolution, the production of food grains has increased at the cost of the disproportionate use of synthetic fertilizers, which have severely damaged our ecosystem. NFs get delivered at slow rates to extend soil health and fertility with nutrient balance by lowering volatilization, leaching, denitrification of nitrogen and, fixation and runoff of phospate and thus reducing the risk of toxicity. NFs take 40–50 days to release nutrients fully, while synthetic fertilizers do the same in 4–10 days. Plants' nutritional status is improved with the application of NFs to boost yields, stress tolerance, and pathogenesis resistance. Recent researches have shown that the use of NFs induces a considerable rise in the physiological and biochemical indices in crop plants with improved chlorophyll content/SPAD units, and plant productivity associated with upgraded leaf capacity to capture sunlight, RuBisCO activity, photosynthetic CO_2 assimilation, plant performance, nitrogen metabolism, and soluble proteins. The use of NFs results in higher crop quality than using standard fertilizers NFs improve photosynthetic processes, synthesis of photosynthetic pigments, chlorophyll, starch creation, soluble carbohydrates content, soluble sugars, protein, oil of oil seeds, and phytohormones, particularly indole acetic acid (IAA), which aids in starch synthesis and grain development. Seed/seedlings treatment and foliar application of NFs was found to be more efficient than soil application on the uptake and accumulation of NPs in plants and the growth characteristics, namely, length of plants, branch numbers, grain weight, and biological yield. Moreover, we need to ensure the use of these nanofertilizers at an optimum level only, to avoid their excessive or extra release in the environment. On a global scale, the green revolution increased food grain production at the cost of the disproportionate use of artificial/synthetic pesticides and fertilizers, both of which have gravely harmed our ecosystem.

Conclusions

The use of nanofertilizers in agriculture is in the early stage of development, but they have significant potential in different ways, such as increased nutrient-use efficiency, the slow release of nutrients to prevent nutrient loss, targeted delivery, improved abiotic stress tolerance, etc. The evidence shows that the impact of nanofertilizers varies according to the type of nanoparticles, size, shape, and concentration, their manner of application, the type of plant, the soil characteristics, and the soil microorganisms. Once the optimal dosage and plant requirements for nanofertilizers are established, the crop production can be greatly increased.

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CHALLENGES OF MODERN AGRICULTURE

Abhishek Pathak* and KattaSravan Naga Parimala Kumar
Ph.D. Scholar, Department of Agricultural Communication,
College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar
*Corresponding Email: abhi.01.pathak@gmail.com

Abstract
Modern agriculture refers to the contemporary practices, techniques, and technologies employed in the agricultural industry to maximize productivity, efficiency, and sustainability. Modern agriculture faces numerous challenges that impact the sustainability, productivity, and environmental impact of the global food system. These challenges require urgent attention and innovative solutions to ensure food security, protect the environment, and promote the well-being of farmers and consumers alike. By embracing innovative and sustainable solutions, we can create a resilient and future-proof agricultural system that not only meets the world's growing food demands but also protects our planet for generations to come.

Introduction
Modern agriculture refers to the contemporary practices, techniques, and technologies employed in the agricultural industry to maximize productivity, efficiency, and sustainability. It represents a shift from traditional farming methods to more advanced and innovative approaches aimed at meeting the growing demand for food, fiber, and other agricultural products. It is important to note that modern agriculture is a broad and evolving field, encompassing a range of practices and approaches that vary across regions and farming systems.

Despite so many benefits the modern agriculture faces numerous challenges that impact the sustainability, productivity, and environmental impact of the global food system. These challenges require urgent attention and innovative solutions to ensure food security, protect the environment, and promote the well-being of farmers and consumers alike.

1. Climate Change:
Climate change poses a significant threat to agriculture. Rising temperatures, changing precipitation patterns, and extreme weather events disrupt crop production and livestock management systems. Droughts, floods, heatwaves, and storms can cause substantial crop losses and livestock mortality. Moreover, climate change exacerbates the spread of pests and diseases, affecting both plant and animal health.

To mitigate the impacts of climate change, adaptation strategies are essential. This includes the development and adoption of climate-resilient agricultural practices such as crop diversification, agroforestry, and conservation agriculture. Additionally, investment in climate-smart technologies, improved water management, and early warning systems can help farmers anticipate and respond to climate-related challenges.

2. Soil Degradation:
Soil degradation is a pressing challenge facing modern agriculture. Intensive agricultural practices, including the excessive use of chemical fertilizers and pesticides, monocropping, and overgrazing,

contribute to soil erosion, nutrient depletion, and soil pollution. These practices degrade soil health, reduce fertility, and impair its ability to support healthy crop growth.

To combat soil degradation, sustainable soil management practices are crucial. This involves adopting practices such as organic farming, crop rotation, cover cropping, and the use of compost and other organic amendments. These practices improve soil structure, enhance nutrient cycling, and promote beneficial soil organisms, thus maintaining soil fertility and reducing erosion.

3. Water Scarcity:

Water scarcity is a growing concern in agriculture, particularly in regions where water resources are limited. In many areas, irrigation accounts for a significant portion of water usage, leading to overexploitation of water sources and depletion of aquifers. Climate change further exacerbates water scarcity by altering rainfall patterns and increasing the frequency and intensity of droughts.

Efficient water management strategies are vital for sustainable agriculture in water-stressed regions. This includes the adoption of precision irrigation techniques, such as drip irrigation and micro-sprinklers, which minimize water wastage. Additionally, water recycling, rainwater harvesting, and the use of drought-tolerant crop varieties can help optimize water use and reduce the overall water footprint of agriculture.

4. Biodiversity Loss:

The loss of biodiversity in agricultural landscapes poses a significant challenge to modern agriculture. The expansion of monocultures, the use of chemical inputs, and the conversion of natural habitats into farmland contribute to the decline of pollinators, beneficial insects, birds, and other vital organisms. This loss of biodiversity disrupts ecosystem services and hampers the natural balance within agricultural systems.

Preserving and enhancing biodiversity in agriculture is essential for ecosystem resilience and sustainable food production. Agroecological approaches, such as agroforestry, organic farming, and integrated pest management, promote biodiversity conservation by creating habitat diversity, reducing chemical inputs, and fostering ecological interactions. Protecting and restoring natural habitats adjacent to farmland also support the presence of beneficial species and promote ecological balance.

5. Food Waste and Loss:

A significant challenge in modern agriculture is the high rate of food waste and loss throughout the supply chain. Poor post-harvest management, inadequate storage and transportation infrastructure, and inefficient distribution systems contribute to substantial food losses. This wastage has economic, environmental, and social consequences, including the inefficient use of resources and the exacerbation of food insecurity.

Reducing food waste and loss requires a multi-faceted approach. Improving post-harvest handling techniques, investing in proper storage facilities, and enhancing transportation infrastructure can minimize food losses. Additionally, raising consumer awareness about responsible consumption, implementing effective food redistribution networks, and facilitating better market access for small-scale farmers can contribute to reducing food waste and promoting a more sustainable food system.

6. Economic Viability for Farmers:

Economic viability is a critical challenge for farmers, particularly small-scale and family farmers. Fluctuating market prices, high production costs, and unequal market access often leave farmers vulnerable to financial instability. Global trade imbalances, unfair market practices, and inadequate access to credit and resources further exacerbate the economic challenges faced by farmers.

Supporting the economic viability of farmers requires policies and initiatives that promote fair trade practices, provide access to credit and resources, and foster value-added opportunities. Strengthening farmers' cooperatives, promoting direct marketing channels, and implementing price stabilization mechanisms can help mitigate the economic risks faced by farmers and create a more equitable agricultural system.

7. Human Health and Pesticide Use:

The extensive use of synthetic pesticides and chemical fertilizers in modern agriculture raises concerns about human health risks. Prolonged exposure to pesticides has been linked to various health issues, including respiratory problems, neurological disorders, and certain types of cancer. Moreover, the excessive use of antibiotics in livestock farming contributes to the development of antibiotic resistance, posing a significant threat to public health.

To address these concerns, promoting sustainable pest and disease management practices is essential. Integrated pest management (IPM) approaches, which prioritize biological control methods, crop rotation, and the use of pest-resistant varieties, can minimize pesticide reliance. Organic farming practices that exclude synthetic chemicals and antibiotics also contribute to safer food production systems and reduce health risks for farmers and consumers.

Conclusion

In conclusion, modern agriculture faces a multitude of challenges that demand urgent attention and innovative solutions. The impact of climate change, soil degradation, water scarcity, biodiversity loss, food waste, economic viability, human health risks, and technological advancements all pose significant obstacles to the sustainability and resilience of our agricultural systems. These challenges require collaborative efforts from policymakers, researchers, farmers, and consumers to address them effectively. By prioritizing climate-smart agricultural practices, sustainable soil management, efficient water use, biodiversity conservation, and reduction of food waste, we can mitigate the negative impacts on agriculture and safeguard our future food security. Furthermore, supporting farmers' economic viability and promoting fair trade practices can ensure their livelihoods while fostering a more equitable agricultural system.

Investing in research and innovation, particularly in the areas of agro-ecology, precision farming, and sustainable pest management, can provide the tools and knowledge necessary to overcome these challenges. Additionally, consumer awareness and responsible consumption habits play a crucial role in reducing food waste and supporting sustainable agricultural practices. Overcoming the challenges of modern agriculture requires a holistic approach that considers the interconnections between environmental sustainability, economic viability, and social well-being. By embracing innovative and sustainable solutions, we can create a resilient and future-proof agricultural system that not only meets the world's growing food demands but also protects our planet for generations to come.

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UNTAPPED VEGETABLES IN THE HILLY REGION OF WEST BENGAL

Subom Rai[1*], Shibnath Basfore[1], Sushmita Subba[2], Sangay Golay[1] and Dibya Jyoti Mukhia[1]

[1]Department of Vegetable and Spice Crops,
Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal-736165
[2] Young Professional 1, National Research Centre for Orchid,
Pakyong, Sikkim-737106
*Corresponding author: subomrai99@gmail.com

Introduction

With the growing population, the demand for food is also increasing simultaneously day by day. It is estimated that the agriculture system by 2050 will be under immense pressure to produce quality food to feed the growing population by 40% (Behera *et al*., 2022). It has also been reported that victims of hunger globally increased by 828 million in 2021, an increase of about 46 million since 2020 and 150 million since the epidemic of COVID-19 (WHO 2022). Under such situations, utilization of untapped crops including untapped vegetables will be very much helpful in meeting the nutritional security in future days.

Untapped vegetable crops/plant species are "those species with underexploited potential for contributing to food security, health (nutritional/medicinal), income generation, and environmental services" (Jaenicke and Hoeschle 2006). Those crops grab the local's attention as they are easy to grow, being hardy nature, they perform very well in adverse soil and climatic conditions. Most of them are rich sources of vitamins, minerals, and other nutrients such as carbohydrates, proteins, and fats (Rai *et al*., 2005).

Due to improper care and lack of awareness the potential of those crops is underestimated and underexploited. It may also lead them to the danger of continued genetic erosion. The challenges can be tackled with the proper utilization of underexploited vegetable crops, as they are reported to be a rich source of nutrition and medicinal properties. The capabilities of these crops are still under-exposed and neglected due to the lack of knowledge and scientific research.

The State West Bengal is situated in the eastern part of India with 23° N latitude and 88° E longitudes spreading over an area of 88,752km^2. The hilly region of West Bengal with its favourable Argo climatic condition and fertile land is endowed with an enormous number of untapped vegetables that are yet to be exploited. *Sechium edule*, *Cyclanthera pedata*, *Tupistra nutans, Solanum gilo*, *Cyphomandra betacca*, *Nasturtium officinale,* etc. and these underexploited crops are found to be the rice source of vitamins, minerals, antioxidants and other compounds which help to overcome the nutrient deficiencies and provide a diverse and healthy diet to the people. Additionally, many studies have confirmed that these crops have various medicinal properties like anticancer, anti-diabetic, anti-tuberculosis, anti-inflammatory, hypoglycaemic etc., hence, the awareness and the cultivation of these underexploited crops may help to maintain the plant genetic resource, ensures food, nutrition and economic security for future.

Importance of underexploited vegetable crops

1. Underexploited Vegetables contain an enormous amount of nutritional and medicinal properties.
2. These crops can generate extra income for the local farmers.
3. They are having diverse sensorial characteristics.
4. They play an important role in maintaining the plant's genetic resources.
5. Several underexploited vegetables play a vital role in keeping alive cultural diversity correlated with food habits, health practices, religious rituals and social exchange (Jena *et al*., 2018).

Some major untapped vegetables in the Hills of West Bengal

1. Watercress (*Nasturtium officinale*) belongs to the family Brassicaceae. It is known by its local name "Simrayo" in the hilly region of West Bengal and Sikkim (Rai *et al*., 2021). It is a perennial aquatic or semi-aquatic herb native to Western Asia, India, Africa, Egypt and Europe. It prefers marshy lands and is mostly seen in the marshy areas and running springs of the hills. The aerial part of the plant is consumed by the locals as cooked vegetables or soups (Bhujel *et al*., 2018). This crop is reported to have various nutritional properties like fat, fibre, protein, vitamin A, vitamin B_1, vitamin C, and vitamin K (Rai *et al*., 2021). It is reported that intake of this vegetable helps to reduce the risk of cancer (Cohen *et al*., 2000). Watercress contains medicinal properties which are curable against diseases like diabetes, scurvy, asthma, tub erculosis, and high blood pressure (Pradhan and Tamang, 2015) and helps to improve the appetite.

2. Slipper Gourd (*Cyclanthera pedata* L.) is a cucurbitaceous vegetable locally known as Chuche karela (Rai *et al.,* 2022) and belongs to the family Cucurbitaceae. It is an annual, monoecious, viny crop found in the hills of West Bengal. The fruit of the slipper gourd is consumed as a cooked vegetable. In hilly regions, this crop is mostly observed in everyone's kitchen garden and consumed in different forms of dishes (Rai *et al*., 2022). Slipper gourd is found to be nutritious as it contains protein, vitamin C, anthocyanins, calcium, phosphorous etc (Rivas *et al*., 2013). It is also reported to be helpful in reducing blood cholesterol (Sukorno *et al*., 2019), curable against inflammation, and hypoglycaemic (Montoro *et al*., 2005).

3. Scarlet eggplant (*Solanum gilo*) belongs to the family Solanaceae. Locally known as Teetay Behe. It is mostly grown as mixed cropping with different vegetable crops like chilli, brinjal, beans tuber crops etc in the hilly region of West Bengal. In the Northeast region, it is found to be grown by the tribals in homesteads and jhum fields as mixed cropping with different crops (Lalhmingsanga *et al*., 2018). The fruits are picked at a fully developed green stage and cooked as a vegetable. *Solanum gilo* is found to be nutritious as it contains protein, carbohydrates, ascorbic acid etc. (Lalhmingsanga *et al*., 2018). The leaf juice of bitter brinjal is reported to be curable against uterine complaints, swollen joint pains, gastro-oesophageal reflux disease, constipation, and dyspepsia (Bello *et al*., 2005). Besides, its fruits hold analgesic, anti-inflammatory, anti-asthmatic, anti-glaucoma, hypoglycaemic, and hypolipidemic properties (Odetola *et al*., 2004).

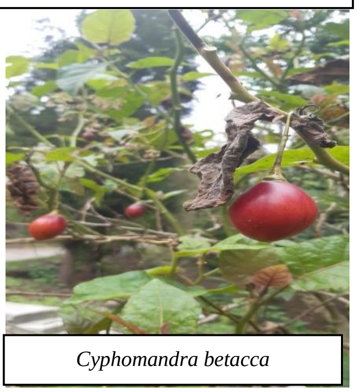
4. *Tupistra nutans* Wall locally known as Nakima belongs to the family Asparagaceae. It is a perennial crop with long strap-shaped leaves (1-2 metres in length) native to Asia. Nakima is commonly grown in Kalimpong and Darjeeling districts of West Bengal (Rai *et al.,* 2020) and other hilly neighbouring states such as Sikkim (Khatoon *et al*.,2018). Being a wild underexploited vegetable crop *Tupistra* inflorescence is collected by the locals from the forest areas and consumed as cooked vegetable or pickled (Rai *et al*., 2020). Due to its nutritional and medicinal benefits, it is reported to be cultivated widely in different parts of the region.
5. Tamarillo (Tree tomato) botanically known as *Cyphomandra betacca* belongs to the family Solanaceae, native to South America. It is a perennial shrub tender 2-3 meters tall tree grown as a backyard venture crop in Meghalaya and Sikkim (Thakur *et al*., 1988). The fruit of tamarillo is consumed as delicious chutney when raw or after roasting and peeling off the skin (Rai *et al*., 2005). The demand for tamarillo is increasing due to its unique taste and nutritious quality.
6. Chow chow (*Sechium edule*) is a cucurbitaceous vegetable crop, native to Tropical America. In the hilly region of Meghalaya, Manipur, Mizoram, Nagaland and Sikkim it is found to be grown vigorously without proper care (Rai *et al*., 2002). It is also grown abundantly in the hills of West Bengal. Locally it is popular as Iskuh. Chow chow is grown for its starchy fruits and tuberous roots which can be consumed as a cooked vegetable along with other vegetables. Its fruits are found to be nutritious and therapeutic.

Nasturtium officinale

Cyclanthera pedata

Solanum gilo

Tupistra nutans



Cyphomandra betacca

Sechium edule

Table no.1 Nutritional values of some untapped vegetable crops in the hilly region of West Bengal

Botanical name	Parts used	Nutritional value	Early Reported Literature
Cyclanthera pedata	Fruits	Ascorbic acid, protein, calcium, magnesium	Rai *et al.,* 2022
Nasturtium officinale	Leaves and Stems	Calories, protein, fat, fibre, vitamin A, vitamin B_1, vitamin C, vitamin K	Rai *et al.,* 2021
Tupistra nutans	Flowers	Protein, fats, carbohydrate sodium, calcium, potassium	Rai *et al*., 2020
Solanum gilo	Fruit	Carbohydrates, ascorbic acid, phenol, protein	Lalhmingsanga *et al*., 2018
Cyphomandra betacca	Fruit	Protein, fat, carbohydrate, phosphorous, calcium, carotene	Gopalan *et* al., 2009
Sechium edule	Fruits, Tender Stems and Root Tuber	Fats, protein, carbohydrates, dietary fibre, vitamin A, vitamin B_1, vitamin B_2, vitamin B_9	Coronel *et al.,* 2017

Table no. 2 Medicinal values of some untapped vegetable crops in the hilly region of West Bengal

Botanical name	Parts used	Nutritional value	Early Reported Literature
Cyclanthera pedata	Fruits	Reducing blood cholesterol, anti-inflammatory, hypoglycaemia	Rai *et al.,* 2022
Nasturtium officinale	Leaves and Stems	Diabetes, scurvy, asthma, tuberculosis, high blood pressure	Rai *et al.,* 2021
Tupistra nutans	Flowers	Diabetes, control high blood pressure and sugar level	Rai *et al*., 2020
Solanum gilo	Fruit	Asthma, skin infections, anti-inflammatories and roots are used to control high blood pressure	Lalhmingsanga *et al*., 2018
Cyphomandra betacca	Fruit	Maintains skin health and treats inflamed tonsils	Rana & Brar 2017
Sechiun edule	Fruits, Tender Stems and Root Tuber	Kidney stones, hypertens hypertension	Coronel *et al.,* 2017

Conclusion

The present article provides an important information regarding the hidden treasure of the hills of West Bengal and their therapeutic and nutritional values which may play a vital role in nutritional security in future days. The reason for the low utilization of the untapped vegetables is mainly due to lack of awareness on nutritional and medicinal importance. Thus, several initiatives need to be taken up like genetic resources exploration, management, utilization and improvement of underutilized vegetable crops to ensure food, nutritional and economical security for future.

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PEST MANAGEMENT IN BANANA

Akkabathula Nithish
Scientist (Agri. Entomology)
Fruit Research Station, Sangareddy,
SKLTSHU
Corresponding Email: nitishakkabattula@gmail.com

Banana is otherwise called 'Apple of Paradise'. It is one of the oldest and most popular fruit in India which is mainly gown in western, central, eastern and coastal regions by small-scale farmers mainly for home consumption and income generation. In mitigating food shortage, bananas are playing a key role, as they are becoming a common staple food for most of the Indian communities. They gained popularity because of their adaptability to different environments, easy to produce and has a ready market. Identification of insect pests affecting bananas by farmers at the initial stage may prevent the spread of the pests and is an important milestone to increased banana production. There are more than 182 insect pests of banana in India among which e banana weevil and Pseudostem borer are the most destructive. Most of the other insect pest feeding on this plant are of local importance and are not specific to banana. The aphid is however important not as a pest but as vector of very serious disease called Bunchy top of banana.

1. Banana rhizome weevil

The weevil infestation starts at the base of the outermost leaf-sheath and in lower parts of the pseudostem with more damage on young plantations. Initially grubs make several longitudinal tunnels in the surface tissue until they are able to penetrate to adjacent inner leaf-sheaths. After penetration, they bore into the pseudostem base and rhizome, suckers and into roots in which tunnels may run for the entire length. Grubs also make holes on outer surface where blackened mass comes out from the holes. Infested plants have dull yellow green floppy foliage and become weak. Young infested suckers often wither and fail to develop. Plants are easily blown down by mild to strong winds. The weevil spreads through infested suckers to different places.

IPM

Pre infestation measures

Field should be kept cleaned by removing the dried leaves and plant debris and destroy them by burning or by dumping in pits.

Do not take banana crop in the same field to avoid initial infestation and adopt crop rotation with non hosts like paddy and sugarcane.
Use healthy and pest free corms for plantation and should be dipped in a solution of chlorpyriphos @ 2.5 ml/l and after that dip the corms in hot water at 52 to 55° C for 15 to 27 minutes before planting.

Apply castor cake @ 250 g or phorate granules @ 10 g per pit before planting.

Adopt paring and pralinage of banana suckers before planting.

Avoid growing Robusta, Karpooruvally, Malbhog, Champa and Adukkar and grow less susceptible varieties like Poovan, Kadali, Kunnan, Poomkalli in endemic areas.

Post infestation measures

- The rhizomes should be trimmed regularly.
- Infested rhizomes should be uprooted and destroyed.
- Trap adult weevils with pseudostem chopped into small pieces and kept clump at 65/ha near infested areas.
- Keep pheromone (cosmolure) traps @ 5 traps/ha. The position of traps should be changed once in a month.
- Apply carbofuron @ 20 g/plant during 3rd, 5th & 7th month after planting around pseudostem.
- Spray the pseudostem and drench around the base of the tree with chlopyriphos @ 2.5 ml/l.
- Cut the banana plants after harvest at the ground level and treat it with chlorpyriphos @ 2.5 ml/lit at the cut surface.

2. Pseudostem borer

The incidence is observed after 5th month. Grubs are attracted by the volatiles released by the banana plants. Infestation normally starts in 5 month old plants. Early symptoms of the infestation are the presence of small pinhead-sized holes on the stem, fibrous extrusions from bases of leaf petioles, presence of adult weevils and exudation of a gummy substance from the holes on the pseudostem. During the advanced stages of infestation, the stem when split open, exhibits extensive tunneling both in the leaf sheath and in the pseudostem. When the pseudostem and peduncle are tunneled after flowering, the fruits do not develop properly. Rotting occurs due to secondary infection of pathogens and a foul odour is emitted with premature ripening of the bunch itself. Weakening of the stem by larval tunneling may result in breakage by wind or inability to bear the weight of the maturing bunch. It is estimated that the stem weevil causes 10-90% yield loss depending on the growth stage of the crop.

IPM

Pre infestation measures

- Dipping the suckers in 20% neem seed solution at planting.
- Apply carbofuran 3G granules @ 20 g or Phorate 10G granules @ 12 g or neem cake @ 1/2 Kg per pit at planting.
- Remove old & dried leaves periodically and keep the field clean. Adopt good cultivation practices and prune the side suckers every month.
- Planting material should be trimmed to reduce the number of eggs and grubs.
- Do not dump infested materials into manure pits.
- Inject chlorpyrifos (150 ml/350 ml water) solution @ 2ml/plant in the opposite directions, one at two feet height and other one at 4 feet above ground level at 30 degree angle on

either side of the plant at monthly intervals from 5th - 8th month. Beyond 8 months no injection should be given after flowering. Injection needle should reach only to 2 or 3 leaf sheath depth without touching the central core into the bored hole.

- Treat the cut end of the leaf petiole with chlorpyriphos (2.5ml/lit) + 1 ml sticking agent
- After harvesting of banana bunch cut the tree at base and spray *Beauveria bassiana* @ 10 g/litto avoid breeding site for the pest.
- Avoid matttocking in weevil endemic area.
- After harvesting, the pseudo stem has to be cut into 30 cm length bits and use it as a trap for weevil collection, instead of keeping it in heaps.
- Apply mud slurry mixed with neem oil 5% on the pseudostem five month after planting in heavily infested areas to prevent oviposition.

Post infestation measures

- Uproot severely infested trees, chop into pieces and burn.
- Swab the cut surface of the longitudinal split traps with 20 g of the formulation either entomopathogenic fungus, *Beauveria bassiana, Matarhizium anisopliae* or entomopathogenic nematode, *Heterorhabditis indica* (1x108 spores/ mg) and keep the split traps near the banana plant facing cut surface to soil.
- Spray chlorpyriphos @ 2.5 ml/l + 1 ml wetting agent or Azadirachtin (5 ml/l) for two or three times at three weekly intervals in case of severe infestation.

3. Banana aphid

Aphids are seen in colonies on leaf axils and pseudostems. Both nymphs and adults suck the cell sap from leaf sheath and pseudo stem. Green streaks initially appear on the secondary viens on the ventral side of the lamina. Affected leaves become brittle, small and petioles get elongated with wavy margins and rolled upwards. Plants do not produce bunches. Honey dew secretion appears on the plants which attracts the ants. Crown composed of narrow stunted leaves gives bunchy top appearance. Aphids act as a vector for bunchy top virus.

Management

- Ensure clean cultivation and use healthy and pest free suckers to check the pest incidence.
- Rogue out diseased plants with rhizome.
- Inject pseudostem with chlorpyrifos @ 2 ml in 4 ml of water per tree at 45 days interval from the 3rd month till flowering. Avoid injection after flowering.
- Destruction of weeds and alternate hosts.
- Introduction braconid wasps, *Lysiphlebiustestaceipes* and predators such *Scymnus*, *Chilomenes sexmaculatus*, *Chrysoperla carnea* and other coccinellids
- Spray Acephate (1.5g/lit) on infested plants thoroughly on petioles, furled leaves, whorls or on young suckers

4. Rust thrips

Both nymphs and adults lacerate and suck sap from leaves and fruits. The early symptoms of damage appear as water-soaked smoky areas where the colonies of thrips congregate to feed and oviposit between touching or adjacent fruit.These areas then develop the typical rusty-red to dark brown-black spots. Yellowing of leaves and rusty reddish discoloration on the fingers leads to scab

formation on fruits. In severe cases the skin develops longitudinal cracks and sometimes fruit may split. The taste and texture of the fruit within these peels remains unaffected but the exterior discoloration reduces the marketability.

Management

- Destroy all volunteer plants and old neglected plantations.
- Use healthy and pest free suckers for planting.
- Dip the rhizomes in hot water prior to planting.
- Release coccinelid predators like lacewings, ladybird beetles etc in the field.
- The plantations should be sprayed with fipronil @ 2ml/lit in case of severe infestation.
- Cover the buches full length to provide some protection.

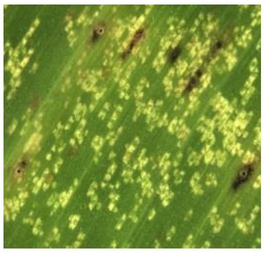
5. Leaf eatingcaterpillar

During night time young larvae feed by scrapping the chlorophyll of leaves from ventral surface initially and later on they feed voraciously. Severe infestation leads to defoliation.

Management

- Collect and destroy the egg masses and caterpillars in early stage of attack.
- Use light trapsduring night time to attract and kill the adults.
- Spray imidacloprid @ 0.3 ml/lit in case of sever infestation during rainy season when incidence is noticed.

6. Lacewing bug:



Bugs damage appears as small white, chlorotic spots on the upper leaf surface which causes a sickly and spotted appearance of the plant. Lower portions of the leaf surface are left with dark insect secretions.The colonized areas of leaves turn yellow to brown over time and later dry out. Infected trees have a stunted growth withsickly look.The pest infestation is more common during the post monsoon period especially in drier regions of the country.

Management

- Collect and destroy the damaged portions of the plants.
- Spray dinotefuran @ 0.4g/lit or imidacloprid @ 0.3 ml/lit in case of severe infestation.

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ELECTROSTATIC SPRAYERS: TRANSFORMING AGRICULTURE THROUGH PRECISION AND EFFICIENCY

Abhishek Patel*, Rohit Dilip Nalawade, Aman Mahore, Mohit Kumar and Abhishek Upadhyay

ICAR - Central Institute of Agricultural Engineering, Bhopal
*Corresponding Email**:** abhishekpatel2910@gmail.com

Abstract

Electrostatic sprayers have emerged as a revolutionary technology in Indian agriculture, offering precision, efficiency, and sustainability in pesticide and fertilizer application. These sprayers utilize an electrostatic charge to create a fine mist of charged droplets that adhere to plant surfaces, ensuring superior coverage and effectiveness. By addressing challenges such as uneven distribution, resource optimization, environmental impact, and worker safety, electrostatic sprayers provide solutions for Indian farmers. Benefits include improved crop yield, cost efficiency, environmental stewardship, and enhanced crop health and quality. The adoption of these sprayers is increasing, supported by government initiatives promoting sustainable farming practices. With their transformative potential, electrostatic sprayers are reshaping Indian agriculture and paving the way for a more productive, efficient, and environmentally conscious farming sector.

Introduction

In the realm of modern agriculture, technology continues to play a crucial role in improving productivity, sustainability, and profitability. One remarkable innovation that has gained significant traction in recent years is the electrostatic sprayer. This cutting-edge device has revolutionized the way farmers apply pesticides, herbicides, and fertilizers to crops, offering unparalleled precision, efficiency, and environmental benefits.

Understanding Electrostatic Sprayers

Electrostatic sprayers are advanced agricultural tools that utilize the principles of electrostatics to deliver a fine mist of charged droplets onto plants. Unlike conventional sprayers that rely solely on mechanical force, these innovative devices generate an electrostatic charge to create a powerful attraction between the droplets and the target plant surfaces. Agricultural electrostatic spraying technology is superior to non-electrostatic spraying technology. Electrostatic droplets have better “adhesion, penetration, and encircling ability” in crops. Electrostatic spraying technology is used to charge droplets to induce an electric field on the surface of the crop leaves, thus adsorbing electrostatic droplets and achieving directional movement of the charged droplets. This electrostatic force ensures that the spray evenly coats the foliage, reaching every nook and cranny, including the undersides of leaves and other hard-to-reach areas ((Zhou, 2018).

Several parameters create influence on droplet charging such as solution characteristics, physical properties of the nozzle, charging voltage, air flow speed, radius of charging electrode, liquid flow rate and horizontal distance between the electrode and nozzle tip (Liu,2021). Induction charging electrode is placed inside the Teflon frame which completely isolated from installation bass. The distance between electrode and nozzle is calculated with the reference of electrostatic field. Most effective variables are nozzle type and size, solution composition, and configuration of the induction electrode (Law, 2001).

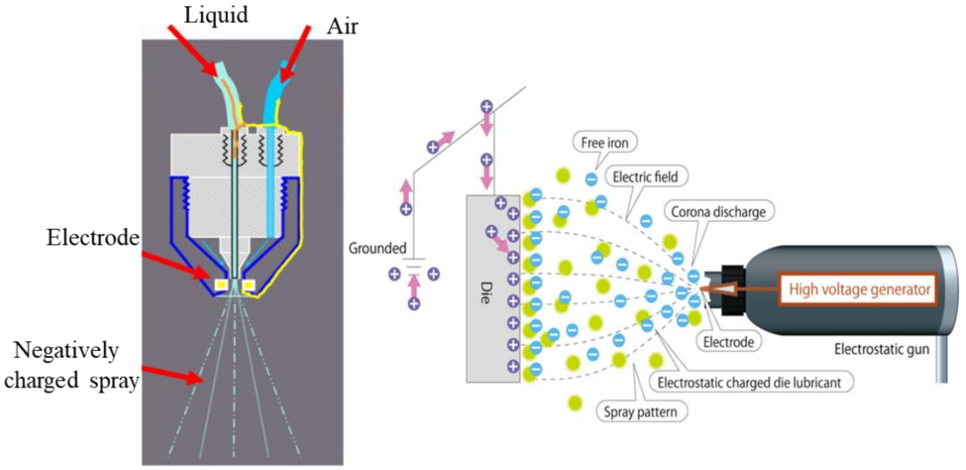


Fig.1 Working principle of electrostatic sprayer (Source: PCB online, 2019)

In this system the ring electrode is an agent for charge induction. Sprayers produce small droplets, which are electrically charged as they leave the nozzle. These electrically charge droplets pulls towards the plant is up 60 times greater than the force of gravity. Droplets change direction and move upwards against gravity to coat all of the plant surface. Electrostatic sprayers achieve greater spray droplets. Most of the Agricultural universities, comparing Electrostatics spray with conventional and air blast sprayers, shows 3.7 times better spray penetration and coverage on hidden areas and dense canopies. Better spray coverage equates to lower chemical consumption. Electrostatic spray is the best solution for the agricultural problems like thrips, aphids, downy mildew, mealybugs, early blight, late blight and listeria.

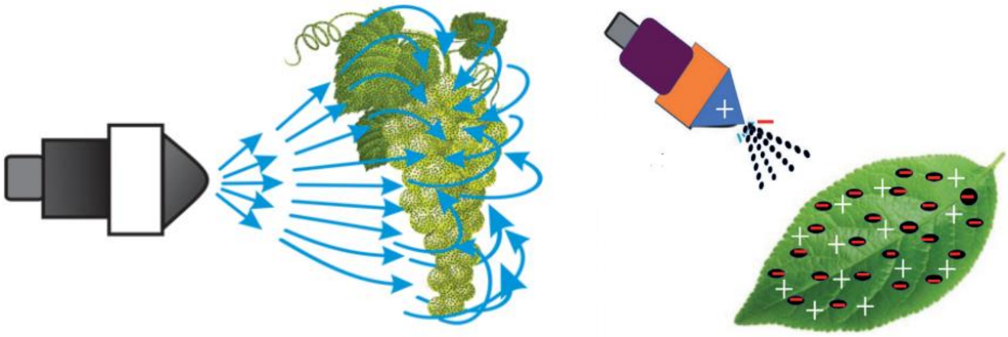


Fig. 2 Spray deposition pattern of on leaf surface (*Source*: Tathastu, 2022)

Knowledge Base

There are three types charging methods used for electrostatic spraying, including conduction charging, induction charging and corona charging. Among these the induction charging is the most widely used because of the following advantages compared with conduction charging: The high voltage does not directly contact the liquid; The electric field strength is below the breakdown strength of the air, so with high working voltage can charge particles. High voltage Electrode isolation and insulation from mounting becomes easier. In this method we can prevent voltage dropping by principle, there is no current drawn from the power supply, therefore the current capacity can be very small. Electrode is not directly connected to the liquid, so voltage dropping is not happening in induction spraying. Out of the various liquid charging methods, the induction charging approach has appeared to be convenient and practical for the electrification of liquid particle.

Different types of electrostatic sprayer

a) b) c)

Fig. Petrol engine operated, b) tractor operated and c) different types of sprayer gun

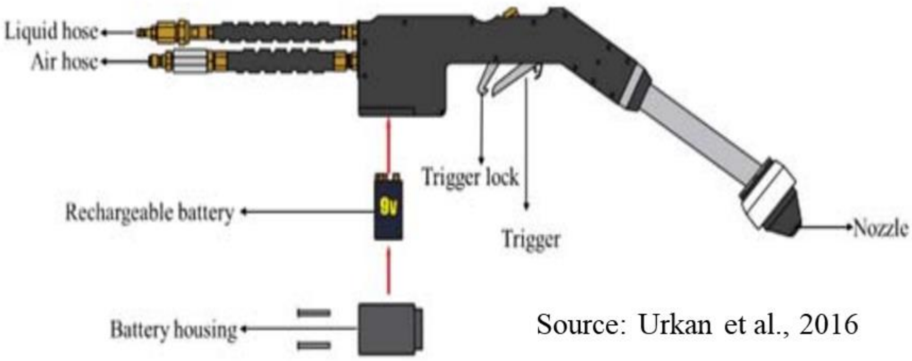


Fig. Parts of sprayer gun

Enhanced Precision and Efficiency

One of the most significant advantages of electrostatic sprayers is their remarkable precision and efficiency in delivering agrochemicals. The electrostatic charge applied to the droplets enables them to actively seek out and adhere to plant surfaces, even in the presence of natural obstacles such as wind or plant canopies. As a result, farmers achieve superior coverage with fewer passes, reducing the overall application time and optimizing resource utilization.

Reduced Chemical Usage and Environmental Impact

The precise application provided by electrostatic sprayers offers substantial benefits in terms of reducing chemical usage. Farmers can achieve the same or even better results using significantly lower volumes of pesticides, herbicides, and fertilizers. This reduction not only saves costs but also minimizes the environmental impact by decreasing the potential for chemical runoff and drift. Additionally, the targeted application ensures that the chemicals are applied where they are most needed, reducing the risk of contamination to non-target areas.

Improved Worker Safety

Electrostatic sprayers also prioritize the safety of agricultural workers. With conventional spraying methods, farmers often find themselves exposed to potentially harmful chemicals during application. However, electrostatic sprayers generate a fine mist that minimizes the risk of direct exposure to operators. Furthermore, the reduced chemical usage translates into fewer chemicals stored on-site, further enhancing the overall safety of the agricultural operation.

Enhancing Crop Health and Yield

By ensuring optimal coverage and reducing wastage, electrostatic sprayers contribute to improved crop health and yield. The precise application of pesticides and fertilizers directly onto the plant surfaces enhances their effectiveness, leading to better pest control and nutrient absorption. As a result, farmers can mitigate crop damage, improve overall plant health, and achieve higher yields, ultimately maximizing their profitability.

Adoption and Benefits in Indian Agriculture

The adoption of electrostatic sprayers in Indian agriculture has been steadily increasing, with farmers experiencing significant benefits:

1. Improved Crop Yield: Electrostatic sprayers provide optimal coverage, allowing agrochemicals to reach every part of the plant, including undersides of leaves and dense canopies. This comprehensive coverage leads to improved pest control, enhanced nutrient absorption, and ultimately higher crop yields.

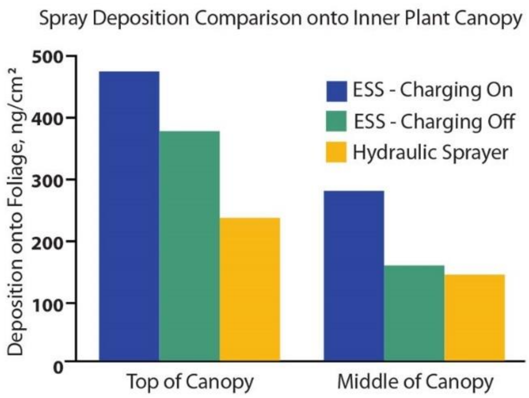
2. Cost Efficiency: While electrostatic sprayers may require a higher initial investment, they offer long-term cost benefits. By reducing chemical usage and optimizing resource utilization, farmers can achieve substantial cost savings over time. The enhanced efficiency of these sprayers also allows for quicker application, resulting in increased productivity.

3. Environmental Stewardship: Electrostatic sprayers align with India's commitment to sustainable agriculture and environmental stewardship. By minimizing chemical usage and preventing wastage, these sprayers contribute to reducing the ecological footprint of farming practices. They also support the conservation of water resources by minimizing chemical runoff.

4. Enhanced Crop Health and Quality: Electrostatic sprayers ensure that crops receive the right amount of agrochemicals at the right time, preventing under or over-application. This precision application leads to improved crop health, reduced crop losses, and enhanced product quality, which can positively impact market value and farmer income.

Case study

Figure 3a shows the results of a large-scale test with fluorescent tracer powder added to the spray tank. After spraying, researchers measured the amount of tracer deposited on each individual leaf. Results showed that the air-assisted electrostatic system deposited 72% more active ingredient than the conventional sprayer and 49% more than the uncharged air-assisted sprayer (Giles, 1992).



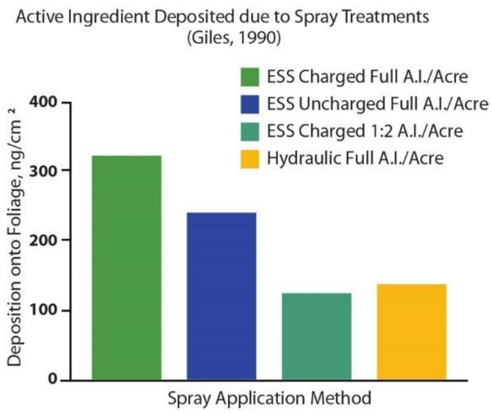


Fig. 3 a) Spray deposition on broccoli plant b) Spray deposition on strawberry plant

Field trials (Figure 3b) show that an electrostatically charged sprayer deposited 2.4 times more spray per leaf than a conventional high-pressure strawberry spray rig. Further trials using the air-assisted electrostatic sprayer with the charging unit turned off revealed the benefit of the air-assist feature alone: the spray deposition was 1.7 times higher than the hydraulic sprayer (Giles, 1992).

Conclusion

The advent of electrostatic sprayers has marked a significant milestone in the agricultural industry. By harnessing the power of electrostatics, these advanced devices have transformed the way farmers apply agrochemicals, offering unmatched precision, efficiency, and environmental benefits. As the demand for sustainable and efficient farming practices continues to rise, electrostatic sprayers have emerged as a valuable tool, ensuring the well-being of crops, farmers, and the environment. Embracing this technology opens up new horizons for the future of agriculture, where productivity and sustainability go hand in hand.

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MANAGING CLIMATE CHANGE : A STRATEGY FOR INDIA

K. N. Tiwari[1*] and Himanshi Tiwari[2]

[1]Ex. Director, International Plant Nutrition Institute-India Programme,
7A Lakhanpur Housing Society, Lakhanpur, Kanpur 208024
[2]Freelance Writer, 4B/861, Gomati Nagar Extension, Lucknow 226010
*Corresponding email: kashinathtiwari730@gmail.com

Abstract

India accounts for 4.5 percent of the world's greenhouse gases, so it plays a crucial role in combating climate change. As per estimate natural disasters exacerbated by climate change cost the Indian government roughly $30 billion (US dollars) between 2010 and 2015. That number will likely rise along with the global temperature. India is likely to witness more extreme weather events, including intense heat waves, heavy flooding and severe drought that pose challenges to food and energy security for the most populous nation. The country must plan to deal with such events and invest in climate change mitigation and adaptation measures.

Introduction

India has about 18 per cent of the world's population, while its land, forest and clean water make up a meagre 2.4, 2 and 4 per cent of the world's respective totals. Currently, humans are consuming 1.7 times the resources the Earth can replace in one year. By 2030, humans will require the resources produced on two Earths. In the Indian context, the country will require 2.5 times more natural resources to meet its demand by 2030. India has lower per-capita consumption of natural resources than many countries, but overshoot occurs due to its high population and limited resources. Since the industrial revolution, human activities have increasingly destroyed and degraded forests, grasslands, wetlands and other important ecosystems, threatening human well-being. Seventy five per cent of the Earth's ice-free land surface has already been significantly altered, most of the oceans are polluted, and more than 85% of the area of wetlands have been lost. This destruction of ecosystems has led to 1 million species (500,000 animals and plants and 500,000 insects) being threatened with extinction over the coming decades to centuries, although many of these extinctions are preventable if we conserve and restore nature (IPBES 2019). This paper analyzes the impact of climate change and its various aspects in the Indian context.

Green House Effect, Global Warming and Climate Change

Green House effect is the phenomenon whereby the earth's atmosphere traps solar radiation, and is mediated by the presence in the atmosphere of gases such as carbon dioxide, water vapor, and methane that allow incoming sunlight to pass through, but absorb the heat radiated back from the earth's surface while the global warming is defined as an increase in the average temperature of the Earth's atmosphere, especially a sustained increase great enough to cause changes in the global climate. The term global warming is synonymous with enhanced greenhouse effect, implying an increase in the amount of greenhouse gases in the earth's atmosphere, leading to entrapment of more and more solar radiations, and thus increasing the overall temperature of the earth. Global Warming is described as a gradual increase in the average temperature on the earth's atmosphere and its oceans, a change that is believed to be permanently changing the earth's climate. Climate change and global warming are the main environmental challenges the world is facing today.

India faces a number of issues that heighten the dangers of global warming. Record-breaking heat waves have become a regular occurrence in India, killing thousands in each of the last two summers. Much of its water comes from glaciers melting in the Himalayas—a melt that has been expedited in recent years by rising temperatures. India's water supply could suddenly surge as a result of melting before drying up, creating massive waves of displaced and starving people. As global temperatures continue to rise, hot-weather countries like India feel the limits of habitability being stretched. India's position on climate change is given below.

India's Position on Climate Change

- India is world's third largest emitter of greenhouse gases (GHGs), after China and the US.
- Major sources of emissions – Coal power plants, rice paddies, cattle.
- Per-capita emissions remain below global average.
- Displacement and extinction of animal population due to habitat loss adds more species to 'threatened' and 'extinct' list.
- Spread of diseases like malaria, etc. puts stress on health sector.
- The country has pledged a 33-35% reduction in the "emissions intensity" of its economy by 2030, compared to 2005 levels.
- Increase tree cover to create an additional cumulative carbon sink of 2,500-3,000Mt CO2 by 2030.
- India also aims to install 5GW of offshore wind by 2022 and 30GW by 2030. None has yet been installed.
- The country could integrate 390GW of low-cost wind and solar generation into its grid by 2030, according to the Climate Policy Initiative (CPI).
- India's climate pledge notes that around 70% of its population depends on traditional biomass energy, which is inefficient and causes high levels of indoor air pollution.
- India is targeting 10GW of such bioenergy by 2022.
- India has around 4.5GW of small hydro plants (below 25MW), against a 5GW target for 2022.

India has contributed 4.8% to the global mean surface temperature (GMST) change resulting from historical emissions of CO_2, methane and nitrous oxide (N_2O), a new research paper published in Nature journal in March 2023 by Jayashree Nandi. In comparison, US contributed to 17.3% of the change – highest globally and China contributed to 12.3%. Largest contributors to warming up to 2021 through emissions of all three gases since 1850 were: US (0.28°C); China (0.20°C); Russia (0.10°C); Brazil (0.08°C); India (0.08°C); Indonesia, Germany, UK, Japan, Canada (each contributing 0.03-0.05°C). One of the main areas affected by the climate crisis is the global rainfall cycle, resulting in less rain, more droughts, and extreme rain events. The paper titled "National contributions to climate change due to historical emissions of carbon dioxide, methane, and nitrous oxide since 1850", authored by researchers from Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia (UEA); CICERO Center for International Climate Research, Oslo, Norway; International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria among others said emissions from developed nations have contributed significantly to warming since the industrial revolution. "Tracking national contributions to climate change is thus critical to understanding the burden of responsibility that a country carries for global warming and can further inform the design of international policies that pursue equitable decarbonization pathways."

In this context, it is important to mention that at the beginning of the 21st century, greenhouse gas emissions from emerging countries, most notably from China, increased rapidly. As the commitments under the Kyoto Protocol covered a limited number of developed countries only, the international community prepared a successor to the Kyoto Protocol, which would include mitigation commitments by a larger group of countries. The first major attempt ended in a failure at COP15 in Copenhagen in 2009, where countries only 'took note' of a document that laid out principles for voluntary contributions in the period up to 2020. The subsequent negotiations focused on an agreement that would allow Parties to determine their contributions in a bottom-up approach but would have legal force and would require all Parties to contribute to its mitigation goals.

The Prime Minister Mr. Narendra Modi said at the United Nations' 2015 Climate Change Talks in Paris, *"Climate change is not of our making. It is the result of global warming that came from the prosperity and progress of an industrial age powered by fossil fuel. But we in India face its consequences today. We see it in the risks of our farmers, the changes in weather patterns, and the intensity of natural disasters."* Modi ratified the Paris agreement on Oct. 2—chosen to coincide with Gandhi's birthday. The pact seeks to limit the Earth's warming to below 2^0C.

Impact of Climate Change

The IPCC has warned that the temperature going beyond 1.5°C will increase the frequency and intensity of climate impacts, such as the heatwaves and storms witnessed across the globe in the last few years. Warmer temperatures over time are changing weather patterns and disrupting the usual balance of nature posing many risks to human beings and all other forms of life on Earth. Nearly all land areas across the world are seeing more hot days and heat waves; 2020 was one of the hottest years on record. Higher temperatures increase heat-related illnesses and can make it more difficult to work and move around. Wildfires start more easily and spread more rapidly when conditions are hotter.

Rising Temperatures on the Tibetan Plateau are causing the melting of the Himalayan glaciers, reducing the water flow in the rivers Ganges, Brahmaputra, Yamuna, and other major rivers, on which the livelihoods of hundreds of thousands of farmers depend. Some changes (such as droughts, wildfires, and extreme rainfall) are happening faster than scientists previously assessed. In July, 2022, the temperatures rose enough to cause 18 billion tons of the Country's ice sheet to melt over three days.

With nearly 310 million people living in coastal areas that will be affected by global sea level rise, nearly 30% of the population living below the poverty line, and over 50% of the people working in the farm industry, global warming will have an impact on every aspect of Indian society. Not only is nearly 70% of its population dependent upon climate-sensitive sectors and natural resources, but many of them do not possess the capacity to adapt to climate change. Thus, climate change is likely to impact all the natural ecosystems as well as socio-economic systems.

A 2019 UN Environment Programme (UNEP) report warns that unless global greenhouse gas emissions fall by 7.6 per cent each year between 2020 and 2030, the world will miss the opportunity to get on track towards the 1.5°C temperature goal of the Paris Agreement. According to the Intergovernmental Panel on Climate Change (IPCC) - the United Nations body established to assess the science related to climate change - modern humans have never before seen the observed changes in our global climate, and some of these changes are irreversible over the next hundreds to thousands of years. Scientists have high confidence that global temperatures will continue to rise for many decades, mainly due to greenhouse gases produced by human activities.

To limit temperatures, annual emissions in 2030 need to be 15 gigatonnes of CO_2 equivalent lower than current unconditional NDCs imply for the 2°C goal; they need to be 32 gigatonnes lower for the 1.5°C goal. On an annual basis, this means cuts in emissions of 7.6 per cent per year from 2020 to 2030 to meet the 1.5°C goal and 2.7 per cent per year for the 2°C goal.[9] To deliver on these cuts, the levels of ambition in the NDCs must increase at least fivefold for the 1.5°C goal and threefold for the 2°C. The IPCC's Sixth Assessment report, published in 2021, found that human emissions of heat-trapping gases have already warmed the climate by nearly 1.1°C since pre-Industrial times (starting in 1750).[1] The global average temperature is expected to reach or exceed 1.5 degrees C (about 3 degrees F) within the next few decades. These changes will affect all regions of Earth.

Global warming is also posing as a mammoth threat to the food security situation in India with recurring and severe droughts and ravaging floods engulfing the arable land. The anticipated increase in precipitation, the melting of glaciers and expanding seas are projected to influence the Indian climate particularly severely, with an increase in incidence of floods, hurricanes, and storms. Climate change is associated with various adverse impacts on agriculture, water resources, forest and biodiversity, health, coastal management and increase in temperature. Decline in agricultural productivity is the main impact of climate change on India. Drought has damaged crops, causing starvation and a rash of farmer suicides. Floods previously considered to be one-in-100-years events could occur ten times a year. Water supply is another concern for India. A majority of population depends on agriculture directly or indirectly. Climate change would represent additional stress on the ecological and socioeconomic systems that are already facing tremendous pressure due to rapid industrialization, urbanization and economic development.

The global Living Planet Index continues to decline. It shows an average 68% decrease in population sizes of mammals, birds, amphibians, reptiles and fish between 1970 and 2016. A 94% decline in the LPI for the tropical subregions of the Americas is the largest fall observed in any part of the world. It matters because biodiversity is fundamental to human life on Earth, and the evidence is unequivocal – it is being destroyed by us at a rate unprecedented in history. Since the industrial revolution, human activities have increasingly destroyed and degraded forests, grasslands, wetlands and other important ecosystems, threatening human well-being. Seventy-five per cent of the Earth's ice-free land surface has already been significantly altered, most of the oceans are polluted, and more than 85% of the area of wetlands has been lost. Species population trends are important because they are a measure of overall ecosystem health. The effects of global warming are expected to be far-reaching and, in many cases, devastating which are already visible on the planet.

United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC 1992) was adopted at the UN Conference on Environment and Development in Rio de Janeiro in 1992 with the objective to stabilize the concentrations of greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The Paris Agreement

Following the 1992 Rio conference, most countries signed and ratified the Convention. Currently it has 197 Parties, including the European Union and each of its Member States. After the entry into force of the Convention in 1994, its first Conference of the Parties (COP) convened in 1995. Besides the COP, other bodies convene at each climate change conference, as summarized in **Table 1** which provides an overview of the status of signature and ratification of the Paris Agreement. At the time of writing this study, there are six Parties which have signed the agreement but not ratified it.

Table 1: The Conference of the Parties and other related bodies

Body	Meeting	Purpose
Conference of the Parties (COP)	Annually since 1995	The COP is the supreme body of the Convention. It reviews and promotes the implementation of the Convention.
Subsidiary Body for Scientific and Technological Advice (SBSTA)	Biannually since 1995	The SBSTA assesses the state of scientific knowledge relating to climate change and responds to scientific, technological and methodological questions raised by the COP.
Subsidiary Body for Implementation (SBI)	Biannually since 1995	The SBI considers the information provided by Parties and assists the COP in the preparation and implementation of its decisions.
Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP)	Annually since 2005	The CMP keeps the implementation of the Kyoto Protocol (cf. chapter 2.2) under regular review and promotes its effective implementation.
Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA)	Annually since 2016	The CMA periodically takes stock of the implementation of the Paris Agreement (cf. chapter 2.3) and promotes its effective implementation.

Source: Moosmann et al. (2019) based on UNFCCC (1992) and related COP decisions.

The Paris Agreement addresses a wide range of topics, from mitigation to adaptation and support, as depicted in **Figure 1**.

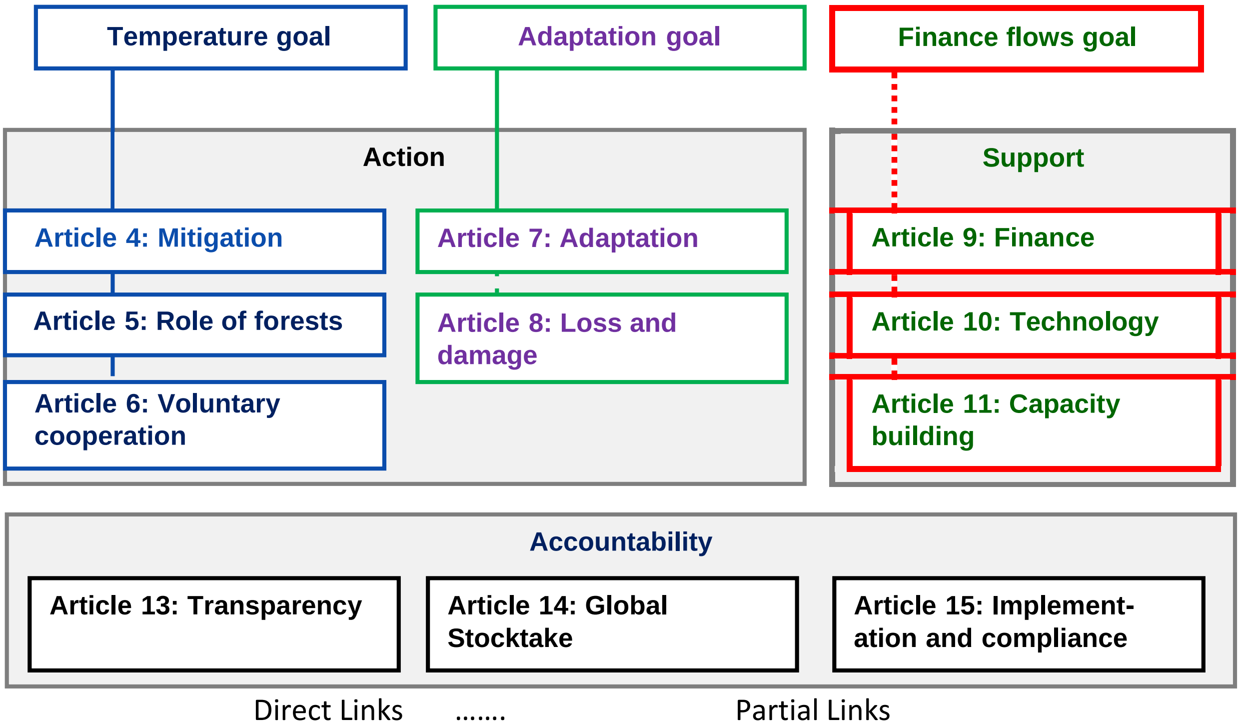

Figure 1: Topics addressed by the Paris Agreement

Source: UNFCCC (2015); figure based on Moosmann et al. (2016) and UNFCCC (2021).

The" temperature goal" aims to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit this increase to 1.5°C while the "adaptation goal" aims to increase the ability to adapt to the adverse impacts of climate change and to foster climate resilience and low greenhouse gas emissions development and finally, the "finance flows" goal aims to make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

Mitigation, Adaptation and Loss and Damage

Mitigation: Mitigation is the reduction of greenhouse gas emissions and the enhancement of sinks of greenhouse gases. It is a cornerstone of the response to climate change. The Paris Agreement, in Article 4, sets out the emissions goal, according to which Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, and to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century.

Adaptation and loss and damage: As human influence has already warmed the atmosphere and changes in the climate system have already occurred (IPCC 2021), adaptation to climate change is needed as a complementary approach to mitigation. It has become more relevant with the passing of time and failure of the international community to address the mitigation of greenhouse gas emissions adequately.

Article 7 of the Paris Agreement establishes a goal on adaptation; its pillars are the enhancement of adaptive capacity, the strengthening of resilience and the reduction of vulnerability to climate change. Article 8 of the Paris Agreement addresses loss and damage. It lists areas of cooperation, inter alia on early warning systems, emergency preparedness, risk assessment and management, and resilience of communities, livelihoods and ecosystems. The Warsaw International Mechanism (WIM) on Loss and Damage, established by the COP in Warsaw in 2013, is subject to the authority and guidance of the CMA.

COP26 Glasgow Summit

India's emissions reduction targets announced at COP26 consisted of a longer-term target of reaching net zero by 2070 and some interim targets for 2030, which are as follows (Ahluwalia and Patel, 2023).

1. Reduce emissions intensity of GDP by more than 45 percent by 2030, compared to the 2005 level, up from the Paris target of 33−35 percent.
2. Raise share of non-fossil fuel-based electricity generation capacity to 50 percent up from the earlier target of 40 percent by 2030. This is based on the target of 450 GW of renewable energy (RE) capacity, predominantly solar and wind.
3. Achieve the afore stated target of creating 2.5−3 Gt-CO_2 equivalent additional forest sink by 2030, that was part of India's Paris nationally determined contributions (NDCs), was not explicitly mentioned, but remains in force.

The target for reducing emissions intensity is likely to be achieved but, of course, reducing emissions intensity will not necessarily lead to a reduction in absolute emissions. Since GDP in 2030 is likely to be 4.5 times what it was in 2005, a 45 percent reduction in emissions intensity would still leave absolute emissions almost 2.5 times the level in 2005, or about 33 percent above the 2020 level (GCP, 2022). The fact that India's emissions are projected to rise over the near future should not cause any surprise because India's per capita energy consumption is currently very low—only a sixth of the average of Organisation for Economic Co-operation and Development (OECD) countries (BP, 2021). India needs to achieve growth of 7–8 percent per annum in its GDP over the next 10 years, to meet legitimate expectations of higher income levels, and this is bound to involve growth in total energy consumption (Ahluwalia and Patel, 2023). India's strategy for decarbonization reconciles growth in energy consumption, with a reduction and ultimately elimination of CO_2 emissions, through a combination of demand-side and supply-side actions on energy. On the demand side the strategy relies on:

i. increasing energy efficiency through adoption of energy-saving technologies, combined with lifestyle changes, which will moderate the growth of energy demand for any given growth of income; and
ii. shifting from direct use of fossil fuels to electricity as the final energy source wherever possible. Electrification of transport is the most obvious possibility which saves on use of petrol and diesel.
iii. shifting away from electricity generation using fossil fuels (mainly coal, and also gas) to electricity from RE (mainly solar and wind)—this transformation on the supply-side is critical for reducing emissions from other demand-side sectors such as transport; and
iv. developing green hydrogen (H_2) as a substitute for fossil fuels in hard to decarbonize areas.

As mentioned by (Ahluwalia and Patel, 2023) above actions must be accompanied by:

(i) expanding forest area to increase natural carbon sinks; and finally,

developing CO_2 capture and sequestration techniques to make them commercially viable to offset emissions from residual use of fossil fuel that may remain.

The COP26 Summit in Glasgow represented a breakthrough because developing countries, for the first time ever, agreed to reduce the level of carbon emissions to net zero by various dates around mid-century. India, along with many other developing countries, had traditionally argued that global warming is occurring due to the accumulation of greenhouse gases (GHGs) in the atmosphere, which is mainly due to the activities of developed countries as they industrialized. Since India had contributed little to the stock of GHGs, and also had a very low energy consumption per capita, imposing emissions reduction obligations on India was seen to be unfair and inconsistent with its development goals. This position changed because of the recognition that technological advancements have made it possible to meet the energy requirements of development using renewable sources of energy, which do not emit GHGs. Prime Minister Modi announced that India would achieve net zero emissions by 2070. Most advanced countries, and also some developing countries like South Africa and Vietnam, announced 2050 as their target net zero date. China, Russia, Saudi Arabia, Indonesia, Nigeria, and others committed to reach net zero by 2060.

A ten-year plan along these lines would help increase public consciousness and generate a public debate on the aspects of a strategy that may seem politically difficult but is necessary to address if progress on climate change is to be made. Fairness requires that the advanced countries should take the lead in announcing tighter transition targets and the others can then follow. If this approach is accepted, the advanced countries would need to tighten their emissions trajectories to reach net zero 5−10 years earlier than currently targeted. China too would have to advance its net zero date to 2050.

If an agreement along these lines is reached, India should also consider advancing its net zero date by some years (Ahluwalia and Patel, 2022). India's own requirements call for long-term public international finance (both bilateral plus from the MDBs to increase to about $30 billion per year, which in turn could help to leverage a greater amount of investment from private sources. The international community has yet to decide on the scale of financial assistance to be promised to developing countries after 2025. The current international environment is not conducive to focusing on this long-term objective, but India's chairmanship of the G-20 in 2023 provides a well-timed opportunity to push for a bold global initiative in this area.

National Priorities, International Developments after Copenhagen

Climate policymaking started in India on the basis of the development-first ideology that sees emissions control as a co-benefit. To a certain extent, it worked in the case of industry, especially heavy industry, which steadily increased its energy use efficiency and thus reduced its emissions per unit of output. A recent estimate places this reduction in emissions intensity between 1997 and 2015 at over 17%. In its INDC prepared for Paris, India has pledged an emissions intensity reduction of 30-35% by 2030. The next phase of climate policymaking was about implementing the NAPCC. The plan has nine missions:

- National Solar Mission
  - National Mission for Enhanced Energy Efficiency
  - National Mission on Sustainable Habitat
  - National Water Mission
  - National Mission for Sustaining the Himalayan Ecosystem
  - National Mission for a Green India
  - National Mission for Sustainable Agriculture
  - National Mission on Strategic Knowledge for Climate Change
- National Adaptation Fund for Climate Change (NAFCC)
- National Electric Mobility Mission Plan (NEMMP)

Initial action on all missions – with the partial exception of the missions on solar energy and energy efficiency was largely limited to asking state governments to prepare their own action plans in accordance with NAPCC. The process took years. It also showed that policymakers at state government levels were focussed on development issues, with climate action appearing as a by-product, if at all. As outlined in India's INDC, the country has an ambitious plan to generate 350 GW through renewable sources by 2030. This will be a mix of both grid and off grid installations and will mean 40% of the electricity needed in India will come through these sources. The real challenge here will be to implement this plan. Entrepreneurs in the renewable energy arena have complaints that need to be addressed urgently. Another bigger challenge will be to find the billions of dollars needed to move India to a green development path. Major infrastructure sectors such as railways, road transport and manufacturing require investments that are simply not available in the current global economic climate. Indian policymakers have reposed their faith in technological breakthroughs that will radically reduce the cost of green technologies – but right now it is more a matter of faith than policymaking.

Conclusions

The severity of effects caused by climate change will depend on the path of future human activities. More greenhouse gas emissions will lead to more climate extremes and widespread damaging effects across our planet. However, those future effects depend on the total amount of carbon dioxide we emit. So, if we can reduce emissions, we may avoid some of the worst effects. As climate change is a threat to human wellbeing and the health of the planet. any further delay in concerted global action will miss the brief, rapidly closing window to secure a liveable future.

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UNEARTHING THE ESSENTIALS: UNDERSTANDING PLANT NUTRIENTS FOR OPTIMAL GROWTH

Pooja Singh, Kamesh Singh Chauhan, Abhishek Singh Chauhan* and Saurabh Kumar

Department of Agronomy, Banda University of Agriculture & Technology Banda
Department of Agronomy, CCS University Meerut Uttar Pradesh
Department of Entomology, Banda University of Agriculture & Technology Banda
Senior Research Fellow, ACRIP Mauranipur Jhansi
*Corresponding email: achauhanbuat@gmail.com

Abstract

Plant nutrient management plays a crucial role in optimizing crop growth, development, and overall productivity. Essential nutrients are necessary for various physiological and biochemical processes within plants, including photosynthesis, cell division, and protein synthesis. This abstract provides an overview of plant nutrients, their functions, and the importance of proper nutrient management for sustainable agriculture. Plants require both macronutrients and micronutrients for healthy growth. Macronutrients, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S), are needed in relatively large quantities. These nutrients contribute to plant structure, energy transfer, enzyme activation, and nutrient storage. Micronutrients, such as iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), boron (B), and chlorine (Cl), are required in smaller amounts but are equally essential for various metabolic processes.

Optimal nutrient management involves assessing the nutrient requirements of specific crops and providing adequate amounts through appropriate fertilization strategies. Soil testing and plant tissue analysis are commonly employed to determine nutrient deficiencies or imbalances. Fertilizers, both organic and inorganic, can be applied to supplement nutrient deficiencies in the soil and promote healthy plant growth.

Introduction

Plants, the green wonders of nature, depend on various nutrients to thrive and reach their full potential. Just as humans need a balanced diet, plants require a careful combination of essential elements to grow, develop, and produce vibrant flowers, luscious fruits, and verdant foliage. In this article, we will explore the importance of plant nutrients and delve into the primary macronutrients and micronutrients necessary for healthy plant growth.

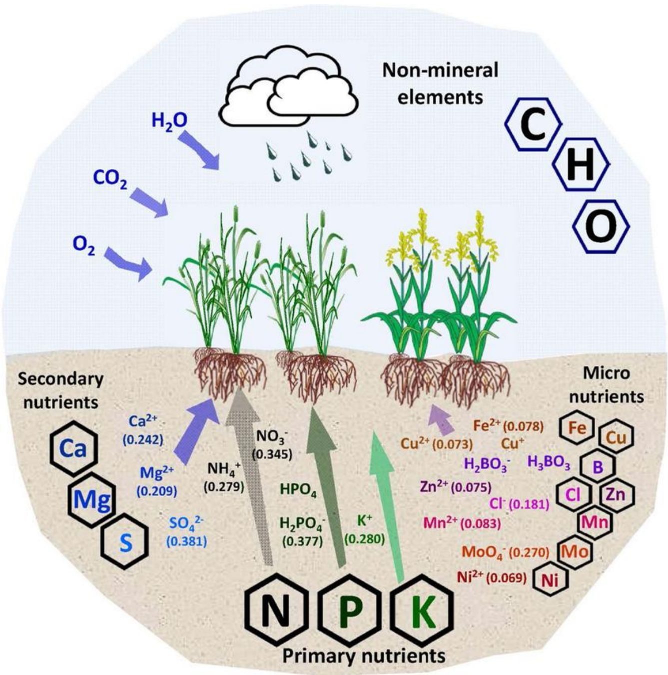
Macronutrients

Macronutrients are the vital elements that plants need in relatively large quantities. They form the foundation of a plant's nutritional requirements and are essential for its overall development. The three primary macronutrients are:

- **Nitrogen (N):** Nitrogen is a key building block for proteins, enzymes, chlorophyll, and DNA. It plays a crucial role in promoting leafy growth and enhancing the plant's ability to photosynthesize. Nitrogen deficiency results in yellowing leaves and stunted growth.
- **Phosphorus (P):** Phosphorus is essential for energy transfer, root development, flowering,

and fruiting. It aids in the transfer of genetic information and promotes overall plant vigor. Insufficient phosphorus levels can lead to weak root systems and reduced flower and fruit production.

- **Potassium (K):** Potassium is involved in various physiological processes, including osmoregulation, enzyme activation, and the synthesis of proteins and carbohydrates. It strengthens plants' ability to withstand stress, improves disease resistance, and enhances the quality of fruits and flowers. A lack of potassium can cause slow growth, weakened stems, and increased susceptibility to diseases.
- **Micronutrients:**
- Micronutrients are equally important for plant health, albeit in smaller quantities. These trace elements are necessary for specific biochemical reactions and play a crucial role in overall plant metabolism. Some essential micronutrients include:
- **Iron (Fe):** Iron is necessary for chlorophyll production and is involved in photosynthesis and respiration. Iron deficiency manifests as interveinal chlorosis, where the veins of the leaves remain green, but the surrounding tissue turns yellow.
- **Zinc (Zn):** Zinc aids in enzyme activity, protein synthesis, and hormone production. It is vital for proper growth and development, including root elongation and shoot formation. Zinc deficiency results in stunted growth, distorted leaves, and reduced flowering.
- **Magnesium (Mg):** Magnesium is a central component of chlorophyll molecules, playing a pivotal role in photosynthesis. It also activates numerous enzymes involved in energy metabolism. Insufficient magnesium leads to chlorosis, with yellowing occurring between the veins of older leaves.
- **Manganese (Mn):** Manganese participates in enzyme activation, photosynthesis, and nitrogen metabolism. It is crucial for the synthesis of chlorophyll and promotes root development. Manganese deficiency leads to yellowing between veins and stunted growth.



Providing Adequate Nutrition

1. To ensure plants receive the necessary nutrients, it is crucial to maintain a balanced and fertile growing medium. This can be achieved through several means:
2. Soil Testing: Conduct regular soil tests to identify nutrient deficiencies and adjust fertilization accordingly. Soil pH levels should also be monitored, as it affects nutrient availability.
3. Fertilization: Supplement the soil with organic matter and employ balanced fertilizers that provide all essential nutrients in appropriate proportions. Follow recommended application rates to avoid over-fertilization, which can harm plants and the environment.
4. Composting: Composting organic waste materials is an excellent way to enrich the soil with nutrients over time. Incorporating compost into the soil enhances its fertility and improves nutrient retention.
5. Crop Rotation: Rotate crops seasonally to minimize nutrient depletion and prevent

Conclusion

Proper plant nutrient management is essential for sustainable agriculture. Understanding the functions of different nutrients, assessing crop nutrient requirements, and employing appropriate fertilization practices contribute to improved crop yields, minimized environmental impacts, and long-term soil health. By adopting holistic nutrient management strategies, farmers can optimize plant nutrition and contribute to a more sustainable and productive agricultural system.

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AQUA-AGRIBUSINESS: EXPLORING THE LUCRATIVE OF FRESHWATER FISH FARMING

Patekar Prakash*[1], Narsale Swapnil[2] Samad Sheikh[1] and Samikshya Mishra[1]

*[1]Ph.D. Scholar, ICAR-Central Institute of Fisheries Education (CIFE),
Versova, Mumbai- 400061, Maharashtra, India.
[2]M.F. Sc scholar, Fisheries College and Research Institute,
Thoothukudi, Tamilnadu – 628008.
*Corresponding author – patekarprakash476@gmail.com

Abstract

An overview of the different aspects of fish farming and aqua-agribusiness in freshwater fish production. It highlights the importance of fish farming to increase fish availability and meet the growing demand for seafood. The abstract discusses the major freshwater farming systems practiced in India, such as ponds, cages, pens, paddy fields, and sewage feed, focusing on the dominant practice of polyculture. It also mentions the government schemes to support fish farmers and increase production. The significance of inland fish production in providing animal protein supplies, especially in rural areas, highlights the increasing demand for freshwater fish due to its nutritional value and affordability. The challenges of matching supply patterns with demand and the need for scientific cultivation practices to enhance production. The abstract further explores the different types of fish farming based on salinity, intensity, species stocked, and enclosure used, providing insights into the characteristics and advantages of each method. Moreover, integrated fish farming, such as aquaponics, paddy-fish farming and integrated livestock-fish farming, offer sustainable and symbiotic systems for fish cultivation alongside other agricultural or aquacultural activities. It emphasizes the importance of sustainable practices in aqua-agribusiness, including efficient water management, nutrient management, sustainable feed sourcing, and biodiversity conservation, for long-term success and meeting consumer demand for responsibly sourced seafood. The potential profitability of aqua-agribusiness ventures and the opportunities they present for entrepreneurs and investors, given the increasing global demand for seafood. It suggests that understanding the dynamics of freshwater fish farming and its associated business opportunities is crucial for individuals looking to tap into this thriving industry.

Introduction

Fish is the cheapest and most easily digestible animal protein and has been obtained from natural sources from time immemorial for consumption. However, due to over-exploitation and pollution, fish availability in natural waters has declined considerably, forcing scientists to adopt various methods to increase production. Fish farming in controlled or under artificial conditions has become the easier way of increasing fish production and its availability for consumption. Farmers can easily take up fish culture in village ponds, tanks, or any new water body and substantially improve their financial position. It also creates gainful employment for skilled and unskilled youths.

India's major freshwater farming are ponds, cages, pens, paddy fields and sewage feed. Polyculture is the dominant cultural system practiced. The major species are carp (Catla, Rohu, Mrigal), freshwater prawns and catfish. India's aquaculture is carp-oriented and the contribution of other species is marginal. Fish culture in India can be classified as extensive, semi-intensive, or intensive and the stocking rate is high at 18,408 fish/ha. Both the central and state governments have devised schemes like Pradhan Mantri Matsya Sampada Yojna (PMMSY) to help the cause of the farmers and the budget allocation to this scheme is about 2050cr. India is a large producer of inland fish, ranking next only to Japan. Out of the total inland fish production of over 3.6 million metric tons, more than 60% is contributed by fish culture in ponds and reservoirs. Farmers adopt fish farming on a commercial scale.

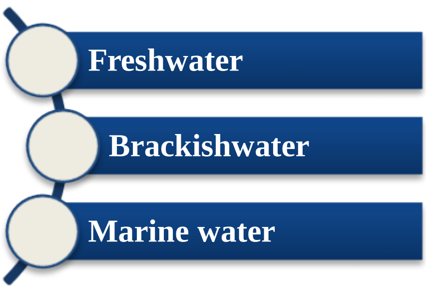
Inland fish production significantly contributes to animal protein supplies in rural areas. Most of the inland output is consumed locally and marketed domestically. Landlocked area consumers generally prefer fresh fish and acceptance of fish as a nutritional value product over the frequent foodies. The inland fish market is relatively informal in the country. Marketing channels are generally short. The annual per capita availability of fish in the world is 12.1 kg. In the context of India, it is 3.2 kg (Das et al., 2020). The yearly per capita consumption of fish is increasing every year. This is mainly because of increased purchasing power, an increase in the nonvegetarian eating population and a preference for fish as a low-cost protein (compared to meat). While the demand for fish is throughout the year, the supply fluctuates. Supply patterns do not match demand patterns. Over the years, there has been a rise in demand for freshwater fish. This has led to a thrust on enhancing production through scientific cultivation practices. The fisheries industry is growing at 5%. With abundant freshwater resources, India has still been unable to tap even 30% of the potential area for inland fish production. This sector can potentially create an enormous market, provided fish cultivation is done scientifically. With the increasing demand for fish, several types of fish farming have emerged. This chapter will discuss the different kinds of fish farming and their characteristics.

Aqua-agribusiness, specifically freshwater fish farming, is a rapidly growing sector that offers lucrative opportunities for entrepreneurs and investors. As the global demand for seafood rises, freshwater fish farming provides a sustainable solution to meet this increasing need (Boyd et al., 2020). With technological advancements, sustainable practices, and demand for responsibly sourced seafood, aqua-agribusiness ventures are well-positioned to capitalize on this growing market. This article delves into aqua-agribusiness, exploring the potential profitability, sustainable practices, integration with agriculture, and opportunities for entrepreneurs and investors. By understanding the dynamics of freshwater fish farming and its associated business opportunities, individuals can make informed decisions and tap into the potential of this thriving industry.

Different Systems of Aquaculture

Aquaculture is classified in several ways, depending upon the different aspects and situations involved in the cultural practice.

Based on salinity:



Freshwater Fish Farming: Freshwater fish farming involves cultivating fish species that thrive in freshwater environments such as rivers, lakes, dams and ponds. Common freshwater fish species raised in fish farms include catfish, tilapia, carp, trout, and bass. Freshwater fish farming is typically conducted in inland water bodies, and the farming systems can range from extensive pond culture to more intensive recirculating systems.

Brackish Water Fish Farming: Brackish water fish farming occurs in environments that have a mixture of freshwater and saltwater, such as estuaries, coastal lagoons, and mangrove swamps. This type of farming is suitable for fish species that can tolerate varying salinity levels. Some examples of brackish water fish species farmed include mullet, milkfish, sea bass, and shrimp. Brackish water fish farming is common in regions where these environments are prevalent.

Marine Fish Farming: Marine fish farming involves cultivating fish species adapted to full saltwater environments, such as the open ocean or coastal areas. It requires specialized infrastructure and technology to maintain suitable water quality and provide appropriate conditions for marine species. Popular marine fish species cultivated in fish farms include salmon, tuna, sea bream, silver pompano and grouper. Marine fish farming is commonly practiced in coastal areas with access to the sea.

Each type of fish farming requires specific management practices, infrastructure, and water quality, feeding, and disease control considerations. The choice of fish farming type depends on the desired species, available resources, and environmental conditions in a particular location.

Based on intensity:

Extensive Fish Farming: Extensive fish farming involves low stocking densities and relies on biological productivity and the availability of nutrients in the water body (Kaleem et al., 2021). This method is commonly used in open ponds, lakes, or reservoirs where fish are reared with minimal or no additional feed inputs. The fish are left to feed on natural food sources such as algae, plankton, and insects. Extensive fish farming is typically practiced for species with a high tolerance for variable environmental conditions and can adapt to low-nutrient environments. Previously this method was popular among people and practiced widely.

Extensive Fish Farm

Semi-Intensive Fish Farming: Semi-intensive fish farming involves intermediate stocking densities and a combination of natural productivity and supplementary feed. The fish are reared in ponds or tanks where additional feed is provided to supplement their natural diet. This method allows for higher production levels than extensive farming, as the fish receive a more controlled and nutrient-rich diet. Water quality management and aeration systems may also be employed to maintain optimal conditions for fish growth. Now most people use this technology for fish farming and many shrimp farmers have semi-intensive ponds only.

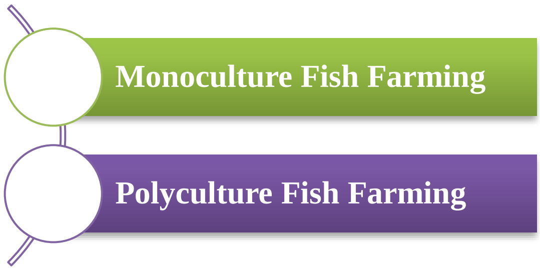
Semi-Intensive Pond

Intensive Fish Farming: Intensive fish farming involves high stocking densities and relies heavily on formulated feeds and controlled environmental conditions. The fish are typically reared in tanks, raceways, or recirculating aquaculture systems (RAS) where water quality, temperature, oxygen levels, and other parameters are closely monitored and regulated. Intensive fish farming allows for maximum production in a limited space but requires significant feed, water treatment, and management inputs. Species commonly raised through intensive fish farming include salmon, trout, tilapia, and catfish.

The choice of fish farming intensity depends on various factors such as the cultivated species, available resources, market demand, and environmental considerations. This type of farming is one of the most expensive and in the Indian subtropic, its use is very minimum. Each type of fish farming has its advantages and challenges, and selecting the appropriate method is crucial for sustainable production and profitability.

RAS (Department of Food Science and Technology, Virginia)

Based on species stocked for farming:

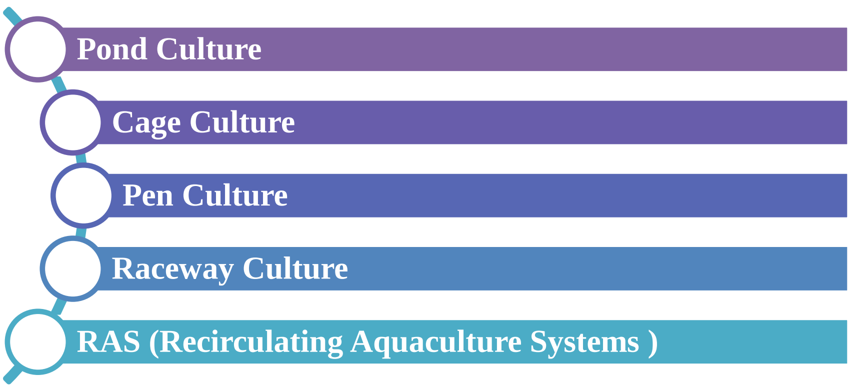


Mono-culture: Mono-culture in fish farming refers to cultivating a single fish species in a specific production unit or system. In monoculture, the focus is on maximizing the production of a particular fish species, often chosen based on its market demand, growth rate, and economic viability. It only focuses on the economic way. The cultivation environment, feeding regime, and management practices are tailored to meet the specific requirements of that particular fish species. Mono-culture allows for more precise control of factors such as water quality, feeding, and disease management, as the entire production unit is dedicated to a single species.

Polyculture: Polyculture in fish farming involves the simultaneous cultivation of multiple fish species in the same production unit or system and simultaneously focuses on economical and sustainable ways (Thomas et al., 2021). In polyculture, different fish species with complementary ecological characteristics are stocked together to create a balanced and sustainable ecosystem. It uses every niche of water, which results in the full use of potential to take advantage of the natural interactions and relationships between different species, where one species may utilize the waste products or byproducts of another, leading to efficient resource utilization and reduced environmental impacts. For example, some fish species may feed on different trophic levels, with one species consuming plankton, another consuming organic matter, and so on. This helps achieve a better overall ecosystem balance and reduces the risk of disease outbreaks. Polyculture is often practiced in ponds, where multiple species like carps, catfish, tilapia, and shrimp are cultivated together.

Both monoculture and polyculture have their own advantages and considerations. Mono-culture allows for specialization and optimization of production for a particular species, while polyculture promotes biodiversity, resource efficiency, and ecosystem resilience. The choice between these two types of fish farming depends on factors such as market demand, species compatibility, available resources, and management capabilities.

Based on* enclosure used for culture*:



Pond Culture: Pond culture is one of the most traditional and widely practiced fish farming methods. It involves raising fish in enclosed earthen or lined ponds. Ponds can be fresh or brackish, providing a controlled environment for fish growth. The water quality, feeding, and management practices can be adjusted to meet the specific requirements of the fish species being cultivated.

Culture Ponds

Cage Culture: Cage culture involves confining fish within floating cages or net enclosures placed in natural or artificial water bodies such as lakes, reservoirs, rivers, or coastal areas. The cages are typically made of nets or mesh, allowing water to flow freely while preventing fish from escaping. This method utilizes existing water resources and provides good water circulation for fish growth. It is commonly used for salmon, tilapia, and catfish.

Pen Culture: Pen culture is similar to cage culture but typically involves larger enclosures made of netting or fencing and in FW areas, it is widely used for nursery rearing. Pens are usually set up in marine or coastal environments. They provide more space for fish movement and allow for rearing larger fish species like tuna or sea bass. Pen culture may require a more robust infrastructure to withstand the challenges of open water conditions.

Raceway Culture: Raceway culture, also known as flow-through systems, utilizes flowing water channels or tanks to rear fish. Water flows continuously through the channels, providing oxygenation and waste removal. This method is often used for salmonid species such as trout and salmon, where cool and well-oxygenated water is crucial for their growth and survival.

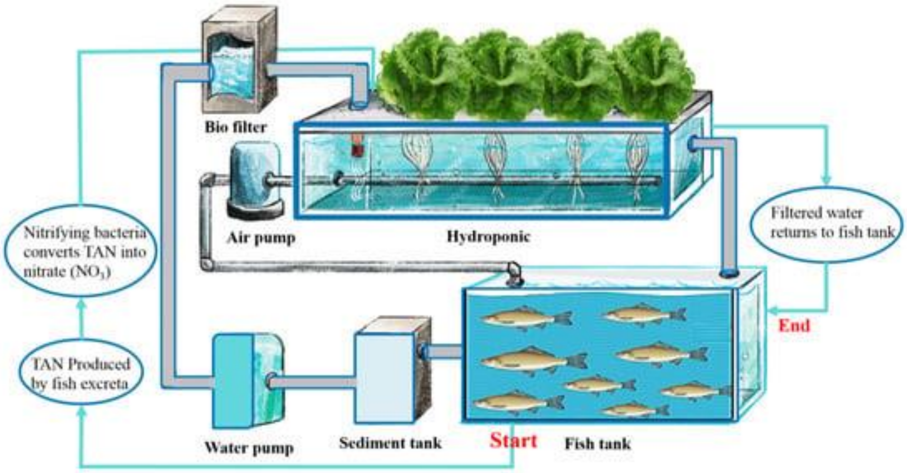
Recirculating Aquaculture Systems (RAS): RAS is a closed-loop system that recirculates and treats water within a controlled environment. It involves tanks or systems where fish are reared, and water is continuously filtered and treated to maintain optimal conditions for fish growth. RAS allows for efficient water and waste management, reduces water usage, and enables year-round fish production. It is commonly used for various fish species, including barramundi and certain types of salmon, Mahaseer, trout and valuable fishes.

Integrated fish farming

Integrated fish farming, also known as integrated aquaculture, is a farming practice that combines fish farming with other complementary agricultural or aquacultural activities. It involves cultivating fish alongside other organisms or crops in a mutually beneficial manner, creating a symbiotic system. The concept of integrated fish farming is based on utilizing the waste products or byproducts of one component to benefit another component. This approach aims to optimize resource utilization, improve overall productivity, and enhance sustainability in aquaculture systems.

Examples of integrated fish farming systems:

Aquaponics: This system combines fish farming with hydroponics, a method of growing plants in a soilless medium. In aquaponics, fish are reared in tanks, and the nutrient-rich wastewater from the fish is used as a fertilizer containing ammonia converted to nitrite and nitrate with the help of a biological filter for the plants. The plants, in turn, filter and purify the water, which is then recirculated back to the fish tanks. It creates a symbiotic relationship between fish and plants, with both benefiting from each other's waste products.



Schematic Representation of Aquaponics (Taha et al., 2022)

Paddy-Fish Farming : Fish are reared in rice paddy fields in this system. The fish provide natural pest control by feeding on insects, larvae, and weeds that could harm the rice crop. The fish also benefit from the shelter and food sources the rice plants provide. Additionally, the fish waste fertilizes the rice crop, reducing the need for synthetic fertilizers.

Integrated Livestock-Fish Farming: This system combines fish farming with livestock farming. The livestock, such as ducks or pigs, are raised on land adjacent to fish ponds (Hasimuna et al., 2023). The livestock waste, along with other organic matter, is directed into the fish ponds, serving as a nutrient source for the fish. The fish, in turn, help maintain water quality by consuming excess nutrients and organic matter, reducing pollution.

Integration with sustainable agriculture practices in Aqua-Agribusiness

Sustainable practices are paramount for the long-term success of aqua-agribusiness ventures in freshwater fish farming. Sustainable practices are essential for the long-term success of aqua-agribusiness ventures in freshwater fish farming. By prioritizing environmental conservation, efficient resource utilization, and meeting market demands, these practices enable ventures to build resilience, enhance reputation, and secure a sustainable future in the industry. Freshwater fish farming can be profitable by integrating sustainable agriculture practices into aqua-agribusiness. It ensures the efficient use of resources, minimizes environmental impacts and addresses consumer demand for sustainably produced seafood. Additionally, embracing sustainability practices can enhance the reputation and marketability of aqua-agribusiness ventures in an increasingly conscious consumer market. Here are some key aspects of integration with sustainable agriculture practices in aqua-agribusiness.

1.Water Management

Efficient water management is essential to minimize water usage and prevent water pollution. Implementing water recirculation systems, such as recirculating aquaculture systems (RAS), helps reduce water consumption by continuously filtering and reusing water. Water-saving technologies like drip irrigation and proper pond design can also optimize water use and minimize wastage.

2. Nutrient Management

Proper nutrient management is vital to prevent eutrophication and maintain water quality. Managing feed inputs, optimizing feed formulations, and monitoring feeding practices can minimize excess nutrient release into the water. Implementing techniques like integrated farming systems, where fish waste can be utilized as crop fertilizers, helps close nutrient loops and reduce reliance on synthetic fertilizers.

3. Sustainable Feed Sourcing

The choice of fish feed has a significant impact on the sustainability of aqua-agribusiness. Using feeds sourced from sustainable and responsibly managed sources, such as alternative proteins (plant-based, insect-based) or byproducts from other industries, reduces reliance on wild fish stocks and minimizes the ecological footprint associated with feed production. It is also important to optimize feed conversion ratios to minimize waste and improve overall efficiency.

4. Biodiversity Conservation

Maintaining sustainability along with economic development is a significant challenge and preserving biodiversity is critical in aqua-agribusiness. Careful selection of fish species, avoiding the use of invasive species, and preventing escapes from fish farms are important measures to protect native aquatic ecosystems. Proper farm design, including secure netting and monitoring protocols, can help minimize the risk of escapes and protect the surrounding environment.

5. Disease Management

Disease prevention and control are crucial to ensure the health and welfare of farmed fish. Implementing biosecurity measures, regular health monitoring, alternative use of probiotics and prebiotics and responsible use of veterinary treatments can minimize the use of antibiotics and chemicals. Good management practices (GMPs), such as maintaining proper water quality, adequate nutrition, and appropriate stocking densities, can also help enhance the natural disease resistance of fish.

Consumer Demand, Environmental Conservation, Organic Certification, Market Opportunities and Government Support are some key points regarding expanding sustainable and organic fish farming in aqua-agribusiness. By embracing sustainable practices, aqua-agribusiness ventures can not only meet market demands but also contribute to environmental conservation and secure long-term profitable.

Opportunity

Aqua-agribusiness in freshwater fish farming offers a range of opportunities for entrepreneurs and investors. Multiple avenues exist from meeting the increasing demand for seafood to embracing sustainability, leveraging technology, exploring value-added products, targeting international markets, providing ancillary services, and fostering collaborations to build successful and profitable ventures in the aquaculture industry.

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HARNESSING THE POWER OF PLANT HORMONES: A GUIDE TO PROMOTING GROWTH AND HARMONY

Pooja Singh*, Kamesh Singh Chauhan, Abhishek Singh Chauhan and Pushpendra

Department of Agronomy, Banda University of Agriculture & Technology Banda
Department of Agronomy, CCS University Meerut Uttar Pradesh
Department of Entomology, Banda University of Agriculture & Technology Banda
Junior Research Assistant, Banda University of Agriculture & Technology, Banda
*Corresponding email: psinghbuat@gmail.com

Abstract

Plant hormones, also known as phyto-hormones, play a crucial role in regulating various aspects of plant growth and development. These molecules control a wide range of physiological processes, including seed germination, root and shoot growth, flowering, fruit ripening, and responses to environmental stimuli. In this article, we provide an overview of the major plant hormones and their functions. Understanding the complex interactions and signaling pathways of these plant hormones is crucial for optimizing crop production, improving plant stress tolerance, and manipulating plant growth and development for various agricultural purposes. Further research in this field will contribute to our knowledge of plant biology and may have practical implications for sustainable agriculture and plant breeding programs.

Keywords: Plant hormones, phytohormones, auxins, gibberellins, cytokinins, abscisic acid, ethylene, brassinosteroids, plant growth, plant development, crop production, stress tolerance, sustainable agriculture.

Introduction

Plants possess a remarkable ability to adapt, grow, and flourish in their environments. Behind their growth and development lies a sophisticated system of signaling molecules known as plant hormones or phytohormones. These natural compounds regulate various physiological processes within plants, influencing everything from seed germination to flowering and fruiting. With a deeper understanding of plant hormones, we can harness their power to promote growth and create harmony in our gardens, farms, and ecosystems.

Understanding Plant Hormones

Plant hormones are chemical messengers produced by plants that regulate and coordinate their growth, development, and responses to environmental stimuli. There are five major types of plant hormones: auxins, cytokinins, gibberellins, abscisic acid, and ethylene. Each hormone plays a specific role in plant growth, and their interactions orchestrate the plant's overall response to its surroundings.

Promoting Growth with Auxins

Auxins are primarily responsible for regulating cell elongation, root development, and apical dominance. To utilize auxins effectively, gardeners can apply synthetic auxin-based products like indole-3-butyric acid (IBA) to stimulate root growth in cuttings or enhance lateral root development. Careful application of auxins can help optimize plant growth and improve overall productivity.

Enhancing Development with Cytokinins

Cytokinins are vital for promoting cell division and influencing plant growth, including the formation of lateral shoots, leaf expansion, and delayed senescence. They are commonly used in tissue culture and micro-propagation techniques to stimulate shoot regeneration. By applying cytokinins, gardeners can enhance plant development, induce lateral branching, and delay leaf aging, resulting in healthier, more vigorous plants.

Stimulating Growth and Seed Germination with Gibberellins

Gibberellins play a crucial role in promoting stem elongation, seed germination, and flowering. Synthetic gibberellins sprays can be utilized to induce uniform and faster germination of seeds, especially for crops that have hard seed coats or require cold stratification. By manipulating gibberellins levels, we can optimize plant growth, overcome dormancy barriers, and achieve consistent germination rates.

Regulating Stress Responses with Abscisic Acid

Abscisic acid (ABA) is known as the "stress hormone" and helps plants respond to adverse environmental conditions such as drought, cold, and salinity. ABA regulates stomatal closure, inhibits shoot growth, and promotes seed dormancy. By understanding ABA's role, we can develop strategies to mitigate stress in plants, including the use of ABA analogs or foliar sprays to conserve water, improve drought tolerance, and enhance overall stress resilience.

Managing Ripening and Fruit Senescence with Ethylene

Ethylene is a gaseous hormone that influences various physiological processes, including fruit ripening, senescence, and abscission. Farmers and gardeners can utilize ethylene inhibitors or releasers to control fruit ripening and extend the shelf life of harvested produce. This knowledge enables us to optimize post-harvest storage and transportation, reducing food waste and ensuring high-quality, fresh products reach consumers.

Conclusion

Plant hormones are remarkable tools that allow us to understand and manipulate plant growth, development, and responses to environmental cues. By harnessing their power, we can create harmony in our gardens, farms, and ecosystems. Understanding the role of each hormone empowers us to optimize growth, improve stress tolerance, and enhance crop productivity. However, it is essential to apply plant hormones responsibly and in accordance with recommended guidelines to avoid unintended consequences. With further research and innovation, we can continue.

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OAT: AN ALTERNATIVE GREEN FODDER CROP IN INDIA

Raj Kumar[1]*, Vivek Kumar[1], Gaurav Mishra[2] and Nandan Kumar[3]

[1]Department of Genetics and Plant Breeding, SVP University of Agriculture and Technology,Meerut.

[2] Department of Vegetable Science,CSA Uni. Of Ag. And Technology, Kanpur.

[3] Department of Vegetable Science, SHUATS, Prayagraj.

Corresponding Email: rajkumarmtg@gmail.com

Abstract

Oat (*Avena sativa* L.) has been gaining attention in India as a green fodder for animals and as a breakfast meal for humans, rather than being considered a weed crop. It has been grown for the past hundred years to fulfil the winter forage scarcity. It has higher yield potential than other fodder crops, and it can be grown easily with barseem, peas, and lucerne as a mix and intercropping. Along with green fodder, it can be used as a cover crop, forage for grazing, hay, straw, and silage. It provides a sufficient amount of protein, fibre, and minerals compared to other cereals as fodder. Due to its high palatable nature, it is easily digested, gaining attention among animals, and providing more qualitative milk to humans compared to other cereal fodder.

Key words: Oat, Fodder, Forage.

Introduction

Oats, like rye come into cultivation later than wheat and barley. The oat cultivated species are descended from the wild forms that were probably found as a weed in cultivated cereals in the Mediterranean region, Asia Minor, North Africa and Transcaucasia. Whole-crop oats are a good source of forage and many farmers use it as hay, silage or pasture for cattle and sheep. Forage oats are bred for leafiness and often grow longer in the vegetative state than typical grain oats. Leaves are wide, and the plant grows taller before heading. There's a higher leaf to stem ratio, which means that more of the plant is made up of leaf biomass of higher nutritional value and containing more digestible fiber than the stem. Oat is a hexaploid 2n=6x=42 consists of chromosomes. Great change have taken place in the areas where fodder oats are important. Oats are now a very important winter fodder on small farms in Pakistan and Northern India. In the Himalayan zone – often in association with dairying- oats have changed from a minor fodder to a major crop in the past twenty years, mainly because of the availability of improve cultivars and ability to produce green feed during the midwinter lean period. Oat is one of the most important cereal fodder crops of rabi season in North , Central and West Zone of the country.

Comparative Importance

Nutritional importance

It provides soft and palatable fodder rich in crude protein (10-12%). Oat is also used as straw, hay or silage . Its grain makes a good feed particularly for horses, sheep and poultry. Oat contains 10-11.5% C.P, 55-63% neutral detergent fibre, 30-32% acid detergent fibre, 22-23.5 % cellulose and 17-20% hemicellulose. When harvested at 50% flowering stage of plants. The comparative nutritional valve of barley and oat has been given in table.1 and 2.

Oat can be used as:

Hay: Oats are occasionally used for haymaking in countries with suitable conditions of enough sun and warmth during the haymaking period. Oats are cut for hay before full grain formation in order to avoid grain loss during manipulation, tedding and baling. Up to that stage, oats have better digestibility and nutritive value than later.

Straw: Oat straw and chaff are softer and finer than the straw of the other white-straw cereals and have a higher nutritive value. It is a favorite by-product for feeding ruminants or for bedding.

Silage: When taken at this stage, oats are high in digestible fiber and have a crude protein level comparable to alfalfa at late bud stage. Their protein content is often higher than corn silage, but energy content is lower.

Cover crop: Although many oats winterkill with heavy frost, (not as common in southern regions) their rapid and abundant fall growth keeps soil covered, suppressing weeds and reducing erosion, which is ideal for leaving the field open for an early spring planting. Planted in either spring or fall, an oats seeding can provide a “catch crop”, uptaking and retaining nutrients after a manure application or during an empty space in the rotation. Even winter killed oats effectively cover soil and hold valuable nutrients in their tissue, which are gradually released as the residue is broken down by microbes.

Grazing: As long as they are sufficiently mature, oats can withstand high grazing pressure and produce abundant forage early in the season. Start grazing when plants are 8-10 inches tall, after roots have had a chance to become well-developed, and take about half the growth. Once the weather become warm enough, plants can grow quite rapidly, and you want to graze early and hard enough to maintain them in the leafy, vegetative state. This also helps them form tiller growth. For quickest recovery, only graze down to the height of the lowest stem node, about 5-6 inches above ground level. Avoid hard grazing, which can remove the growing points and delay regrowth. Adjust animal numbers to keep the crop at the maximum quality level - boot stage or a little lower in maturity. Don't worry if a few plants head out. Avoid grazing in wet conditions, since the crown and root will be more vulnerable to damage, also hampering regrowth. Rotational grazing between two or more paddocks is recommended, since it allows the crop to regrow between grazing and there is less loss to trampling. (Number of paddocks will depend on stocking rate.) Depending on conditions, you may get several grazing. Strip grazing also works well, increasing crop utilization and decreasing selection and trampling losses.

Milk Quality: Harvesting an oat at preboot (full flag leaf emergence) or boot stage (when the grain swells in its sheath) will produce high quality forage, suitable for lactating cows or finishing beef. Oat fodder to dairy animals increase the quality of milk like Compare to barley high milk fatty acid yield due oat fed is obtained for palmitic acid, stearic acid and oleic acid. The fat yield in milk due to oat is higher compare to barley but in case of protein , protein yield is higher in barley compare to the oat.

Production management

Soil: Well drained clay to clay loam soils.

Field preparation: The land should be opened with soil inversion plough followed by 2 to 3 operations by desi plough/ cultivator.

Sowing time: Normally oat sowing should be started in early October to end of November in North-West to East Zone of the country. For regular supply of fodder from December to march, scattered sowing is also advocated. Its optimum growth is attained in sites with 15-25 degree Celsius temperature in winter with moist conditions.

Varieties: JHO-851, JHO-822, JHO-99-1, JHO-99-2, JHO-2001-3, JHO-2004, RU-19, HFO-114, Kent,OS-6, OS-7, Palampur-1, IGFRI-5-54, UPO-94, UPO-212.

Seed rate and sowing method: A seed rate of 75-80 kg /ha is recommended for uniform stand in oats however bold seeded variety like Kent requires 100-125 Kg seed per hectare with 20-25 cm row spacing. Higher seeding rates can yield oats with thinner stems and more digestible fiber.

Manures and fertilizers: The crop may be manured with 15 tonnes of FYM 10-15 days before sowing. In addition to this application of 80 Kg N, 40KgP /ha to single cut and a dose of 120 kgN, 40 kg K/ha to multicult varieties attains good crop growth. In double and multicutvarities, top-dressing of 40 kg N/ha after first cut and two equal split doses of 40kg N/ha after first cut should be done respectively.

Irrigation: Oats require 3-5 irrigations including the pre-sowing irrigation depending on soil type. If soil is dry, first irrigation is given before preparing the seedbed. Next irrigation may be given at 20-25 days of sowing.

Weed control: Effective control of grassy and broad-leaved weeds in oats can be obtained with weeder cum mulcher at 4 week crop stage followed by application of 2,4-D@0.37 kg a.i./ha at 6 weeks crop stage. Application of Metasulfuron methyl@8gm/ha+one hand weeding found best among chemical weed control.

Pest and Disease: Root rot and leaf blotch are major disease in oat. Root rot characterized by yellow and stunted growth of young shoot, in severity embryo of the young seedling may be killed. In leaf blotch long brick red blotches appear on young plants in third and fourth leaf stage treatment with Thiram@3gm/kg of seed reduce the infestation of these disease. In addition of disease aphid also cause damage to crop by sucking cell sap resulting mottling and distortion of leaf may occur. Application of Dimethoate 30 EC@ 0.03% prevent aphid attack care should be taken that do feed the fodder to animal at least 10 days after spray.

Harvesting: The harvesting of single cut oat varieties is done at 50% flowering. In double cut varieties, first cut should be taken at 60 days followed by second cut at 50% flowering stage. Howeve , in multicut varieties, first cut is recommended at 60 days, second at 45 days after first cut and third cut at 50 % flowering . For seed production, the crop should be left for seed after the first cutting, which would be taken 50-55 days after sowing. For good re-growth, first cut should be taken 8-10 cm above the soil surface.

Yield: The average green fodder yield from single, double and multicut varieties of oat ranges from 30-45, 40-55, and 40-60 tonnes/ha respectively. If crop is left for seed, 25 tonnes/ha green fodder from first cut and 2- 2.5 tonnes/ha seed and 2.5-3 tonnes/ha straw is obtained.

Conclusion

Oats as grains and whole crops have a lower nutritive value than maize and some cereals, and cannot meet the energy requirements of high-yielding animals. This is the main cause of the decrease in oat areas on a global scale. However, the high content of watersoluble carbohydrate in the whole plant means oats make good silage and can thus supplement the forage needs of the farm. Oats can be grown on abandoned land to get additional benefits with a minimum tillage operation. It can be grown with mix and intercropping to increase the production of fodder in the winter season. Intercropping with legumes and cereals ensures the nutritional security of dairy animals and also increases the quality of the milk.

Table No.1.Chemical composition of Cereal Silages.

Item (% DM basis) stage of maturity	Barley (soft dough)	Oat (milk stage)
Dry Matter	35.6	38.5
Neutral Detergent Fiber	55.0	53.5
Acid Detergent Fiber	35.5	34.2
Hemicellulose	18.9	19.3
Cellulose	25.2	27.1
Lignin	2.5	4.2
Crude protein	11.0	11.5
Acid detergent insoluble crude protein	3.9	4.5
Ash	17.3	14.9
pH	4.32	4.46

Table No.2.Nutrient composition of barley and oat forages.

Nutrient	Barley	Oat
Dry Matter	34.5	34.5
Organic Matter (%DM)	91.5	91.4
Neutral Detergent Fiber	50.9	51.1
Acid Detergent Fiber	27.8	28.6
Non-saturated Carbohydrates	21.9	24.2
Starch	23.7	25.7
Ash	8.6	8.5
Crude protein	14.6	12.1
Soluble crude protein	87.8	86.9
Non protein nitrogen	79.5	75.6
Neutral detergent insoluble crude protein	8.5	8.4
Acid detergent insoluble crude protein	3.5	2.7
Acid detergent lignin	8.1	7.1
Total digestible nutrients	69.6	67.6
Net energy for lactation	1.58	1.54

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THE ROLE OF FORENSIC ZOOLOGY IN CRIME SCENE INVESTIGATIONS

Shailja Singh

Assistant Professor, Department of Forensic Science,
ITM University Gwalior, M.P.
Corresponding mail- shailjasingh235@gmail.com

Introduction

Forensic science is a crucial component of modern criminal investigations, and while disciplines such as forensic pathology and entomology are well-known, forensic zoology is an emerging field that holds great potential. By studying the interaction between animals and crime scenes, forensic zoologists provide invaluable insights into cases involving animal-related evidence. This article explores the multifaceted world of forensic zoology, its applications in solving crimes, and its contributions to the justice system.

Animal-Based Evidence at Crime Scenes

Animals can leave a wide range of evidence at crime scenes, including fur, feathers, bite marks, tracks, and biological fluids. These clues can be instrumental in establishing the sequence of events, identifying suspects, and providing crucial timelines for criminal investigations. Forensic zoologists specialize in identifying and analyzing these animal-related traces, contributing to the overall understanding of the crime.

Forensic zoologists utilize a variety of techniques to examine animal evidence

Microscopic analysis of fur or feathers can reveal crucial details about the species involved, providing important information about the location or timing of a crime. DNA analysis can help identify the source of biological samples, aiding in the identification of victims or potential suspects. Bite mark analysis, a branch of forensic odontology, can provide critical evidence in cases involving animal attacks or animal-human interactions.

Wildlife Forensics

In addition to its role in traditional crime scene investigations, forensic zoology plays a significant role in combating wildlife crime. Wildlife crimes, such as poaching, illegal animal trafficking, and animal cruelty, pose serious threats to biodiversity and the environment. Forensic zoologists employ their expertise to investigate and combat these crimes, playing a vital role in wildlife conservation and law enforcement.

Through the analysis of animal remains, such as ivory, horns, or skins, forensic zoologists can identify the species involved, determine their origin, and track illegal wildlife trade routes. By collaborating with law enforcement agencies and conservation organizations, they provide essential evidence in prosecuting wildlife offenders, disrupting illegal networks, and protecting endangered species.

Case Studies and Success Stories

Numerous real-life cases highlight the significance of forensic zoology in crime scene investigations. In a murder investigation, the presence of animal hair on the victim's clothing led forensic zoologists to identify a specific breed of dog present at the crime scene, which ultimately helped in identifying the perpetrator. Similarly, the analysis of bird feathers found at the scene of a hit-and-run accident played a critical role in identifying the species involved and subsequently identifying the responsible driver.

The contributions of forensic zoology extend beyond domestic crimes. In cases of wildlife trafficking, forensic zoologists have been instrumental in uncovering smuggling operations, identifying protected species, and aiding in the prosecution of offenders. By combining their scientific expertise with collaboration across disciplines, these professionals contribute to the preservation of global biodiversity.

Conclusion

Forensic zoology plays a pivotal role in crime scene investigations by analyzing animal-related evidence and providing valuable insights into criminal cases. From domestic crimes to wildlife offenses, forensic zoologists employ their expertise to uncover vital information, aid in suspect identification, establish timelines, and contribute to the conservation of endangered species. As the field continues to evolve and gain recognition, the role of forensic zoology in the justice system will undoubtedly expand, further enhancing our understanding of the intricate relationship between animals and crime scenes.

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SCENARIO OF VEGETABLE TRANSPLANTING TOWARD MODERNIZED AGRICULTURE

Mohit Kumar*, Vikas Pagare and Maharani Din

ICAR- Central Institute of Agricultural Engineering Bhopal-462038
*Corresponding Email: mohit130794@gmail.com

Vegetable is the most prominent crop in aspect of profitable business among all crop cultivation. This is the major source of income of farmer due to its high yielding. Thus, India is the second largest producer of vegetable, where it is using 2.8 % area of vegetable farming. The vegetable demand has been increasing day by day with increasing the population. Accordingly, corresponding to the global demand, the area under vegetable production was 10.83 million ha in 2021 where it produced about 200.45 million metric tonnes vegetables. Different vegetable crops are cultivated corresponding to the different climatic zone, soil type and conditions. Potato, tomato, cauliflower, cabbage, onion, brinjal etc. are commonly cultivated vegetables in India. Nevertheless, the level of mechanization of the vegetable crop in India is observed to be less than 5-10 per cent. With increasing the urbanization and industrialization, labour scarcity is the major issue to fulfill the cultivation process with timeliness. So, now mechanization of the farming system is giving the proper solution of all hurdles. Transplanting is an crucial operation in crop cultivation practice as the productivity of the transplanted crop is completely dependent on method of transplanting. Generally, the transplanting is done manually. This operation requires precision, careful handling, and significant labor input. This article provides complete insight of various vegetable transplanters.

Vegetable transplanting practices

Transplanting of vegetable crops is an important method which may ultimately affected the total yield, if the process is not done with time being. Most of the part of India, transplanting of seedlings is done manually. However, mechanized way of transplanting is also growing and enhancing the performance of transplantation. Mainly 3 type of vegetable seedlings namely bare root, plug type and pot type seedlings are mainly used for transplanting process. The labour requirement for manual transplanting of vegetables varies between 240 to 320 man-h/ha. But, in case of close space crop (such as on onion), labour requirement is increased upto 400 man-h/ha. Labour requirement during peak season may ultimately create the ample effect on the potential yield of the crops. Thus, the mechanization in transplanting operation can reduce the labour requirement, and increase the capacity of transplantation on the field.

Different type of seedlings for transplanting

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Transplanter for vegetable transplanting

Transplanter are mainly classified based on the operation method adopted for transplanting. This is mainly sub-devided as Hand held transplanter, semi-automatic transplanter, automatic transplanter and robotic transplanter.

Hand held

Hand held tranplanter are mainly used for transplanting in raised beds. It is made up of a dropping structutre, mainframe, furrow opener, handle and seedling plate. The hole punching mechanism at the transplanter's lower end consisted of a pair of jaws capable of penetrating the plastic mulch film and creating a tapered hole for seedling placement. Seedling transplanting rate varied form 720-900 seedlings/h.

Semi-automatic:

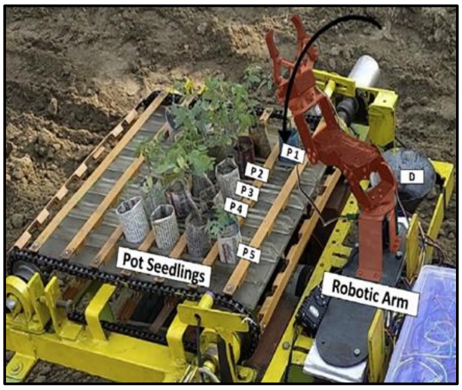
Semi-automatic transplanters involve partial human involvement, specifically for the mechanical singulation and transferring of seedlings from trays to the metering unit.Different type of metering system are developed such as pocket type, conveyor type, rotating cup type metering system are used in the semi-automatic transplanter. Thesemi-automatic vegetable transplanter is difficult to usebecause the manual feeding of seedlings into the hopper isdependent on the operation interval and operatorexpertise. In these type of transplanters, seedling are manually fed at atime, the semi-automated transplanter is not suitable forcontinuous operation for an extended period of time and couldn't maintain higher speed. Operatig speed of semiautomatic transplantersvaried from 0.6 to 1.4 km/h.

Automatic

Various 2 rowsautomatic vegetable transplanter has been developed. Automatic vegetable transplanters involvethe process of seedling picking from the tray andplanting it into the soil and reducing the labor requirementfor feeding the seedlings.Automatic transplanting devices are a synchronizedcombination of automatic seedling pickup and plantingmechanisms. In order to improve the low transplanting efficienciesand simplify the complex structures of current automatictransplanters, a mechanical high-speed transplanter forpicking plug seedlings that is suitable for planting on plasticfilms was also develiped by reaserchers. The automatic vegetable transplanter can feed arow of the seedlings to the conveyor mechanism where it isfurther fed into the hopper of the planting devicemechanically. 4, 6 and 8 rows automatictransplanter are available commercially.Presently, the use of automatic transplanting machines isnot popular, mainly due to the complicated mechanicalstructures and high production costs and it is difficult tocombine agricultural machinery and agronomicseffectively.Plug and pot type seedlings are most widely used for automatic transplanting system, their overall forward speed varied from 0.8-2 km/h with the planting rate of 30-108 seedling/min per row and also their field capacity varied between 0.08-0.2 ha/h.

Robotic

The robotic transplanting is different from automatic transplanting based on its vision system. Various robotic vegetable transplanters are developed suitable for either plug seedlings or pot seedlings due to ease in discrimination of individual seedlings by metering mechanism. A robotic transplanter consists of manipulator, image recognition device, tray conveyor, and a end-effector to transplant seedling into the pot. The most important thing in developing transplanting robot is to decide the optimal method and time through the careful analysis of target vegetable's growing pattern. If the transplanting method is not good, it could yield serious damage to the leaves or roots. Robotic vegetable transplantersare at very initial stage in India and has structural complexity in its metering mechanism. They are sensitive to the seedling type and uniformity, required skilled labour to operate. Thus, there is vast scope of robotic transplanting system which caneasily operated, increase transplanting rate and reduce labour cost.



Future vision of vegetable cultivation

Future vision encompasses complete automation, AI-powered decision-making, sensor technology, integration with other robotic systems, smart data analytics, sustainability, and adaptability. The agricultural industry can achieve significant advancements in transplanting efficiency, productivity, and environmental stewardship, paving the way for a more sustainable and technologically advanced future of vegetable farming.

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INTEGRATED PEST MANAGEMENT FOR VEGETABLE CROPS: SUSTAINABLE SOLUTIONS FOR HEALTHY HARVESTS

Kamesh Singh Chauhan, Pooja Singh,
Abhishek Singh Chauhan* and Saurabh Kumar

Department of Agronomy, CCS University Meerut Uttar Pradesh
Department of Agronomy, Banda University of Agriculture & Technology Banda
Department of Entomology, Banda University of Agriculture & Technology Banda
Senior Research Fellow, ACRIP Mauranipur Jhansi
*Corresponding email: achauhanbuat@gmail.com

Abstract

Integrated Pest Management (IPM) is an ecologically-based pest management strategy that promotes the sustainable control of pests in agricultural systems. This article focuses on the application of IPM principles specifically in vegetable crop production. Vegetable crops are highly susceptible to a wide range of pests, including insects, diseases, and weeds, which can significantly reduce yield and quality if left, unmanaged.

The objective of IPM for vegetable crops is to minimize the use of synthetic pesticides while effectively managing pest populations through a combination of preventive measures, biological controls, cultural practices, and judicious pesticide application. This approach aims to protect crop health, increase productivity, reduce environmental impact, and promote economic viability for farmers.

Introduction

In the world of agriculture, vegetable crops play a vital role in providing essential nutrients and sustenance for millions of people. However, the success of vegetable cultivation is often challenged by the presence of pests, which can cause significant damage and lead to reduced yields and economic losses. Traditional methods of pest control, such as the indiscriminate use of chemical pesticides, have proven to be unsustainable and detrimental to both human health and the environment. In response, farmers and researchers have embraced a holistic approach known as Integrated Pest Management (IPM), which offers a sustainable and effective solution to address pest problems in vegetable crops. This article explores the principles and benefits of IPM and highlights its application in vegetable crop production.

Understanding Integrated Pest Management (IPM)

Integrated Pest Management is a comprehensive and environmentally-friendly approach to pest control that seeks to minimize the use of synthetic chemicals and maximize the use of natural and biological control methods. It involves the integration of multiple pest management techniques, including preventive measures, biological control, cultural practices, and the judicious use of pesticides, to maintain pest populations at an economically tolerable level while minimizing risks to human health and the environment.

Key Components of IPM for Vegetable Crops

Identification and Monitoring: The first step in IPM is identifying the specific pests and diseases affecting the vegetable crop. Regular monitoring of the crop's health, including visual inspections and the use of traps and pheromone lures helps detect pest population's early, enabling timely intervention.

Prevention and Cultural Practices: IPM emphasizes preventive measures to reduce pest infestations. Crop rotation, planting resistant varieties, and optimizing planting density and spacing can help create an unfavorable environment for pests. Proper irrigation, nutrient management, and sanitation practices also play a crucial role in maintaining plant health and reducing pest susceptibility.

Biological Control: Encouraging the presence of beneficial organisms that naturally control pests is a cornerstone of IPM. This can be achieved by introducing predator insects, parasitoids, or beneficial nematodes into the crop environment. Additionally, providing shelter and food sources for these beneficial organisms promote their establishment and effectiveness in pest control.

Mechanical and Physical Controls: Physical barriers such as nets, screens, or row covers can effectively exclude pests from the crop area. Mechanical methods like handpicking, trapping, and using vacuum devices can be employed to physically remove pests. These techniques are particularly useful for larger pests such as caterpillars or beetles.

Judicious Use of Pesticides: While chemical pesticides are used as a last resort in IPM, their application is carefully considered. Pesticides with low toxicity to non-target organisms are preferred, and their use is timed to coincide with peak pest activity. Proper application techniques, including dosage and targeted spraying, minimize their impact on beneficial organisms and the environment.

Benefits of IPM for Vegetable Crop Production

Reduced Environmental Impact: By minimizing the use of chemical pesticides, IPM helps preserve biodiversity, protect natural habitats, and safeguard water and soil quality. It promotes a more balanced ecosystem and reduces the risk of pesticide residues in crops and the environment.

Cost-effective Approach: IPM encourages farmers to adopt a proactive approach to pest management, resulting in reduced reliance on expensive chemical inputs. By integrating different control methods, farmers can optimize pest control measures and allocate resources more efficiently.

Improved Crop Quality and Safety: IPM focuses on maintaining plant health and preventing pest damage, leading to higher-quality vegetable crops. By reducing pesticide use, IPM also enhances food safety by minimizing pesticide residues, thereby ensuring consumer confidence.

Long-term Sustainability: By promoting the use of biological control methods and cultural practices, IPM contributes to the long-term sustainability of vegetable crop.

Conclusion

Integrated Pest Management (IPM) offers a holistic and sustainable approach to managing pests in vegetable crop production. By integrating multiple pest control tactics and minimizing reliance on chemical pesticides, IPM promotes environmental stewardship, reduces pesticide residues in food, and ensures long-term viability of vegetable crop systems. Continued research, outreach, and adoption of IPM practices are crucial for a resilient and sustainable agricultural future.

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NULL HYPOTHESIS: A MAGICAL TOOL IN AGRICULTURE TO FORMULATE EXPERIMENT

Yogesh Garde*, Nitin Varshney and Alok Shrivastava

Department of Agricultural Statistics,
Navsari Agricultural University, Navsari, Gujarat– 396450
*Corresponding Email: y.garde@nau.in

“The null hypothesis is never proved or established but is possibly disproved, in the course of experimentation. Every experiment may be said to exist only to give the facts a chance of disproving the null hypothesis." ***R. A. Fisher***

In agricultural research, the null hypothesis (H_0) is a statement that suggests there is no significant difference or relationship between the variables being investigated. It is often used in experimental design to test whether an intervention or treatment has a measurable effect on a specific agricultural outcome.For example, in an agricultural experiment that aims to test the effectiveness of a new fertilizer on crop yield, the null hypothesis would state that there is no significant difference in crop yield between the group treated with the new fertilizer and the control group that did not receive any treatment. This implies that any observed differences in crop yield between the two groups are due to random chance, rather than the effect of the fertilizer.

The null hypothesis is typically used in conjunction with an alternative hypothesis (H_1), which suggests that there is a significant difference or relationship between the variables being investigated. In the above example, the alternative hypothesis would state that there is a significant difference in crop yield between the two groups, and any observed differences are not due to chance.

Statistical analysis is often employed to test the null hypothesis using data collected from the experiment. If the statistical analysis provides sufficient evidence to reject the null hypothesis, it suggests that the intervention or treatment has a significant effect on the outcome being measured. On the other hand, if the statistical analysis fails to provide sufficient evidence to reject the null hypothesis, it suggests that the intervention or treatment does not have a significant effect on the outcome being measured, and any observed differences are likely due to random chance.

In agricultural research, you may formulate a null hypothesis as follows:

Example 1: Effect of a new pesticide on pest control

Null Hypothesis (H_0): There is no significant difference in pest control efficacy between the group treated with the new pesticide and the control group treated with the standard pesticide.

Alternate Hypothesis (H_1): There is a significant difference in pest control efficacy between the group treated with the new pesticide and the control group treated with the standard pesticide.

Example 2: Impact of different irrigation methods on crop yield

Null Hypothesis (H_0): There is no significant difference in crop yield between the group irrigated with drip irrigation and the group irrigated with sprinkler irrigation.

Alternative Hypothesis (H_1): There is a significant difference in crop yield between the group irrigated with drip irrigation and the group irrigated with sprinkler irrigation

Example 3: Comparison of two different crop varieties for disease resistance

Null Hypothesis (H_0): There is no significant difference in disease resistance between Crop Variety A and Crop Variety B.

Alternative Hypothesis (H_1): There is a significant difference in disease resistance between Crop Variety A and Crop Variety B.

Example 4: Impact of different fertilizer treatments on plant height

Null Hypothesis (H_0): There is no significant difference in plant height between the group treated with Fertilizer Treatment A and the group treated with Fertilizer Treatment B.

Alternative Hypothesis (H_1): There is a significant difference in plant height between the group treated with Fertilizer Treatment A and the group treated with Fertilizer Treatment B.

Example 5: Evaluation of the effect of a new biopesticide on the pest population

Null Hypothesis (H_0): There is no significant difference in pest population between the group treated with the new biopesticide and the control group treated with water.

Alternative Hypothesis (H_1): There is a significant difference in pest population between the group treated with the new biopesticide and the control group treated with water.

Applications of null hypothesis in agricultural experiments

Null hypothesis is used to make objective conclusions about the results of an experiment by testing whether any observed differences or relationships between variables are statistically significant, or if they could have occurred by chance. Here are some common applications of the null hypothesis in agricultural experiments:

1. ***Comparing treatment effects:*** Agricultural experiments often involve comparing the effects of different treatments or interventions on crop yield, plant growth, or other agricultural parameters. The null hypothesis in this case would state that there is no difference between the treatments, and any observed differences are due to random variation or chance.
2. ***Testing for no effect:*** In some agricultural experiments, researchers may want to test whether a specific intervention or factor has no effect on the outcome of interest. For example, in a pesticide trial, the null hypothesis would state that the pesticide has no effect on pest control, and any observed differences in pest populations are due to random chance.

3. ***Assessing genetic traits:*** Agricultural experiments may also involve evaluating the inheritance or expression of specific genetic traits in plants or animals. The null hypothesis in this case would state that there is no genetic difference or association between the traits being studied, and any observed differences are due to chance.
4. ***Comparing means or proportions:*** Agricultural experiments may involve comparing means or proportions of different groups or treatments. The null hypothesis would state that there is no significant difference in the means or proportions being compared, and any observed differences are due to random chance.
5. ***Testing for independence:*** Agricultural experiments that involve evaluating the relationship between different variables, such as soil pH and plant growth, may require testing for independence. The null hypothesis in this case would state that there is no association or relationship between the variables being studied, and any observed associations are due to chance.
6. ***Assessing treatment interactions:***Agricultural experiments that involve multiple treatments or interventions may require testing for treatment interactions. The null hypothesis would state that there are no interactions between the treatments, and any observed interactions are due to random chance.

In agricultural research, a statistical test based on the Null hypothesis is used

In agricultural research, various statistical tests can be used to test the null hypothesis. The choice of statistical test depends on the research question, the type of data being analyzed, and the specific objectives of the study. Here are a few commonly used statistical tests based on the null hypothesis in agricultural research:

t-test:	The t-test is used to compare the means of two groups and is commonly used when analyzing data with a continuous outcome variable (e.g., yield, plant height) and a binary categorical variable (e.g., treatment group, crop variety). H_0: there is no significant difference between the means of the two groups being compared.
Analysis of Variance (ANOVA):	ANOVA is used to compare the means of more than two groups. It is commonly used in agricultural research when comparing means of three or more groups or treatments (e.g., the effect of different fertilizers, irrigation levels). H_0: there is no significant difference among the means of the groups being compared.

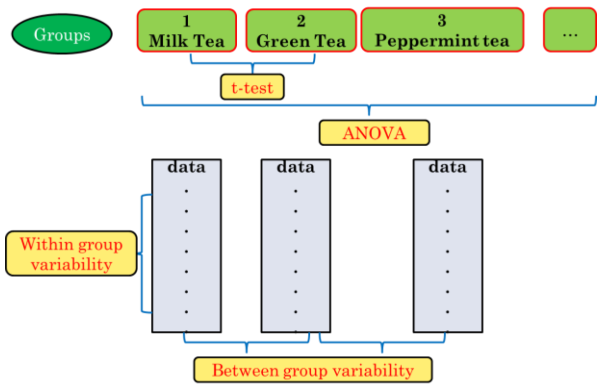

Fig 1: Comparison between t-test & ANOVA

Chi-square test:	The chi-square test is used to analyze categorical data, such as frequencies or proportions. It is commonly used in agricultural research to assess the association between categorical variables, such as disease occurrence in different crops or the presence of pests in different fields. H_0: there is no significant association between the variables being compared.
Regression analysis:	Regression analysis is used to explore the relationship between two or more variables and can be used in agricultural research to model the effect of various factors on an outcome variable of interest (e.g., crop yield, plant growth). H_0: there is no significant relationship between the predictor variables and the outcome variable.
Correlation analysis:	Correlation analysis is used to assess the strength and direction of linear association between two continuous variables. It is commonly used in agricultural research to examine the relationship between variables such as temperature and crop growth or soil pH and nutrient availability. H_0: there is no significant correlation between the variables being compared.

It is important to follow some precautions to choose the appropriate statistical test based on the research question, study design, and type of data being analyzed to ensure valid and reliable results.

Precautions while formulating a null hypothesis

When formulating the null hypothesis in an agricultural experiment, it is important to carefully choose the appropriate statistical test to ensure the accuracy and reliability of the experimental results. With these precautions, you can ensure that your null hypothesis is properly formulated in your agricultural experiment, which is crucial for drawing valid conclusions from your experimental results. Here are some precautions to be considered:

1. ***Be specific:*** The null hypothesis should be clear, specific, and well-defined. It should state the absence of an effect or relationship between the variables being studied. Avoid vague or ambiguous statements that can be interpreted in different ways.
2. ***Use proper terminology:*** The null hypothesis should be written in scientific language, using appropriate terminology related to agriculture and the specific variables being investigated. This ensures that the null hypothesis is aligned with the scientific rigor and standards of the agricultural field.
3. ***Make it testable:*** The null hypothesis should be formulated in a way that it can be tested using statistical analysis. It should be written in a way that allows for data collection and statistical analysis to determine if the null hypothesis can be rejected or not.
4. ***Be conservative:*** The null hypothesis should assume the absence of an effect or relationship between variables. It is generally conservative in nature, assuming that there is no significant difference or relationship unless proven otherwise through rigorous statistical analysis.
5. ***Consider directionality:*** Depending on the research question and experimental design, the null hypothesis may or may not include a directionality. For example, if you are

investigating the effect of a particular fertilizer on crop yield, the null hypothesis may state that there is no significant difference in crop yield between the fertilized and non-fertilized groups. However, if you have a specific directionality in mind, such as expecting the fertilizer to increase crop yield, you may include that in the null hypothesis as well.

6. ***Consider sample size:*** The sample size of your experiment can impact the formulation of the null hypothesis. If you have a small sample size, you may need to be more conservative and cautious in formulating the null hypothesis, as small sample sizes may have limited statistical power to detect small effects.
7. ***Consider experimental design:*** The experimental design of your agricultural experiment can also impact the formulation of the null hypothesis. The null hypothesis should align with the specific design and objectives of your experiment, whether it's a randomized controlled trial, a factorial design, or another type of experimental design.
8. ***Consult with experts:*** If you are unsure about how to properly formulate the null hypothesis in your agricultural experiment, it's always a good idea to consult with experts in the field, such as agricultural researchers, statisticians, or professors with expertise in agricultural research design.

Software for testing Null hypothesis in agricultural experiment

There are several software options available for conducting hypothesis testing in agricultural experiments, specifically for testing the null hypothesis. Some commonly used software programs for agricultural research and data analysis are included below:

R:	R is a popular open-source statistical programming language and environment that provides a wide range of statistical tests for hypothesis testing, including t-tests, ANOVA, regression, and non-parametric tests. It offers extensive libraries and packages for agricultural data analysis. **# Independent 2-group t-test** t.test(y~x) # where y is numeric, and x is a binary factor **# Independent 2-group t-test** t.test(y_1,y_2) # where y_1 and y_2 are numeric **# paired t-test** t.test(y_1, y_2,paired=TRUE) # where y_1&$y_2$are numeric **# one sample t-test** t.test(y,mu=3) # Ho: mu=3
SAS:	SAS (Statistical Analysis System) is a widely used statistical software suite that offers a comprehensive range of statistical procedures for hypothesis testing, including mixed models, ANOVA, regression, and generalized linear models. Various Proc are available in SAS *i.e. Proc ttest, Proc GLM etc.*
SPSS:	SPSS (Statistical Package for the Social Sciences) is a widely used statistical software package that offers a range of statistical tests for hypothesis testing, including t-tests, ANOVA, regression, and non-parametric tests. SPSS is known for its user-friendly interface and is often used in agricultural research for data analysis and hypothesis testing. To run an Independent Samples t-test in SPSS: click Analyze > Compare Means > Independent-Samples ttest,

	To run one way ANOVA: Click Analyze > Compare Means > One-Way ANOVA
Minitab:	Minitab is a statistical software package that offers a range of statistical tools for hypothesis testing, including t-tests, ANOVA, regression, and control chart analysis. Minitab is known for its ease of use and is often used in agricultural research for data analysis and hypothesis testing.
JMP:	JMP is a statistical software package developed by SAS that offers a range of statistical tools for hypothesis testing, including t-tests, ANOVA, regression, and design of experiments (DOE). JMP is known for its interactive data visualization capabilities and is often used in agricultural research for exploratory data analysis and hypothesis testing.

These are just a few examples of the many software options available for conducting hypothesis testing in agricultural experiments. The choice of software will depend on the specific requirements of your experiment, your familiarity with the software, and the data analysis techniques you plan to use.

Conclusion

Overall, the null hypothesis is a magical tool in agricultural experiments as it helps researchers make objective conclusions about the effects of different interventions, factors, or treatments on agricultural outcomes, while accounting for the variability and uncertainty inherent in experimental data. It's important to carefully consider the specific variables, treatments, and outcomes of your study when formulating your null and alternative hypotheses. Additionally, it's crucial to use appropriate statistical tests to analyze your data and draw conclusions about whether to reject or fail to reject the null hypothesis based on the evidence obtained from your research to ensure accuracy and reliability of the experimental results. Furthermore, it’s important to choose a software program that best fits your needs and allows you to accurately analyze and interpret your agricultural research data.

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ASSESSING THE IMPACT OF MULCHING ON WATER CONSERVATION IN DROUGHT-AFFECTED AREAS USING REMOTE SENSING AND GIS

D. D. Vadalia, S. H. Parmar*, G. V. Prajapati and P. A. Pandya

Centre of Excellence on Soil and Water Management,
Office of Research Scientist (Agril. Engg.), Junagadh Agriculture University, Junagadh, India
*Corresponding Email: sanjayparmar5151@gmail.com

Water scarcity in drought-affected areas necessitates effective water conservation strategies. Mulching, the application of a protective layer on the soil surface, has gained recognition for its potential to mitigate water loss through evaporation and improve soil moisture retention. This research article presents a comprehensive assessment of the impact of mulching on water conservation using remote sensing and Geographic Information Systems (GIS). By integrating these technologies, the study evaluates spatial and temporal variations in water availability and vegetation health. The findings highlight the effectiveness of mulching in reducing evapotranspiration, enhancing soil moisture content, and promoting vegetation growth.

Introduction

Droughts are severe natural phenomena that have detrimental effects on agricultural productivity and the overall sustainability of the environment. During these periods of water scarcity, it becomes imperative to adopt innovative and effective water conservation measures. Water is a main constraint in arid and semi- arid regions for intensive irrigation (Pandya and Rank, 2014).Mulching has emerged as a promising technique for mitigating water loss and enhancing soil moisture retention, making it a valuable tool in drought-affected regions. Drought is a major environmental challenge that affects water availability and agricultural productivity, particularly in arid and semi-arid regions (Thiam *et al.* 2021). Water conservation practices, such as mulching, have been widely promoted to mitigate the impact of drought on crops and the environment. Mulching involves covering the soil surface with organic or inorganic materials to reduce evaporation, control soil temperature, suppress weed growth, and enhance soil moisture retention (Karuku 2018). Remote sensing and Geographic Information Systems (GIS) have emerged as powerful tools for monitoring land cover changes and assessing the impact of water conservation practices on vegetation growth and water use efficiency (Chowdary *et al.* 2009). This study aims to assess the effectiveness of mulching in conserving water resources in drought-affected areas using remote sensing and GIS techniques.

Mulching involves the application of a protective layer, typically organic or inorganic material, on the soil surface. This layer acts as a barrier, reducing the direct exposure of the soil to external factors such as sunlight and wind. As a result, mulching plays a crucial role in reducing evaporation, which is a significant pathway for water loss from the soil. By minimizing evaporation, mulching helps to conserve water resources and maintain soil moisture levels, even in arid and drought-prone environments. Prajapati and Subbaiah, (2018) revealed the use of silver black plastic mulch with drip irrigation scheduled at 0.8ETc resulted in superior performance in terms of morphological variables, yield attributes, and water use efficiency compared to wheat straw mulch, drip irrigation without mulch, and furrow irrigation. The integration of remote sensing and Geographic Information Systems (GIS) technologies provides a powerful means to assess the impact of mulching on water conservation in drought-affected areas. Remote sensing involves the acquisition of data from satellites and other aerial platforms, allowing for the monitoring of various environmental parameters, including land surface temperature, vegetation indices, and soil moisture content. GIS, on the other hand, enables the spatial analysis, integration, and visualization of these data, providing a comprehensive understanding of the spatial and temporal dynamics of water availability and vegetation response.

By utilizing remote sensing data, researchers can track changes in land surface temperature, which is a key indicator of water availability and heat stress on plants. Lower land surface temperatures in mulched areas compared to non-mulched areas indicate the effectiveness of mulching in reducing heat stress and conserving water. Parmar *et. al* (2019) demonstrated the potential of using MODIS satellite imagery, specifically the LST_Night_1km band, along with regression equations to simulate maximum and minimum temperatures at the CAET, Godhra, and Kakanpur gauge stations in Gujarat. The results showed promising agreement between the MODIS imagery and ground-measured temperatures, indicating the applicability of remote sensing for temperature estimation in the region. Additionally, remote sensing can provide insights into vegetation indices, which measure the health and vigor of plants. Higher vegetation indices in mulched regions suggest improved plant growth and productivity, indicating the positive impact of mulching on vegetation response during drought conditions. Pandya *et al.* (2022) developed the composite drought index using a linear combination with PCA based weights of three parameters including meteorological drought index, vegetation drought index and inverse of maximum consecutive dry days. Furthermore, remote sensing can assist in monitoring soil moisture content, a critical parameter for assessing water availability in agricultural systems. By analyzing the spectral characteristics of the soil surface, remote sensing data can provide valuable information on soil moisture levels, indicating the efficacy of mulching in enhancing soil moisture retention. This information, when integrated with GIS, allows for a spatial analysis of the distribution and effectiveness of mulching practices across a given area, highlighting areas of potential improvement and targeting interventions.

Mulching as a Sustainable Solution for Water Conservation

Mulching has emerged as a sustainable solution for water conservation in drought-affected areas (Golla, 2021). It involves covering the soil with organic or inorganic materials to reduce water evaporation and improve soil health (Prosdocimi *et al*. 2016). Prajapati and Subbaiah, (2019) emphasized the overestimation of seasonal crop evapotranspiration when using adjusted FAO Kc values, highlighting the importance of verification before their blind application. The development of Kc curves for Bt. cotton was pursued due to its simplicity and minimal data requirements, enabling effective irrigation scheduling and water management. The use of remote sensing and GIS technology has made it easier to assess the impact of mulching on water conservation. By analyzing satellite images, researchers can determine the amount of vegetation cover and moisture content in different areas before and after mulching (Livingston 2004). This information helps farmers and policymakers make more informed decisions about using mulching as a water conservation strategy. Moreover, mulching offers additional benefits such as reducing soil erosion, increasing crop yield, and improving soil fertility. As such, it is a cost-effective and eco-friendly solution to address water scarcity in arid regions (Abiye, 2022).

The Role of Remote Sensing and GIS In Assessing the Impact of Mulching

The use of remote sensing and GIS has revolutionized the assessment of the impact of mulching on water conservation in drought-affected areas. With these technologies, it is now possible to obtain accurate and detailed information on the distribution and extent of mulching practices across large areas. Through satellite imagery, remote sensing can provide information on vegetation cover, soil moisture content, and other important variables that affect water conservation (Livingston 2004).Parmar and Tiwari, (2020) revealed that remote sensing-based data exhibited comparable performance to point estimations from field studies in accurately estimating ET0. GIS, on the other hand, allows for spatial analysis and mapping of mulching practices in relation to other factors such as topography, land use, and climate patterns (Tesfaye *et al*. 2018). By combining these two technologies, researchers can gain a better understanding of how mulching impacts water conservation in different regions and develop effective strategies for sustainable agriculture in drought-prone areas (Thiam *et al.* 2021).

Case Studies on The Effectiveness of Mulching in Water Conservation

Several case studies have been conducted to assess the effectiveness of mulching in water conservation in drought-affected areas using remote sensing and GIS (Masroor*et al*. 2022). One such study was carried out in the semi-arid region of Kenya, where mulching helped to reduce soil moisture loss by up to 30% (Golla, 2021). A similar study was conducted in South Africa, where mulching reduced soil evaporation rates by up to 50% (Ma *et al.* 2022). Vadalia and Prajapati (2022) observed a considerable deviation in adjusted FAO and sensor based Kc. In India, a study showed that mulching can increase crop yield and reduce water use by up to 25% (Kader *et al*. 2019). Another study conducted in California demonstrated that mulching can reduce irrigation needs by up to 50%. Prajapati and Subbaiah, (2015) revealed the drip irrigated silver plastic mulch enhanced the yield by 13.69%, biodegradable plastic mulch 23.94%, wheat straw mulch 28.74% , drip without mulch 52.43% and furrow irrigation at 0.8 ETc.

Implications for Water Conservation

The findings of this study have important implications for water conservation efforts in drought-affected areas. By understanding the relationship between drought conditions and soil erosion, it is possible to develop strategies that promote water conservation and minimize the loss of valuable topsoil. Mulching, for example, has been shown to be an effective technique for water conservation in drought-affected areas. By applying mulch to the soil surface, evaporation can be reduced, and water infiltration and retention can be improved. Vadalia*et al*. (2022) observed adjusted FAO Kc predicts higher value than sensor-based Kc values under both land configurations. This helps to maintain soil moisture levels and minimize the impact of drought on agricultural productivity.

Policy Measures for Drought and Soil Erosion Management

The findings of this study underscore the need for policy measures to address the challenges posed by drought and soil erosion. Effective watershed management practices, such as the implementation of sustainable land management strategies, can help mitigate the impact of drought and soil erosion (Masroor *et al*. 2022). By integrating remote sensing data and GIS analysis, policymakers and land managers can make informed decisions regarding water conservation and soil erosion control. Pandya *et al.* (2022) fond that the district-wise CDI expressions using SPEI/RDI among meteorological drought indices and VCI/NDVIA among vegetation drought indices showed a higher correlation with cotton and groundnut crop yields as compared to existing indices and detected crop yield anomalies of historic dry and wet years effectively. This can include the implementation of mulching techniques, the promotion of sustainable land management practices, and the development of targeted drought management plans.

Conclusion

The integration of remote sensing and GIS in assessing the impact of mulching on water conservation in drought-affected areas provides valuable insights into the effectiveness of mulching practices. By analyzing remote sensing data, including satellite imagery, key parameters such as land surface temperature, vegetation indices, and soil moisture content can be evaluated. The use of GIS techniques enables spatial analysis, data integration, and visualization, facilitating a comprehensive understanding of water availability and vegetation response. Through field surveys, researchers validate remote sensing data and gather additional information on mulching techniques, soil properties, and vegetation health. This holistic approach allows for a thorough assessment of the impact of mulching on water conservation. the assessment of mulching's impact on water conservation using remote sensing and GIS provides accurate and valuable information for sustainable agriculture and water resource management in drought-affected areas. The research findings contribute to the development of effective strategies for mitigating drought's impact, promoting water conservation, and ensuring environmental sustainability and agricultural productivity in these regions.

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Official Address :
Peshok Tea Estate
P.O.- Peshok, Dist.- Darjeeling
West Bengal, India
PIN-734312

Contact No : +91 7501389678
email : agriindiatoday@gmail.com