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PROMOTING SUSTAINABLE AGRICULTURE THROUGH THE SYNERGY OF FARM MECHANIZATION AND OPTIMAL SOIL AND WATER RESOURCE MANAGEMENT

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Introduction

Sustainable agriculture stands as an imperative for our world's future. With a growing global population and the increasing effects of climate change, the need for agricultural practices that maximize productivity while minimizing environmental harm has never been greater. In this quest for sustainability, two key components emerge as indispensable: the judicious use of farm mechanization and the efficient management of soil and water resources. This article delves into the pivotal role these practices play in achieving sustainable agriculture, supported by data and meaningful insights.

The Farm Mechanization Revolution

Farm mechanization represents a transformative force in modern agriculture. It involves the use of advanced machinery and technology to streamline farming processes, increase productivity, and reduce resource waste.Indian agriculture is characterized by over-whelming small holdings due to higherpopulation density and nearly two-third of its population residing in the rural areas coupled withunabated land fragmentation due to the inheritance laws of the country (Verma 2016). Mechanization has evolved significantly over the years, from the introduction of tractors in the early 20^{th} century to today's precision agriculture techniques that employ GPS-guided machinery and advanced data analytics. Farm mechanization means the improved way of doing farm practices that needs least effort and resource (Kumar and Kutumbale, 2019).

Increasing Productivity

One of the primary benefits of farm mechanization is its ability to boost productivity. According to data from the United Nations Food and Agriculture Organization (FAO), mechanized farming practices have led to substantial increases in crop yields. In some cases, yields have doubled or even tripled compared to traditional farming methods. Parmar et. al (2019) revelled the gridded information on temperature are generally being used for various application in agriculture. Most of the methods to determine spatial variation in temperature often use spatial interpolation and extrapolation of data from the nearest meteorological stations. The erratic fluctuations in soil-water potential can adversely affect crop productivity (Vadalia and Prajapati 2022).

The use of modern tractors and other machinery significantly reduces the time and labor required for planting, harvesting, and other essential tasks. This increased efficiency allows farmers to cultivate larger areas of land and produce more food with fewer resources.

Reducing Resource Waste

Efficiency is at the core of sustainable agriculture, and farm mechanization is a key driver of resource optimization. Data from the U.S. Department of Agriculture (USDA) demonstrates that precision agriculture techniques, such as GPS-guided tractors and variable rate application

systems, enable farmers to apply fertilizers and pesticides with unparalleled accuracy. As a result, overuse of these inputs is minimized, reducing the risk of soil and water contamination. This not only benefits the environment but also saves farmers money by reducing input costs.

The Role of Soil in Sustainable Agriculture

Soil is a finite and precious resource. Its management is central to sustainable agriculture, as it directly impacts crop health, yields, and long-term land viability. Efficient soil management involves practices that maintain or improve soil health while preventing degradation and erosion.

Conservation Tillage

Conservation tillage, a practice facilitated by farm mechanization, is a prime example of soil-friendly farming. This technique involves minimal or no disturbance of the soil through tillage. Instead, crop residues are left on the field, protecting the soil from erosion and improving its structure. According to research conducted by the Soil Science Society of America, conservation tillage can reduce soil erosion by up to 90% compared to conventional tillage methods. Furthermore, it enhances soil organic matter content, which is critical for nutrient retention and water-holding capacity.

Cover Cropping

Cover cropping, supported by mechanized equipment for planting and termination, is another sustainable soil management practice. Cover crops are grown between cash crops to prevent erosion, suppress weeds, and enrich the soil with organic matter. Data from the Natural Resources Conservation Service (NRCS) in the United States indicates that cover cropping can reduce soil erosion by up to 95% and improve soil moisture retention. Additionally, it can enhance soil fertility by increasing the availability of nutrients for subsequent crops.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.Prajapati and Subbaiah, (2019) emphasized that relying solely on adjusted FAO Kc values could lead to an overestimation of crop evapotranspiration throughout the growing season.

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Therefore, they advised caution and suggested the need for additional verification or validation when using these adjusted values to ensure accurate estimations of crop water requirements. Prajapati and Subbaiah, (2015) demonstrated that different mulching and irrigation techniques had varying impacts on crop yield, with drip irrigation combined with silver plastic mulch showing a relatively lower yield increase compared to other methods.

Precision Nutrient Management

Efficient soil management also encompasses the precise application of nutrients. Mechanized equipment equipped with GPS technology and soil sensors enables farmers to apply fertilizers and nutrients exactly where they are needed, based on soil analysis data. Sowing of seed is considered as one of the most important operation that involves factors like correct seed rate, appropriate depth of seed placement and required seed spacing (Delvadiya*et al*., 2019). A study published in the Journal of Environmental Quality demonstrated that precision nutrient management can reduce nutrient runoff into water bodies, thereby mitigating water pollution and preserving water quality. This practice not only benefits the environment but also conserves resources and reduces costs for farmers.

The Critical Role of Water in Sustainability

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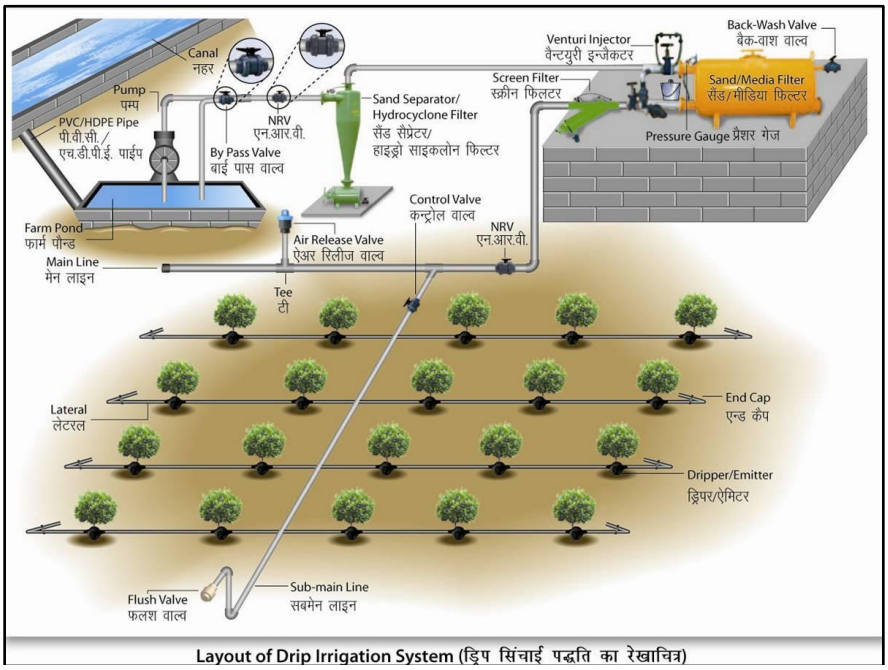
Water is a fundamental resource for agriculture, and its responsible management is essential for sustainable farming. Efficient water management involves practices that optimize water use, minimize wastage, and protect water quality.

Drip Irrigation Systems

Mechanized drip irrigation systems have revolutionized water management in agriculture. Water scarcity poses a significant challenge in arid and semi-arid regions, making intensive irrigation difficult (Pandya and Rank, 2014). These systems deliver water directly to the root zones of plants, reducing water wastage through evaporation and runoff. Data from the Irrigation Association suggests that drip irrigation can be up to 90% more efficient in water use compared to traditional surface irrigation methods. Altering the land configuration offers a promising avenue to enhance both water use efficiency and minimize soil erosion in field crops (Vadalia*et al*. 2022).



Layout of Drip Irrigation System (ड्रिप सिंचाई पद्धति का रेखाचित्र)

Automated Weather Stations

Precision agriculture, facilitated by mechanized data collection and analysis, includes the use of automated weather stations. These stations provide real-time weather data that allows farmers to make informed decisions regarding irrigation scheduling.A study published in the journal Water Resources Management found that the use of automated weather stations for irrigation management can result in water savings of up to 20%, as farmers can adjust irrigation schedules based on actual weather conditions rather than relying on preset schedules.In arid and semi-arid regions, irrigated agriculture stands as the largest consumer of water (Parmar *et al*., 2023). The escalating impact of global warming is projected to heighten evaporation rates, resulting in drier ground conditions and a gradual build-up of water vapor in the atmosphere (Pandya and Gontia 2023).

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Conservation Buffer Strips

Mechanized establishment and maintenance of conservation buffer strips along water bodies play a crucial role in water resource management. These buffer strips, planted with vegetation, serve as natural filters, trapping sediment and nutrients before they enter water bodies. This difficulty arises from the intricate interplay between crop genotype, soil moisture availability, and climate conditions (Pandya *et al*. 2022). Research from the Environmental Science & Technology journal highlights the effectiveness of buffer strips in reducing nutrient runoff into streams and rivers. This not only protects water quality but also supports aquatic ecosystems.

Smart Irrigation Controllers

Farm mechanization extends to the development and implementation of smart irrigation controllers. These controllers use data from soil moisture sensors and weather stations to adjust irrigation schedules in real-time. According to the American Society of Agricultural and Biological Engineers, smart irrigation controllers can reduce water usage by up to 50% compared to traditional irrigation methods. This not only conserves water but also lowers energy costs associated with pumping and distributing water.

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The Synergy of Farm Mechanization and Soil-Water Management

The true power of sustainable agriculture lies in the synergy between farm mechanization and efficient soil and water management. When these two elements are harmoniously integrated, the results are transformative.

Precision Agriculture and Soil Health

Precision agriculture, made possible by farm mechanization, contributes significantly to soil health. By precisely managing planting, fertilization, and irrigation, farmers can create optimal growing conditions for crops. This approach minimizes soil compaction, reduces nutrient imbalances, and ensures that crops receive the right amount of water, all of which are critical factors for soil health. Data from a long-term study conducted by the USDA's Natural Resources Conservation Service demonstrates that precision agriculture practices, including GPS-guided machinery and variable rate technology, can improve soil health indicators such as organic matter content and nutrient availability.

Conservation Tillage and Water Conservation

The combination of conservation tillage and efficient water management practices results in a win-win situation for soil and water resources. Conservation tillage, driven by mechanization, reduces soil erosion, which, in turn, helps preserve water quality bypreventing sediment and nutrient runoff into water bodies. Research from the Journal of Soil and Water Conservation indicates that conservation tillage can reduce surface runoff and increase water infiltration into the soil, leading to better water retention and reduced irrigation needs.

Cover Cropping and Soil-Water Management

Cover cropping, when integrated with mechanized planting and termination equipment, enhances both soil and water management. The practice prevents soil erosion and suppresses weeds, reducing the risk of soil and nutrient runoff into water bodies.

Conclusion

In the pursuit of sustainable agriculture, the synergistic blend of farm mechanization and optimal soil and water resource management emerges as a beacon of hope. These two pillars of modern farming hold the key to addressing the challenges of a burgeoning global population, climate change, and environmental conservation. Farm mechanization, driven by technological innovation, empowers farmers to produce more with less, reducing resource waste and environmental impact. Precision agriculture techniques, such as GPS-guided machinery and automated weather stations, are ushering in a new era of efficiency, where every drop of water and gram of fertilizer counts. Simultaneously, the stewardship of soil and water resources is paramount. Conservation tillage, cover cropping, and precision nutrient management safeguard our soils, preserving their fertility and structure. Drip irrigation, smart controllers, and conservation buffer strips ensure the responsible use and protection of our precious water resources. The synergy of farm mechanization and soil-water management is the linchpin of sustainable agriculture. It not only bolsters crop productivity but also nurtures the environment upon which our future depends. The data and insights presented here underscore the undeniable benefits of this synergy, offering a path forward towards a more sustainable, prosperous, and resilient agricultural landscape. It is a transformation that transcends our fields and irrigates the very roots of our shared future.

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RENEWABLE ENERGY: MITIGATING CARBON EMISSIONS AND HARNESSING CARBON CREDITS

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Abstract
Burning fossil fuels including coal, diesel, gasoline and natural gas emits varying levels of CO_2 for energy generation. Despite of this, India is actively transitioning to renewables such as solar and wind power to curtail its carbon output. The nation's rapid economic and industrial growth has heightened energy consumption and emissions. India is taking measures to address climate change by embracing non-fossil fuel-based power and energy efficiency. Renewable energy's crucial role in mitigating climate change is highlighted, supported by data showing its impact on global electricity generation and CO_2 emission reduction. The mechanism of carbon credits in renewable energy projects is explained with empirical research demonstrating their effectiveness in reducing emissions. There are various benefits over the harnessing of carbon credits through renewable energy whichis scientifically supported strategies to combat emissions, foster economic growth and address the pressing challenges of climate change.

Key Words : Fossil fuels. Carbon emission, carbon credit, Renewable Energy, climate change

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Introduction

In 2021, India's total carbon dioxide emissions were around 2.6 billion metric tons that making it the third-largest emitter globally followed by China and United States (Anonymous, 2022). India's energy mix includes a significant share of coal which is a carbon-intensive fossil fuel(IEA, 2021; Raghuvanshi*et al.,* 2006). However, the country is also making efforts to increase the use of renewable energy sources, such as solar and wind power to reduce its carbon footprint. India's rapid economic growth and industrial development have contributed to increased energy consumption and emissions. India has taken steps to address climate change and has committed to increasing the share of non-fossil fuel-based power in its energy mix and implementing energy efficiency measures. India's per capita carbon emissions are lower compared to many developed countries. However, due to its large population, the cumulative emissions are significant. As the global climate crisis intensifies, the scientific community has underscored the urgent need for sustainable and low-carbon energy solutions. Harnessing carbon credits through renewable energy projects offers a scientifically sound and effective pathway towards mitigating greenhouse gas emissions and combating global warming.

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Understanding Carbon emission and carbon credit

Carbon emissions represent the release of greenhouse gases into the atmosphere and contribute to climate change, while carbon credits represent the quantified reduction or avoidance of greenhouse gas emissions and are used as a currency to promote emission reduction activities. The concept of carbon credits aims to balance carbon emissions by rewarding emission reduction actions, contributing to global climate change mitigation efforts.

Carbon Emission: Carbon emissions refer to the release of carbon dioxide (CO_2) and other greenhouse gases (GHGs) into the atmosphere as a result of human activities, such as burning fossil fuels (Coal, Oil and Natural gas), deforestation, industrial processes, and agriculture. These emissions are a major driver of climate change, as GHGs trap heat in the Earth's atmosphere which leading to global warming and associated environmental impacts. Carbon emissions are measured in metric tons of CO_2 equivalent ($MTCO_2e$) and are commonly used as a metric to assess an individual, organization or country's contribution to climate change. There are three main types of scopes of greenhouse gas emissions commonly used in greenhouse gas accounting.

Scope 1 Emissions : Scope 1 emissions represent direct emissions from sources that are owned or controlled by the reporting entity. These emissions occur from activities within the organization's operational boundaries. The examples of Scope 1 emissions include emissions from directly from fuel combustion and industrial process. The emission of fuels can vary based on their chemical composition and combustion characteristics. The carbon emissions produced by burning of various fossils fuel like natural gas, petrol, diesel and coal are approximately 0.201, 0.264, 0.266 and 0.93 per Kwh (Wannes Vanheusden 2020; Mittal *et al.,* 2012).

Scope 2 Emissions : Scope 2 emissions represent indirect emissions from the generation of purchased electricity, heat or steam consumed by the reporting entity. These emissions are associated with electricity and energy purchased from external sources. Scope 2 emissions occur outside the organization's operational boundaries but are a consequence of its activities. The emissions result from the carbon intensity of the electricity supplied by the grid or other external energy providers.

Scope 3 Emissions : Scope 3 emissions represent all other indirect emissions that occur as a result of the reporting entity's activities but outside its operational boundaries. These emissions encompass the entire life cycle of the organization's products or services, including activities related to the supply chain, transportation, employee commuting, business travel, and waste generation. Scope 3 emissions are generally the most challenging to quantify and manage as they involve multiple stakeholders and extensive supply chain considerations.

Carbon Credit : On the other hand carbon credits are a market-based mechanism designed to incentivize and reward actions that reduce or offset carbon emissions. Each carbon credit represents one ton of avoided or reduced CO_2 emissions (or its equivalent in other GHGs). Carbon credits are generated through projects or activities that contribute to greenhouse gas emission reduction or removal from the atmosphere. For example, a renewable energy project that displaces fossil fuel-based electricity generation and, as a result, reduces CO_2 emissions, can earn carbon credits based on the amount of avoided emissions. These carbon credits can then be sold or traded in carbon markets. Carbon credits enable companies, organizations, and governments to take responsibility for their carbon footprint and support emission reduction efforts. They provide

a financial incentive for implementing sustainable practices and investing in projects that promote a low-carbon future.

Let's understand the Carbon credit generation through the following example. Let's assume that the 1000 kWh electricity have been generated using a mix fuel of coal and natural gas with an emission factor of 0.8 kg per kilowatt-hour (kg CO_2/kWh). The total emission produces (Baseline Emissions) are 800 Kg $CO_2$from coal and natural gas base power plant. Now, by the installation of solar photovoltaic base power plant of 1000 kWh produces the zero emission (Project Emissions). The emission reduction (Baseline Emissions - Project Emissions) is 800 Kg CO_2. Now, convert the emission reductions (800 kg CO_2) into carbon credits by 1,000 kg (one carbon credit for every 1,000 kg of CO_2 equivalent) to calculate the carbon credit which is 0.8.

Renewable Energy and Carbon Mitigation : Scientific evidence highlights the pivotal role renewable energy sources play in the global effort to mitigate climate change. According to the Intergovernmental Panel on Climate Change (IPCC), transitioning to renewable energy can limit global warming to 1.5°C above pre-industrial levels, a critical threshold for averting the worst impacts of climate change. Data from the International Renewable Energy Agency(IRENA) demonstrates that renewable energy accounted for approximately 26.3% of global electricity generation in 2020 (IRENA, 2020). Notably, this resulted in the avoidance of nearly 2.3 billion tons of CO_2 emissions, equivalent to the annual emissions of India, the world's third-largest emitter.

How Carbon Credits Work with Renewable Energy

Empirical studies conducted by prominent research institutions have elucidated the mechanics of carbon credits in renewable energy projects. When an entity invests in renewable energy, such as solar or wind power, the transition displaces the use of fossil fuels for electricity generation. As a result, the avoided emissions are quantified and corresponding carbon credits are issued. Research by the World Resources Institute (WRI) reveals that renewable energy projects accounted for more than 90% of the total carbon credits issued globally in 2021. These credits were instrumental in driving a cumulative reduction of approximately 5.2 billion tons of CO_2 emissions since the inception of carbon markets.

The Benefits of Harnessing Carbon Credits through Renewable Energy

1. Climate Change Mitigation: Scientific consensus emphasizes that renewable energy and carbon credits are indispensable tools for achieving significant reductions in greenhouse gas emissions and meeting climate targets.
2. Financial Incentives: In addition to the environmental benefits, scientific data demonstrates that investing in renewable energy projects and selling excess carbon credits can yield substantial financial returns.
3. Sustainable Branding: Research from Harvard Business Review shows that companies adopting renewable energy and carbon credit initiatives experience improved brand reputation and increased customer loyalty.
4. Cleaner Air and Health Benefits: A study published in Nature Communications indicates that the global adoption of renewable energy could prevent approximately 3.6 million premature deaths annually by reducing air pollution.
5. Job Creation and Economic Growth: According to the International Labour Organization (ILO), transitioning to renewable energy can create up to 42 million new jobs worldwide by 2050, driving economic growth and prosperity.

6. Compliance with Regulations: Research by the Carbon Disclosure Project (CDP) reveals that renewable energy and carbon credit utilization are instrumental in helping companies and nations meet regulatory emission reduction targets.
7. Technological Advancements: Empirical data establishes that the demand for carbon credits stimulates technological innovation in renewable energy, leading to increased efficiency and affordability.

Conclusion

The scientific evidence overwhelmingly supports the integration of renewable energy and carbon credits as key strategies for combating climate change. As the world faces ever-increasing challenges from global warming, adopting these scientifically-driven initiatives becomes imperative. Empowered by data and research, businesses, governments, and individuals can collaboratively embrace renewable energy and carbon credits to pave the way for a sustainable low-carbon future. Through this scientific approach, we can collectively safeguard the planet for current and future generations.

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BIRDS AND CLIMATE CHANGE

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Abstract
Rising temperatures and an increase in precipitation are two of the various changes brought about by complex climate change that constitute dynamic environmental alterations for birds. Birds which are an essential part of the ecosystem, play a vital role in balancing the ecosystem as well and their sensitivity toward their habitat makes them a suitable biological indicator of climate change. This article intends to disclose the effects of climate change on birds' behavior and raise people's understanding of how climate change will affect them, giving an overview of climate change and how it affects birds briefly describing the measures taken which encourage them to take proactive measures to solve the issue for future generations and lessen its consequences.

Introduction
Climate change, a global physical phenomenon has been considered a major threat to biodiversity. It is evident that the climate of the Earth system has already risen over the past century. It is an alarming issue nowadays among the scientific as well as political communities. The Himalayan region is the area of the world most vulnerable to climate change. The Himalayas are experiencing a three times faster increase in temperature than the rest of the world. The Himalayas' temperature has been rising at the moment by 0.06°C a year. It is expected to alter the structure, function and composition of the Himalayan ecosystem, a fragile and sensitive ecosystem of the world (IPCC, 2007).

Birds are widespread in their distribution and occur in almost all environments. They are particularly intrigued by climate change since they are known to respond to a variety of climate disturbances, and their responses are frequently well-documented. According to recent studies, one-eighth of bird species face a high risk of extinction in the coming decades, necessitating human intervention to save them (King and Finch, 2013). According to study, 600–900 species of birds will go extinct in 2100 if global temperatures rise by 3.5 degrees Celsius, with the tropics accounting for 89% of those extinctions (Scridel et al.2018). Climate change poses the greatest threat to captive birds since they have low metabolic rates and minimal temperature variance. Also, they are an essential component of ecosystem and are crucial in maintaining balance. They are a good bioindicator of climate change because of their sensitivity to their habitat (Mariappan et al. 2013). Approximately 9,000 bird species are known so far, out of which India accounts for about 1250 species having approx. 14 percent of the world's total avian diversity (Kukreti and Kukreti, 2015). The records suggested that the Himalayan region has around 980 bird species out of which35 bird species are endemic to the Himalayan region.

Effect of climate change on Birds
Birds are particularly sensitive to climate change and have a strong negative impact on their population, leading to a change in their behavior like nesting and migratory patterns, changing

breeding seasonality and shifting their distribution range to obtain optimum food resources necessary for their survival.

- **Migration**
  According to research, global warming affects how often migratory birds migrate and where they choose to spend the winter. Studies have shown that the average monthly temperature and the first arrival date of most birds are inversely associated, meaning that the warmer the temperature, the earlier the bird will arrive (Brown et al. 2019).
  Since warming affects the spatial distribution of habitats and resources, migratory animals may react to warming in ways other than by altering their migration schedules. With the increase in temperature, suitable breeding and staging areas are probably shifting towards the north (Jackson et al. 2015).

- **Habitat**
  A significant threat to the survival of several bird species is the habitat change brought on by global warming. A decrease in the number of species will result from warmer temperatures degrading the habitat of birds. Warmer temperatures will also cause alpine species across the world to shift upward (Huntley et al.2006). The snowline in the Himalayas has moved upward through time because of the warming climate. This change has given birds in the alpine regions new niches, expanding their altitudinal ranges upward. In an effort to adapt to climate change, species from low- to mid-elevation locations have also increased their altitudinal range (Xu et al.2009).

- **Breeding**
  In general, birds begin reproducing sooner than usual in response to climate change. It is thought that birds delay breeding processes like nest building, egg laying, and even the emergence of hatchlings (Acharya and Chettri, 2012).A mismatch between the timing of nesting and the availability of essential food for birds can be driven by climate change(Visser et al.1998).
  Initial studies indicate that some birds begin breeding sooner than usual and are producing eggs sooner than in the past, or have fewer young ones because of a lower reproductive rate, which causes the population to fall suggesting that climate change may have an impact on the timing of egg laying in birds (Wormworth and Sekercioğlu, 2011).High spring temperatures may accelerate the typical flowering and leafing period, reducing the amount of food available to birds. The activity and behavior of birds are indirectly impacted by changes in temperature and humidity. When a habitat is abandoned owing to unfavorable weather, vital processes like feeding and breeding displays are hampered. In the mountains, even erratic heavy rainfall during the breeding season can delay their breeding activities by lowering temperatures (Sekercioğlu et al. 2012). Longer and more unpredictable dry seasons as a result of climate change can impact reproductive effectiveness, leading to population reduction or outright breeding failure in birds. This is because many birds time their breeding with increasing resource richness mainly during the wet season (Williams and Middleton, 2008).

- **Food availability**
  Global warming, an increase in the frequency of extreme weather, and altered precipitation rates are just a few examples of how climate change has gradually altered the

natural environment. Studies indicate that climate change has led to a decrease in the abundance of food available to birds, which could pose a threat to their ability to reproduce and grow physically. This information can be used to assess the indirect effects of climate change on the availability of food for birds. In conclusion, the supply of food for birds has decreased due to climate change. Short-term and/or long-term effects of the drop in food supply could include a mismatch between peak food availability dates and avian breeding seasons. However, the way that birds adjust to changing environmental conditions may have an impact on the outcomes (Li et al.2022).

How to help birds?

There are ways by which we can do our part to help birds as temperature aggravates:

- Education regarding how climate change impacts birds, the value of bird species, and how to protect them must be provided to the general people.
- Increasing bird habitat and securely storing carbon can both be accomplished by planting trees.
- Reduce greenhouse gas emission.
- Reducing carbon footprint by choosing smart living.

Conclusion

Birds are found to be an essential part of the ecosystem playing a major role in balancing nature. This article particularly discusses the impact of climate change on birds. For instance, warmer temperatures may cause an earlier migration, alter bird habitats, reduce population size and advance some birds' egg-laying dates, and alter the availability of food. The study also includes strategies for mitigating the effects of environmental change on birds on an individual level. There are still multiple issues regarding global warming that need to be resolved, such as how to deal with the changes in bird habitat brought on by climate change.

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SHORTEST FLOWERING DURATION IN DRAGON FRUIT (*Hylocereus costaricensis* [F.A.C. WEBER] BRITTON AND ROSE) CV. ROYAL MOROCCAN REDUNDER THE LATERITIC ZONE OF BIRBHUM, WEST BENGAL, INDIA: NEW REPORT

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Abstract

Dragon fruit is apropitious, long day, tropical epiphyticcactus with a beautiful one-time night blooming flower and nicknamed as 'Wondrous Fruit' of the 21st century, 'Queen of the Night' and 'Noble Woman'. It is a powerhouse of antioxidants, phenolics, flavonoids, anti-proliferation and medicinal properties, various vitamins, minerals and dietary fibres. All such beneficial factors make dragon fruit a plant of high economic potential as an exotic super fruit crop that is being traded in national and international markets, fetching higher prices. However, the initial investment for dragon fruit farming is relatively high; consequently, first-year production is crucial to mitigating the initial investment. Generally, dragon fruit flowers after 14 months after planting; however, the earliest flowering (10 months and 13 days) after planting were observed in the lateritic zone of Birbhum district, West Bengal. As dragon fruit flowers in eight flowering flushes, the earliest initiation of flowering may significantly increase the number of flowering flushes and ultimately the total production.

Introduction

Dragon fruit (*Hylocereus costaricensis* [F.A.C. Weber] Britton and Rose) is a diploid (2n = 22) and belongs to the family Cactaceae. It is a promising and tropical epiphytic cactus, originated from Central America. It is a long day plant with beautiful one-time night blooming flower and nicknamed as 'Wondrous Fruit' of the 21st century and "Queen of the Night" or "Noble Woman". It is also a powerhouse of anti-oxidants, phenolics, flavonoids and anti-proliferation properties. The fresh fruit contains 82.5-83.0 % moisture, 0.16-0.23 % protein, 0.21-0.61 % fat and 0.7- 0.9 % fiber. The 100 gram of fresh fruit pulp contains calcium (6.3- 8.8 mg), phosphorus (30.2- 36.1 mg0, iron (0.5-0.61 mg) and vitamin C (8-9 mg). According to reports, it promotes gastrointestinal health, boosts immunity and aids in the management of chronic conditions. It is also a rich source of various vitamins, minerals, nutritional fibres and finest alternative for treating obesity, managing diabetes, decreasing cholesterol, etc. All these beneficial factors make dragon fruit a plant of high economic potential as exotic fruit crop and is being traded in national and international markets fetching higher prices.

In India, dragon fruit is cultivated in an area of 400 hectare mainly in Karnataka, Kerala, Tamil Nadu, Maharashtra, Gujarat, Chhattisgarh, Odisha, West Bengal, Andhra Pradesh, Andaman & Nicobar Islands, Mizoram and Nagaland. In West Bengal, it is taking wing in both the northern and southern districts mainly in the plains of Darjeeling, Alipurduar, Cooch Behar, Malda, Murshidabad, Nadia, North and South 24 Parganas and Birbhum districts. The initial investment for dragon fruit cultivation is relatively high; consequently, first year production is directly related

to mitigating the initial investment. Under West Bengal condition flowering starts after 14 months of planting with eight number of flowering flushes per pillar (Parveen *et al*, 2018; Devi *et al*, 2023). The Department of Horticulture under School of Agriculture at Seacom Skills University has observed the earliest flowering (10 months and 12 days) after planting the cuttings. As dragon fruit flowers in eight flowering flushes, the earliest initiation of flowering may significantly increase the number of flowering flushes and ultimately the total production.

Location of the site

The field observation was conducted at the dragon fruit orchard (23°42'5'' N latitude, 87°38'22'' E longitude and 9.75 m above mean sea level) of Seacom Skills University, Kendradangal, West Bengal, India.

Climatic and soil

The sub-tropical climate with characteristics of high summer temperature, erratic rainfall, high humidity and short-mild winter. Red Lateritic soil which belong to the class of sandy loam with medium fertility and neutral in reaction.

Source of planting material and planting.

Dark green and fully matured cladode are collected from Department of Fruit Science, Bidhan Chandra Krishi Vishwavidyalaya, Nadia, West Bengal. The cladode cuttings were processed according to Chettri *et al* (2022), with 30cm cutting length and were treated with IBA at 6000ppm for better rooting and shooting and planted into the polybags filled with the media. Four plants per pillar were transplanted on 10th September 2022 maintaining a distance of 2.5 m x 2.5 m spacing. Fertilizers were applied according to Parween and Hasan (2019) at the rate of FYM 20kg along with N_{450} P_2 O_5 $_{350}$ K_2O_{300} g per pillar as scheduled.

After care

Generally, hand weeding and mulching with paddy straw were done. Irrigation was done immediately just after planting and to provide sufficient moisture during dry season at 6-7 days interval. As the cladodes were fully grown, the hanging and the vertically growing cladodes were pruned at 35 cm from the edge of the ring. Lateral or side shoots, dead, diseased and overcrowded cladodes were removed periodically.

Conclusion

Maturity of cladode selected for preparing cutting, pruning of hanging and vertically growing cladodes at specific length and withholding the irrigation at specific period before the flowering may trigger the earliest flowering in the first year of dragon fruit plantation.

Further research can be taken up on the efficacy of cladode of different maturity, pruning intensity and moisture stress can be tried to study the flowering behaviour of dragon fruit in the future.

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POST HARVEST MANAGEMENT, PROCESSING AND VALUE ADDITION OF ONION

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Onion (*Allium cepa* L.) is one of the oldest bulb crops, known to mankind and consumed worldwide. It is one of the most important commercial vegetable crops grown in West Bengal. The onion is preferred mainly consumed as matured bulb, green leaves and immature bulb. The pungency in onion is due to a volatile compoundknown as allyl-propyl disulphide. Onion has many uses in ayurveda and folk medicine and have important role in preventing cancer, heart diseases, respiratory problems and other ailments.

Harvesting : Onion is ready for Harvesting after 3-5 months after transplanting when there is 50% neck fall. Harvesting is generally done in the evening time when the temperature start declining. Onion is harvested by uprooting the bulb from the ground. This can be done by hands or by machines as well. After harvesting the bulbs are cleaned and washed properly. This is done to remove any sort of soil inoculums from the bulb. After this the bulbs are air dried and are staked for further post harvest operations.

Sorting and grading : After the cleaning of the bulbs, sorting and grading of the bulbs are done. Damaged, doubled, broken, rotten and injured bulbs are discarded immediately to prevent further spread of disease. After this onion are graded by hand or grading machine as well. Size based grading is usually followed in India. Delhi market prefers big sized bulbs (>6 cm diameter), Calcutta, Patna and Lucknow prefers medium size bulbs (4-6 cm diameter) and Bhubaneswar, Guwahati prefer small sized Onion (2-4 cm diameter).

Curing : Curing is an important post harvest operation which is done to remove excess moisture from the outer skin and neck of onion bulbs. It increases storage life of onion bulbs and improve skin colour of onion. Curing is done at a high temperature (38-40 degree Celsius), good ventilation and low humidity. Curing is a drying process intended to dry off the necks and two or three outer layers of the bulb to prevent the loss of moisture and the attack by decay during storage. Onions are considered cured when neck is tight and the outer scales are dried until they rustle. This condition is reached when onions have lost 3 to 5% of their weight. Curing can be done in the field for 7-14 days. In room condition, onions are collected in trays, stacked in a warm, covered area with good ventilation. In cool and damp condition, artificial heat is blown through the bulk at a duct temperature of 30 degrees Celsius. Onions can also be cured by tying the tops of the bulbs in bunches and hanging them on a horizontal pole in a well-ventilated shade. Curing in shade takes slightly longer duration but improves bulb colour and reduces losses significantly during storage. Curing decreases the incidence of neck rot, reduces water loss during storage, prevents microbial infection and is desirable for development of good scale colour. Till date modular ventilated drying structure is most convenient method of curing and the bulbs become marketable within 4-5 days.

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Post Harvest Handling : Bulbs should be handled with extra caution since once small injury might invite rot diseases. The harvested bulbs should be free from cuts and handled with extreme care. Onions should not be dropped to any hard surface from more than 5-6 feet height. Excessive staking of gunny bags one above the other usually leads to compression or abrasion injury of the bulbs. This is why losses due to rot is reported to be more if onions are stored in gunny bags than in loose or wooden crates.

Improper staking and post harvest handling

Packaging onion in wooden crates

Sprouting onion bulb due to Improper curing

Storage : Onion is basically a Rabi season crop and there is a market glut during March-May. There is a tremendous demand of onion during late rainy season and autumn season. This demand is not only in local market but also in gulf counties. This requirement can partially fulfilled by kharif onion cultivation. The best possible solution to mitigate this issue is adoption of proper storage of the main season onion crop. Storage can be improved by adoption of optimum harvesting measures, post-harvest management, improved storage structure and cultivation of good storage capable varieties. In onion, weight loss is maximum when temperature exceeds 35°C during storage. The ideal ambient storage condition for onion is 30-35°C with 65-70% relative humidity. However in case of ambient storage, physiological loss of weight and sprouting contributes 20-25 percent loss in weight. In cold storage, temperature is maintained at 0-2°C while the RH is kept at 60-75%. The onions are bulk stored in special houses with thatched roof and side walls are made up with bamboo sticks or wire mesh for good air circulation. Periodical turning of bulbs or removal of rotten, damaged and sprouted bulbs should be done time to time. Well-ventilated improved storage structures with racks or tiers having two or three layers of bulbs would be desirable for proper storage. Storage quality of onion also depends on the colour of the onion. The storage potential of onions follows the order i.e. yellow>red>white.

Storage losses can be controlled by adoption of the following practices

1. Selection of varieties with good storage potential.
2. Not using excess nitrogenous fertilizers
3. Avoiding irrigation before bulb harvesting.
4. Proper curing of bulbs after harvesting.
5. Complete drying of leaves and shade curing is essential.
6. Use fumigation and ventilation in storage structure to reduce losses

Storage methods : In India onions are stored in heaps/stakes under ambient conditions. Generally different types of structures are used for storage of onions. Development of low cost onion storage structures is also supported by Department of Food Processing Industries and Horticulture, Government of West Bengal, under MIDH schemes. Details about some of the storage structures are given below:

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1. Traditional storage structure : These structures are basically designed by the farmers based on their requirements and availability of materials. These structures are usually made of bamboos or wooden logs whereas the roof is made of grass, palmyrah leaves or asbestos sheets. Depending on the structure, onions can be place in one or two rows. In this storage method, the storage loss ranges upto 50% in four months of storage.

2. Bottom ventilated storage structures : These structures are permanent type structure which is constructed with Galvanized iron framework. The floor of such bottom ventilated storage structures with wooden bamboos. The sidewalls are also constructed with wooden bamboos. The roof is made with asbestos sheets. In this storage method, the storage loss ranges upto 30-40% in four months of storage.

3. Top and bottom ventilated storage structure : Galvanized Iron is used for the construction of these storage structures. Floor is constructed with wooden bantams and it is provided with ventilation. Bamboo is used for making the sidewalls and it is plastered with clay and cow dung paste. Lower portion of western sidewall and upper portion of the eastern sidewall were provided with ventilation. Due to the ventilated structure, the temperature inside the structure is reduced directly. The storage losses in this structure are 25-30% for four months of storage.

4. Low cost bottom ventilated structure : NRC for onion and garlic has designed low cost bottom ventilated structure for small and marginal farmers. This can be easily constructed by farmers with their own farm resources. The structure is constructed with bamboo/wooden framework provided with bottom ventilation. Bamboo or wooden bantams are used for making bottom and sidewalls. Thatch from dried sugarcane leaves or grasses were used for making of the roof. The storage losses in this structure are 30-32% for four months of storage.

5. Zero Energy Cool Chambers : Onion can also be stored in Zero Energy Cool Chamber (ZECC) with minimum physiological loss in weight, minimum sprouting and less rotting. The storage lossesin this structure are 22-25% for four months of storage.

6. Cold storage : Onion can be stored under cold storage at 0-2degree Celsius and 65-70% humidity. This is a considerably costly method but result into minimum crop losses. However the onions when moved out of cold conditions tend to sprout very fast. Cold storage of onion in combination with irradiation treatment results in minimum sprouting. The cold storage chain may be profitable near metropolitan markets and non-onion growing areas.

7. Controlled Atmospheric Storage (CAS) : CA storage of onion at 0-2 degree Celsius at 8% carbon dioxide and 1% Oxygen concentration reported much better storage life of more than 7-9 months. Onion stored in CA condition, also shows minimum sprouting during storage.

Low Cost Onion storage structure

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Packaging : Packaging in onion is not only for the purpose of containment but also for safety during storage, handling and transportation. Packaging of onion should be done in such a way that there is minimum impact, abrasion and compression injury. Packing should ideally be done in a small units for ease in handling during transit. Onions are packed in jute (hessian) bags, Nylon net bags, wooden baskets and plastic crates. Wooden basket and plastic crates ensures minimum damage during transit and transport.

Transport : In India, bulk of onion is grown in Maharashtra, Gujarat, Madhya Pradesh and Rajasthan. Hence these onions are required to be transported in all part of India including West Bengal to compensate the market gap situation. Onion stocks are locally transported in bullock carts or tractor trolleys from local farmers to nearby wholesaler/merchants. In distant markets onion are transported via train wagons and trucks. Gulf countries and South-East Asian countries have a huge demand of onion where transportation is basically done by waterways (cargo ships).

Storage diseases and disorders of onion

1. Neck Rot : Neck rot symptom appears as water-decay at neck area, which moves down word through entire bulb. Light gray fungal growth is generally visible at neck infection and on outer scales. Seed treatment before planting, proper drying and curing of onion are essential to prevent this storage disease.

2. Black mould : Black discoloration and shriveling at neck and on outer scales caused by the fungus *Aspergillus nigre*. This is often associated with brushing and leads to bacterial soft rot. Low temperature storage delays growth of fungus, but it is high under high temperature and high humid conditions. Proper shading curing reduces infection.

3. Bacterial rots : Several types of bacterial diseases have been reported to affect the onions in storage. Among them slippery skin, sour skin are common. Water-soaked, foul smelling, viscous liquidly rot is caused by *Erwinia* sp. The slippery skin is generally visible only at neck area and upon cutting to expose inner scales. Scales have a watery-cooked appearance. In Sour skin, slimy, yellow-brown decay generally limited to inner scales, which give off a sour odor when exposed. These diseases can be control by proper sanitation and crop rotation.

Bacterial rot of onion

Black mould of onion

4. Sprouting of bulb : This disorder is basically a natural phenomenon in which the germination and growth of green coloured sprout from the onion takes place. This takes place in presence of favourable temperature, relative humidity and light. This might be due to application of high nitrogenous fertilizers, direct exposure of sunlight or after removal from cold storage.

Pre-harvest and Post harvest treatments to prevent sprouting : Sprouting in stored onion is always a serious problem. The bulbs after harvesting tend to germinate and green sprout tends to come out. To avoid sprout inhibition, sprout suppressants like Isopropyl N-Chlorophenyl Carbamate (CPIC), TNCB, Malic Hydrazine are used. On-field spraying of 2500 ppm Malic Hydrazine at 75-90 days after transplanting prevent sprouting upto a certain extent. The gamma irradiation process has also been found effective for sprout inhibition. Dormant onion bulbs when subjected to 60-90 Krad Gamma radiation prevent sprouting. Onions stored at controlled atmosphere with 5–15% carbon dioxide at room temperature showed minimum sprouting till 226 days after harvesting.

Value Addition : Onion is more or less a seasonal crop and is available in the market at a very low price during the market glut. The same onion is available in the market during September to January at a very high rate. Adoption of optimum post harvest practices like good handling, proper packaging, transportation and storage might ensure optimum availability during off months. This would not only help the farmers to get a good price for their produce but also help in reduction of post harvest loss. There is a tremendous demand of processed products of onion. Some of the major processed products which can be prepared in West Bengal is discussed below:

1. Dehydrated onion/Dried onion scales : Dehydration in onion is the removal of water from the scales of the onion so as to reduce the available water necessary for growth and multiplication of microbes. Dehydration involves the application of external heat to vaporize water and removal of moist air from the dryer. Dehydrated or desiccated onion can be stored throughout the year and have same cooking properties to that of fresh onion. Dehydrated onions are easier to store as it is light in weight and smaller in volume. Varieties suitable for dehydration are Bombay White, Udaipur-102, Pusa White Round, Pusa White Flat, Ropali, Rangda, Pusa Red, Arka Niketan, Agrifound Light Red, Agrifound Dark Red and Arka Kalyan.

Dehydrated onion flakes

Frozen onion rings

Onion
↓
Peeling
↓
Cut in longitudinal shapes
↓
Spreading uniformly in surface
↓
Drying of the scales
↓
Regular turning of the scales
↓
packing air tight

2. Onion powder : Onion powder is an important value added product which has a tremendous demand in restaurants and preparation of baked products.

Selection of mature onion bulb
↓
Cut the bulbs into slices of thickness of 3-5 mm
↓
Full washing and colour protecting by dipping them in the baking soda solution
↓
Dewatering in centrifuge
↓
Spread the onion slices evenly in the drying machine
↓
Drying at 55-60 degree Celsius for 6-7 hours (final moisture content 4%)
↓
Grind the crunchy dehydrated pulp into powder

3. Onion paste : Onion paste is an important processed product which can also be an important component for day to day domestic use.

Selection of onion bulb free from rot
↓
Cut the bulbs into slices of thickness of 3-5 mm
↓
Grind the slices in the grinder
↓
Remove excess water by filtration
↓
Remove fibers and impurities
↓
Aseptic packaging

Onion Powder

Onion paste

4. Onion Essential Oil: Onion oil is an important flavouring substance which is widely used in the seasoning of processed products and is also used as a natural used preservative in some food products. Essential oil can be extracted using hydro-distillation method, solvent extraction method and supercritical extraction method. The finished onion oil is of a strong flavor of fresh onions.

5. Minimally processed onions : Matured onions are peeled, cut and packed in accepting packaging material so that it can retain its freshness for long duration. This is an innovative processed product suitable for metropolitan busy life where cutting onion is a time consuming event. Minimally processed onion simply needs to be washed slightly and can be cooked instantly.

6. Frozen onion rings : Onions are peeled and sliced into ring shape. After that these ring shaped fresh onion are subjected to freeze drying. Then the freeze dried onion rings are packed in a suitable packaging material under low temperatures. The frozen onion rings have a long storage life upto 12 months.

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FISH DIVERSITY AND FRESHWATER ECOSYSTEM

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Introduction

Freshwater ecosystems are a crucial component of the planet's biodiversity. They exhibit higher species richness compared to both terrestrial and marine ecosystems (Kar, 2007). This ecosystem supports a wide variety of animals, plants, and fungi, contributing significantly to vertebrate and invertebrate diversity. India is recognized as one of the twelve mega-biodiversity countries globally. It ranks 9th in terms of freshwater mega-biodiversity (Mittermeier and Mittermeier, 1997). The Northeastern region of India is identified as a biodiversity "Hotspot" by the World Conservation Monitoring Centre (WCMC, 1998). Historically, freshwater resources in India were primarily considered for economic purposes, such as irrigation, urban water supply, hydro-electric power generation, and waste disposal. The utilitarian perspective did not account for the conservation of the rich freshwater biodiversity present in these ecosystems.

Definition of Biodiversity : Biodiversity encompasses the range and variations found among both living and non-living entities, along with the intricate ecological systems they inhabit. This includes plants, animals, microorganisms, and their interactions. It is essential for ecosystem stability, environmental preservation, and acknowledging the intrinsic value of all species on Earth (Ehrlich and Wilson, 1991).

Importance of Biodiversity : Biodiversity offers a wide range of valuable goods and services to human societies. Some of these benefits are unique and irreplaceable. Preserving biodiversity is crucial for maintaining ecosystem health, ecological balance, and the well-being of both human and natural systems (Covich et al., 2004a). In essence, biodiversity is not solely about the diversity of life forms, but it also plays a critical role in maintaining the equilibrium of

Biodiversity and Fisheries : Freshwater ecosystems in India are significant hubs of biodiversity, particularly in terms of piscine resources (fish species). These resources are essential for nutrition and livelihoods. Despite their importance, the focus was often limited to their economic value, neglecting the need to conserve these resources and ensure sustainable usage for protein sources. Fish inhabit diverse aquatic habitats, with around 21,723 living species recorded. India is recognized as a mega-biodiversity country, occupying the ninth position in freshwater mega biodiversity. Species richness is highest in the tropics and decreases towards polar areas.

Fish Characteristics and Importance: Fish are cold-blooded aquatic vertebrates that breathe through pharyngeal gills and move using fins. They are highly diverse and abundant, making up a significant class of vertebrates in terms of both species and individuals. Fish have immense significance in human life, being staple food items for many, contributing to economies, and providing recreational value.

Bio-geographic Zones: The North Eastern (NE) region of India, spanning around 2,62,379 sq. km., is divided into two bio-geographic zones: Eastern Himalaya and North East India. These divisions

are based on floristic composition, naturalness of flora, and local climate (Rodgers and Panwar, 1988).

Biodiversity Hotspot : The NE region of India holds a substantial share of the country's biodiversity. It's recognized as part of the Indo-Myanmar biodiversity hotspot, contributing to one of the 25 globally recognized biodiversity hotspots.

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GUSTATORY STIMULANTS IN FISH

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Abstract
Many fish are during feeding dependent on both an olfactory and gustatory sense. There is great diversity between fish species concerning the kinds of molecules that are detected by taste buds that are accepted and stimulated for searching feed, the natural food choice being is important. Feed that does not right taste, does not taste at all or that contains bitter compounds is rejected after handling in the mouth of fish. Reduced palatability results in lower growth rates whereas feeding stimulants are a stimulus that promotes ingestion and increases growth rate. It is also important to use feeding stimulants to initiate feeding behavior. Several studies used synthetic amino acids (L-lysine and DL-methionine) as Gustatory Stimulants in fish feed.

Introduction
As profit margins decline for many aquaculture species, there is a need to optimize feed efficiency is paramount in intensive aquaculture systems, This can be accomplished by different strategies such as (a) complete consumption of the optimal amount of nutrients required for maximum growth (b) minimizing the time between feed application and ingestion (c) reducing feed input and concomitant waste and (d) increase the inclusion of low-cost plant materials in the feed formulation. The above strategies can be accomplished by the use of feeds containing highly digestible nutrients and chemical stimulants. The current article focuses on chemoattraction and feeding stimulation of fish and shrimp feed. Chemoreception and feeding stimulation is a chemical process in which water's dissolved stimuli interact with the taste buds' epithelial receptor cells. The taste buds are present all over the fish being highest in lips and barbells followed by the caudal fin area while the least was observed along the body surface. These taste receptors cells have receptors which collect chemical stimuli from the outside environment and transducer them into the basal cell of the dorsal region of the taste buds. The transduction event results in the transduction of stimuli into electrical stimuli and this information is then transmitted to the central nervous system through afferent gustatory nerve fibres (Facial, Glossopharyngeal and Vagal nerve). The ascending gustatory system transfers this electrical stimulus from the primary gustatory system to the secondary and then to the tertiary gustatory system. This way the information is transferred in the brain and the fate of the food is decided by the fish.

Species with highly developed sensory systems have sensitivity to sugar and salts that are 184 times higher than humans. Therefore, in order to consume the food by the fish, chemical stimulation of the taste receptor cells in the taste buds is foremost. So, chemo-attractants or chemical stimuli are therefore generally included in feeds for especially slow-feeding species to

help reduce feed wastage and water fouling by promoting feed efficiency and growth rate through improved feed intake. Feed ingredients rich in stimulants include fish hydrolysate, mollusc flesh (glycine and Betaine), shrimp meal, shrimp waste, squid meal, fish meal (high content of glutamic acid), krill meal, and soya lecithin (phospholipids).

Feeding Stimulants

Substances that enhance feeding in fish have been investigated and results suggest that: (a) taste is chemically mediated by substances inherent to a particular food item, but the ability to sense a stimulus depends upon the chemical nature of the food and the chemo sensitivity of a particular fish species, (b) mixtures rather than single compounds are more effective to stimulate feeding response, and (c) L-amino acids enhance feeding response in fish particularly the neutral amino acids. Dietary stimulants are phago-stimulatory substances that provide proper 'signals' that allow fish/shrimp to recognize the food source (Claus and Sorensen, 2017.). Common physiological properties of feeding stimulants are: non-volatile, low molecular weight (<1,000 kdal tons), nitrogen containing amphoteric, and water soluble in nature. According to Claus and Sorensen (2017), fish have a specific demand with regard to feeding stimulants (species-specific). Although a variety of feeding stimulants have been identified from experiments conducted with various fish species, most belong to a small group of chemicals like free amino acids, nucleotides and nucleosides, and quaternary ammonium bases.

The properties of feeding stimulants are consistent with these chemicals. Other stimulatory compounds are bile salts, carboxylic acids, phospholipids, steroid hormones, taurine and organic acids.

(1) Free amino acids

Free amino acids are those that are generally present in free form, are not bound to protein. The stimulatory effects of free amino acids are species specific and the fishes are categorized into two types based on their specificity of free amino acids: a) those that respond to a wide range of amino acids; b) those that respond to limited range. In general, carnivorous fish have higher sensitivity to alkaline and neutral amino acids (glycine, proline, taurine, valine) while herbivorous fishes respond to acidic amino acids (aspartic and glutamic acid). Alanine, glycine, proline, valine, tryptophan, tyrosine, phenylalanine, lysine and histidine are major stimulants for many fish. L-isomer form of amino acid is major stimulant than D-isomer form due to stereospecicity at the amino acid receptor cell in the taste buds. Short chain neutral amino acid (Alanine, glycine, proline) and basic amino acid (arginine) are more stimulatory than acidic amino acid (aspartate) (Olsen and Lundh, 2016.). L-amino acid mixture induced positive response in trout while ineffective for turnout. The gustatory receptors were highly responsive to amino acids containing 3 to 4 carbon atoms having unbranched and uncharged side chains. L-proline and L-Alanine is the most effective stimulus tested in carp gustatory system. L-cysteine is more stimulatory than L-proline in common carp (Wood and Arce Azocar, 2013).

Xue et al. (2001) evaluated the effect of several feeding stimulants on diet preference by juvenile gibel carp. They found the optimum inclusion level was 0.5% for betaine, 0.1% for glycine, 0.25% for L-lysine, 0.1% for L-methionine, 0.25% for L-phenylalanine enhanced the feeding, nutrient utilization and growth of fish. Fish meal supplemented with mixture of amino acids are insensitive as stimulant but when supplemented with plant ingredients shows higher sensitivity and enhanced feed intake. This is due to the presence of endogenous stimulants in the fish meal that

suppress the effect of external stimulants. Mixture of stimulants always shows a greater synergetic effect.

Amino acids mixture (mg/kg of feed): alanine (2000); glycine (3836); proline (305); valine (800); serine (1205);leucine (614); histidine (273); Tryptophan (318) shows a greater feed intake compared to Betaine alone (Kubitza et al. 1997). Betaine was more effective in some fishes when in combination either with single amino acids or amino acid mixtures (Hidaka, 1982; Metailler et al., 1983), suggesting a synergistic interaction between these substances. *Anguilla japonica* preferred a diet supplemented with a mixture of L-alanine, glycine, L-proline, L-histidine and UMP as compared with amino acids supplemented alone.

(2) Nucleosides and Nucleotides

Nucleotides have essential physiological and bio-chemical functions including encoding of genetic information, mediating energy metabolism and cell signaling as well as serving as components of coenzymes (Guo et al., 2017). Besides this, nucleotides show taste enhancer activity in fish feed which is evident by the presence of chemoreceptor's on the lip s of the fish that responded to nucleotides. The following molecular features were essential for activity:

(i) Purine ring
(ii) Oxygen function on position 6
(iii) Hydrogen or amino group on position 2
(iv) Hydroxyl groups on 2' and 3' positions.

Inosine, inosine-5'-monophosphate (IMP), adenosine-5'-diphosphate (ADP), guanosine-5'-monophosphate (GMP) and uridine-5'-monophosphate (UMP) have been identified as feeding stimulants for fish(Hossain et al., 2017). Among these, IMP and Inosine found to be having major stimulatory effect in increasing feed intake in fish. The Threshold for stimulation is 2-3 times higher than the amino acids stimulation. Nucleotides are naturally present in all foods of animal and vegetable origin as free nucleotides and nucleic acids. Devresse (2000) reported the total contents (after complete hydrolysis) of purine and pyrimidine bases in common aqua feed ingredients are fish meal (1.4%), press cake fish meal (0.4%), fish soluble (2.8%), yeast (0.9%), yeast extract (2.3%) and single cell proteins (2.1%). Kubitza et al. (1997) reported that dietary supplementation of IMP (2800 mg kg) enhanced feed intake of largemouth bass compared to the non-supplemented soybean meal-based diet. Rumsey et al. (1992) observed that dietary supplementation with 2.5% and 4.1% yeast RNA extract or 1.85% guanine or 2.17% xanthine significantly increased cumulative feed intake of rainbow trout. In turbot larvae, fed a diet supplemented with both betaine and inosine showed significantly higher growth than larvae fed diets supplemented only with betaine or inosine and a reduced amount of betaine (Metailler et al., 1983). Betaine and IMP were effective when they acted in synergy or in cases where the diet had low fishmeal content (Xue and Cui, 2001). IMP may serve as a primary candidate for feed attractant.

(3) Quaternary amines

Quaternary Amines is a group of organic chemicals that are analogues of ammonia (NH3), in which either one, two or three hydrogen atoms of ammonia are replaced by organic radicals. Quaternary amines have basic nitrogen atoms with cationic charge and the hydrogen atoms are replaced with four acyl or alkyl groups. Quaternary amine shows feeding stimulatory effect which includes glycine-betaine, trimethylglycine, dimethylthetin, and dimethyl-β-propiothetin. These compounds

are highly distributed in fish food organisms (Carr et al., 1996). Glycine betaine and trimethylglycine has been reported to act as feeding stimulant for benthos feeders such as puffer, Fugupardalis (Hidaka. 1982), pinfish, Lagodonrhomboides (Carr et al. 1976), Pigfish; (Carr et al.. 1977). Betaine mainly shows a synergetic effect with other stimulants (mainly with amino acids). However, TMA shows decreased feed intake in salmon, turbot, and sea bream.

Role of feeding stimulants in aquaculture

- Increased initial palatability and reduced feed input (complete consumption) and improved overall nutrient mass transfer (feed- target)
- Reduced levels of uneaten or wasted feed that improved feed conversion and water quality, both potentially enhancing growth rates
- Increased feed utilization and growth rate by reduced leaching of nutrients in water and excreted nitrogen
- Reduced time in weaning from living prey to inert feeds in larvae
- Alternative proteins, such as plant proteins can be incorporated along with stimulants thus minimizing the cost
- Acceptability of medicated feed can be enhanced

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HARNESSING THE FLOW: WATER MANAGEMENT AND IRRIGATION INNOVATIONS FOR A SUSTAINABLE FUTURE

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Introduction

Water, the lifeblood of our planet, sustains all living beings and fuels agricultural productivity. However, with climate change and increasing water demands, efficient water management and irrigation practices have become more crucial than ever. In this article, we will explore the significance of water management in agriculture, the challenges it faces, and the innovative solutions and irrigation techniques that are helping farmers optimize water usage and ensure a sustainable future. As the global population continues to grow, and the impacts of climate change become increasingly evident, water management has emerged as one of the most pressing challenges of our time. Water is a finite and essential resource, and its sustainable management is crucial for ensuring food security, supporting ecosystems, and maintaining human well-being. In this article, we will explore some of the future constraints in water management and the potential challenges that need to be addressed for a sustainable future.

The Importance of Water Management

Water management in agriculture involves the judicious use, distribution, and conservation of water resources to maximize crop productivity while minimizing waste. It plays a vital role in ensuring food security, environmental protection, and socio-economic stability. With the global population projected to reach nearly 10 billion by 2050, managing water resources efficiently is imperative to meet the rising demand for food and sustain our ecosystems.

Challenges in Water Management

1. **Water Scarcity:** Many regions around the world face water scarcity due to erratic rainfall patterns and increasing demands from various sectors. This poses a significant challenge for farmers who rely on adequate water supply for their crops.
2. **Water Pollution:** Pollution from agricultural runoff and industrial waste contaminates water sources, affecting both human health and agricultural productivity. Ensuring clean and safe water for irrigation is essential for sustainable agriculture.
3. **Inefficient Irrigation:** Traditional irrigation methods like flood irrigation often led to excessive water consumption, wastage, and uneven distribution, causing waterlogging and soil degradation.

Innovative Water Management and Irrigation Techniques

1. **Drip Irrigation**: Drip irrigation is a highly efficient method that delivers water directly to the roots of plants through a network of pipes and tubing with small emitters. This targeted approach reduces water wastage, increases crop yield, and minimizes weed growth.

2. **Sprinkler Irrigation:** Sprinkler systems distribute water over crops in the form of a gentle rain, reducing evaporation and providing more uniform water coverage. Modern sprinkler technologies include weather-based controllers to optimize water usage based on real-time weather conditions.
3. **Rainwater Harvesting:** Capturing and storing rainwater during the rainy season can provide a valuable source of water for irrigation during dry spells, reducing reliance on freshwater sources.
4. **Smart Irrigation Systems:** Leveraging the power of technology, smart irrigation systems use sensors, weather data, and advanced algorithms to precisely regulate irrigation schedules based on the specific needs of the crops and soil moisture levels.
5. **Soil Moisture Monitoring:** Installing soil moisture sensors allows farmers to monitor the water content in the soil and determine the optimal timing for irrigation, preventing overwatering and reducing water wastage.
6. **Conservation Tillage:** Conservation tillage practices, such as no-till and minimum tillage, help retain moisture in the soil, reduce erosion, and improve overall water use efficiency.

Conclusion

Water management and irrigation innovations are key to addressing the challenges posed by water scarcity and ensuring sustainable agricultural practices. By adopting efficient irrigation techniques like drip and sprinkler systems, embracing rainwater harvesting, and employing smart technologies for precision irrigation, farmers can optimize water usage, increase crop yields, and reduce their environmental impact. Furthermore, governments and policymakers must support farmers by investing in water infrastructure, promoting water conservation practices, and providing incentives for adopting sustainable irrigation methods. Research institutions can play a crucial role in developing and disseminating new water management technologies and best practices. Together, we can harness the flow of water sustainably, safeguarding our precious water resources and cultivating a future where agriculture thrives, ecosystems flourish, and our planet remains bountiful for generations to come. Water is indeed the elixir of life, and responsible water management is the path to a sustainable and resilient future. Water management is a multifaceted challenge that requires a coordinated and integrated approach to address the constraints and uncertainties that lie ahead. Governments, policymakers, researchers, and communities must collaborate to develop comprehensive water management strategies that consider the impacts of climate change, balance water allocation, prioritize water quality, and promote sustainable practices. Investments in water infrastructure and the adoption of modern technologies can improve water use efficiency and reduce wastage. Additionally, promoting water conservation practices, implementing water pricing mechanisms, and raising awareness about the importance of responsible water management can lead us towards a more sustainable and water-secure future. By acknowledging and acting upon these future constraints, we can ensure that water, the lifeblood of our planet, remains a resource that sustains life and prosperity for generations to come.

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INDIGENOUS TECHNICAL KNOWLEDGE (ITK) IN ORGANIC AGRICULTURE

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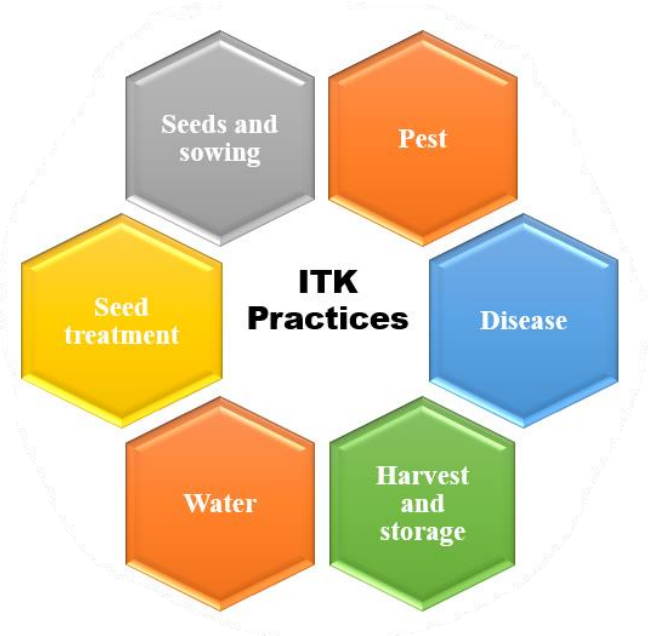
Introduction

ITK is the abbreviation for Indigenous Technical Knowledge, which refers to the knowledge utilised by cultivators for generations. It refers to the knowledge held by cultivators in rural communities regarding the production, protection, and preservation of crops grown by themselves and other locals. Local knowledge is distinctive to the culture of a given society. It serves as the foundation for rural community decision-making in agriculture, healthcare, food preparation, education, and the management of natural resources (Anwesha and Pardeep, 2012).



Seeds and sowing

A few minutes were spent soaking seeds in water before combining them with moist red soil and wood ash. The seeds were planted after sun-drying. This prevented parasite infestations during the stage of crop growth. The chaffy seeds that float on the water's surface were soaked with paddy seeds. The seeds were placed in a gunny bag, and the mouth of the bag was covered with paddy straw to allow for the free movement of air inside. This was stored overnight and distributed to the nursery field the following morning. When the seeds are immersed in water, the unviable seeds will float on the water's surface. These seeds can be extracted, and the sinking seeds can be used for cultivation. This method facilitates the removal of damaged seeds. Put some water in a container and place an egg in it. Slowly add salt until the egg floats to the surface of the

water. When dropped into this water, seeds of superior quality will descend to the bottom. Remove the nonviable seeds floating on the water's surface. Wash the chosen seeds in clean water twice or thrice. If this is not performed, germination capacity will be diminished. Through this method, nonviable seeds can be eliminated. This method should be used when there is a greater quantity of debris.

Seed Treatment

500 millilitres of cow urine should be diluted in 2.5 litres of water. Place the seedlings to be planted in small bags and soak them for 30 minutes in cow's urine extract. Before sowing, the seeds are shade-dried. Five hundred grams of powdered sweet flag rhizome should be diluted in 2.5 litres of water. This is the amount needed to treat seedlings sown on one acre. Place the seeds in small containers and soak them for 30 minutes in this extract. Before sowing, let the seeds dry in the shade. Before sowing cotton seeds, they were treated with ash, cow manure slurry, buttermilk, and a small amount of edible oil to improve germination. Selected banana stems for planting were removed and sun-dried for twenty days. These were planted before the advent of the monsoon (rains) in April and May to promote rapid growth of the sucker. To obtain greater yields, it is preferable to begin planting from the 'Sani moolai' (northeast) portion of the field.

Weed management

The weed population will be reduced by repeated tillage. Erukku (*Calotropis gigantea*) is used as a green manure to prevent the spread of Aarai (*Marsilea quadrifolia*). Horse gramme can be used to control almond grass (*Cyperus rotundus*). To control nut grass, the fields are frequently ploughed with a plough made from neem trees, and neem cake is applied to the soil regularly. When ploughing and sowing, 50 kilogrammes of neem cake are applied to the field to suppress nut grass. Continuous submersion of a field for some time suppresses weeds.

Pest management

Uninterrupted precipitation leads to an increase in the number of parasites and diseases. Plants grown in alkaline soils are more susceptible to disease. Growing 'Thangarali' (T*ecoma stands*) and 'Sevvarali' (*Nerium oleander*) as trap crops and insect control border crops. Near the irrigation channel, bovine dung, cow urine, calotropis leaves, and neem cake are placed in a pit. After decomposition, irrigation water is added. Neem oil and neem seed kernel extract are two of the most widely used organic pesticides. Before transplanting paddy, seedlings are maintained in small portions of water pulverised with ash and neem seeds. Half a Kg of neem seeds and one kilogramme of ash are sufficient for combining with water to accommodate 50 bundles of seedlings per hour for a 15-square-foot plot. The crop produced by treated seedlings is devoid of pests and diseases (Nandan *et al*., 2021).

Harvest and storage

Two days of sun drying and one day of shade drying paddy seeds improve their storage quality. To prevent pest infestation, pearl millet grains are stored with Nochi leaves. Pest escapes with fifty kilogrammes of red gramme seeds combined with one kilogramme of sweet flag powder. Wet ash combined with millet kernels reduces pest infestation. Red soil combined with pulses reduces the attack of Bruchids. Preservation of vegetable seeds was done by pressing it over cow manure paste fixed on the kitchen walls over the hearth. Cow dung and seeds are progressively dehydrated. Before storage, cereals are mixed with lime juice and sun-dried to prevent insect

infestation. After mixing seeds with neem and vitex leaves, they are stored safely in earthen containers. This was done to safeguard the seedlings from insect attack and increase their viability.

Conclusion

Indigenous Technical Knowledge has immense potential to benefit the society but an appropriate association should be needed between the modern and traditional knowledge.

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MANAGING SOIL HEALTHFOR SUSTAINABLE AGRICULTURE

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Summary

Soil is a precious resource that underpins successful and sustainable farming practices. Managing soil in modern agriculture is crucial for achieving sustainability in agriculture. Sustainable soil management practices are essential for maintaining and enhancing soil health, ensuring long-term agricultural productivity, and mitigating environmental impacts. Sustainable soil management is not only beneficial for farmers but also for the environment and society as a whole.

Introduction

Soil plays a fundamental role in agriculture, serving as the foundation for crop growth and providing essential nutrients and support for plants. Understanding soil properties and effectively managing soil in agriculture is crucial for ensuring successful and sustainable farming practices as healthy soils are the foundation of productive and resilient farming systems. Here are some strategies and practices for maintaining and improving soil health in sustainable agriculture:

1. Crop Rotation: Rotate crops in your fields to break pest and disease cycles and prevent soil nutrient depletion. Different crops have different nutrient requirements and root structures, which can help maintain soil health.

2. Cover Crops: Plant cover crops during fallow periods to protect the soil from erosion, improve organic matter content, and fix nitrogen. Common cover crops include legumes like clover and vetch.

3. Minimal Tillage: Reduce or eliminate tillage as much as possible, as excessive tillage can disrupt soil structure and lead to erosion. No-till or reduced tillage systems help retain moisture, improve organic matter, and reduce soil erosion.

4. Organic Matter Management: Incorporate organic matter into the soil through practices like composting and the use of organic mulches. Organic matter improves soil structure, water retention, and microbial activity.

5. Nutrient Management: Use soil testing to determine nutrient needs and apply fertilizers judiciously. Overuse of synthetic fertilizers can lead to nutrient imbalances and soil degradation. Employ precision agriculture techniques to optimize nutrient application.

6. Conservation Tillage: Implement conservation tillage practices such as strip-till or ridge-till, which disturb only a portion of the soil, leaving the rest covered with crop residue. This minimizes soil erosion and preserves soil structure.

7. Crop Diversification: Grow a diverse range of crops to reduce pest and disease pressure and promote beneficial soil microbes. Crop diversity can also improve the overall resilience of the farming system.

8. Soil Testing and Monitoring: Regularly test your soil for pH, nutrient levels, and organic matter content. Monitoring helps you make informed decisions about soil amendments and management practices.

9. Water Management: Implement efficient irrigation techniques like drip or precision irrigation to prevent waterlogging and soil erosion. Proper water management helps maintain soil structure and prevents nutrient leaching.

10. Integrated Pest Management (IPM): Use IPM practices to reduce the need for chemical pesticides. This can include biological control methods, crop rotation, and the use of resistant crop varieties.

11. Agroforestry: Integrate trees and woody shrubs into your farming system to improve soil health, provide shade, and offer additional income opportunities through timber or fruit production.

12. Soil Conservation Structures: Construct terraces, bunds, and contour farming systems to control erosion and manage water runoff effectively.

13. Soil Testing: Regularly test your soil for pH, nutrient levels, and organic matter content. Soil tests provide valuable information to guide nutrient management.

14. Education and Training: Stay informed about the latest research and best practices in soil health management. Attend workshops, webinars, and training programs to improve your knowledge and skills.

15. Economic Viability: Consider the economic viability of soil management practices. Sustainable soil health practices should not only benefit the environment but also be economically feasible for your farm.

16. Long-Term Perspective: Recognize that soil health management is a long-term endeavor. It may take several years to see significant improvements in soil health, but the benefits in terms of crop yields, resilience, and sustainability are well worth the effort.

Sustainable agriculture and soil health go hand in hand. By adopting these strategies and practices, farmers can contribute to the long-term health of their soils while maintaining or even improving crop productivity and reducing environmental impacts.

Conclusion

The management of soil in agriculture is essential for ensuring food security, preserving natural resources, and minimizing the environmental impact of farming practices. Sustainable soil management techniques are critical for maintaining soil health and productivity over the long term. Sustainable agriculture requires a holistic approach that considers the interplay of soil health, crop management, and environmental stewardship. By prioritizing soil health, farmers can improve yields, reduce environmental impact, and build resilient farming systems for the future.

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MILLET : SMART NUTRITIVE FOODFOR THE FUTURE

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Abstract
Millets, ancient and versatile grains, are vital for food security and nutrition, particularly in arid regions. India leads global millet production, with 80% of Asia's output. Despite their rich nutritional content and climate resilience, millets lost prominence due to the Green Revolution. However, they are now recognized as "superfoods" or Nutri-Cereals. Millets offer a wealth of nutrients, dietary fiber, and bioactive compounds, aiding in cancer, heart disease, and diabetes prevention. Environmentally, millets reduce carbon footprint and water usage. They align with UNSDGs, promoting zero hunger, good health, climate action, and economic growth. Raising awareness of millets' health benefits is crucial, especially amidst rising lifestyle diseases. Strategies like renaming millets as "Nutri Cereals" and declaring 2023 as the 'International Year of Millets' are underway. Coordinated efforts, policy support, and inclusive initiatives are essential to mainstream millets in agriculture and global markets, fostering a healthier and more sustainable future.

Introduction
Millets are the traditional and most versatile grains that play a significant role in developing food and nutrition security. They are a collective group of small-seeded annual grasses that are cultivated for grain purposes in dry areas of temperate, tropical, and subtropical regions. The cultivation of millets dates back to Indus Valley Civilization around 3000 BC. Derived from the French word “mille” which means a handful of millet containing thousands of seed grains (Taylor and Emmambux 2008). Millets can be broadly classified under 3 categories: Major millets (Pearl Millet, Sorghum, Finger Millet), Minor millet (Foxtail Millet, Proso Millet, Kodo Millet, Little Millet) and Pseudo millets (Buckwheat, Amaranth). Millets comprise an integral part of the local food system in Asia and Africa and have a major contribution towards sustainable agriculture and a healthy world.

Globally, India is the largest grower of millet, producing about 170 lakh tonnes of millet with 26% of the world and 80% of the production of Asia. The major millets producing states of India are Rajasthan, Karnataka, Uttar Pradesh, Haryana, Maharashtra, and Gujarat. In India, majorly cultivated millets with their percentage share of production are bajra (60%), jowar (27%) and ragi (11%). Prior to the Green Revolution, millets made up about 40% of all cultivated grains; this percentage has since fallen to about 20%. Besides, the area under millets has also reduced drastically as it got replaced with profitable commercial crops, oilseeds, and pulses. Socio-economic dynamics relegated them to be the grains of the poor and they were commonly referred to as “coarse cereals” or “Mota Anaj” but realizing the nutritional benefits they are now regarded as superfoods or Nutri-Cereals.

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Millet : A Nutritional Storehouse

Millets are good sources of carbohydrates, micronutrients and phytochemicals. The millets contain 7-12% protein, 2-5% fat, 65-75% carbohydrates and 15-20% dietary fiber (IIMR, 2017). They are considered to be the storehouse of nutrients having a substantial amount of minerals like calcium, potassium, iron, magnesium, zinc and Vit B complex. Millets are gluten-free, non-allergenic and have a low glycemic index. Millets also contain multiple bioactive phytochemicals including feraxans, β-glucan, lignans, inulin, resistant starch, and phenolic compounds (e.g., ferulic acid, caffeic acid) which help to protect from cancer and cardiovascular disease, diabetes, high blood pressure and Parkinson's disease (Dayakar *et al.*, 2017). Polyphenols act as an antioxidant, are anti-carcinogenic and have a neuroprotective mechanism. Millet is prebiotic and supports beneficial gut bacteria which aids in the digestive system. Being rich in magnesium and potassium, millet reduces blood pressure by acting as a vasodilator thus being advantageous for heart patients. They are ideal for lowering cholesterol by eliminating 'bad cholesterol' due to higher levels of dietary fibre. Thus, millets offer a plethora of nutritional benefits supporting a healthy life.

Food grain	Protein (g)	Fat (g)	Crude fiber (g)	Minerals		Sulfur containing amino acids		Unsaturated fatty acids		
				Ca(mg)	Fe(mg)	Methionine	Cysteine	Oleic	Linoleic	Linolenic
Finger millet	7.3	1.3	3.6	344	3.9	210	140	-	-	-
Kodo millet	8.3	1.4	9.0	27	0.5	-	-	-	-	-
Proso millet	12.6	1.1	2.2	14	0.8	160	-	53.80	34.90	-
Foxtail millet	12.3	4.3	8.0	31	2.8	180	100	13.0	66.50	-
Little millet	7.7	4.7	7.6	17	9.3	180	90	-	-	-
Barnyard millet	6.2	2.2	9.8	20	5.0	180	110	-	-	-
Sorghum	10.4	1.9	1.6	25	4.1	100	90	31.0	49.0	2.70
Bajra	11.6	5.0	1.2	42	8.0	150	110	25.40	46.0	4.10
Wheat (whole)	11.8	1.5	1.2	41	5.3	90	140	11.50	56.30	3.70
Rice (raw milled)	6.8	0.5	0.2	10	0.7	150	90	42.50	39.10	1.10

Table: Nutritional status of different millets

Climate-friendly

In contrast to the major cereals like wheat and rice which have greater global warming potential (4 and 3.4 tons CO_2 eq/ha respectively) and also higher carbon equivalent emission rates, overall millet can reduce carbon footprint (Jain *et al.,* 2016). Millet is a drought-resistant cereal crop with a rainfall requirement of as low as 20 cm, which is several folds lower than the staple crops cultivated. For instance, foxtail millet requires just 257g of water for producing 1g of dry biomass, whereas wheat and maize require 510and 470g, respectively (Nadeem *et al*., 2020). Millet can be

grown in a wide range of pH (4.5 to 8) and produced well in acidic, sandy and alkaline conditions. Moreover, it is a short-duration crop (60 to 100 days) and requires minimal or no fertilizer affecting less the soil health. Being a C_4 crop it is environment friendly as it can fix more atmospheric carbon dioxide even under high temperatures, convert it to oxygen, have a low transpiration rate with the highest water use efficiency and have more photosynthetic rate as compared to C_3 plants. Thus, millets can help phase out climatic anomalies and positively contribute to mitigating climate change.

Alignment with SDGs

The enormous potential of millets aligns with the aegis of UN Sustainable Development Goals viz. SDG 2 (Zero Hunger) as millet yields well even in drought situations and contributes to food security, SDG 3 (Good Health and Well-being) being loaded with several beneficial nutrients, SDG 8 (Decent Work and Economic Growth) since millets can earn additional revenue by strengthening market opportunities, SDG 13 (Climate Action) being environment-friendly and more resilient to climate shocks and SDG 15 (Life on Land) as millets possess the potentiality of transforming agriculture production process into a sustainable one with decent life existence. Besides, expanding the millet-based processing network across the value chain may help to generate income among the resource-poor farming community, thus meeting SDG 1 (No Poverty).

Awareness creation

Despite the presence of diverse bioavailable nutrients, there is a popular fallacy that millet is poor man's food as for several decades their consumption was restricted among the resource-poor population offering several opportunities for their cultivation. People's perception of a healthy diet has strengthened corresponding to Covid-19 implications and there is an increased demand for healthy as well as nutritious alternatives to staple diets. Irrespective of rural or urban areas, there has been seen an upsurge in the hidden hunger-led lifestyle diseases which helped to bring back millet in the diet as it is crucial to trigger the immune response by intake of nutritious food (Calder, 2020). They are a good source of antioxidants (quercetin, curcumin and catechins), thus considered to be an immunity booster. Keeping in mind their nutraceutical properties, the generation of awareness through decisive planning followed by strategic promotion is important to help millets attain global attention.

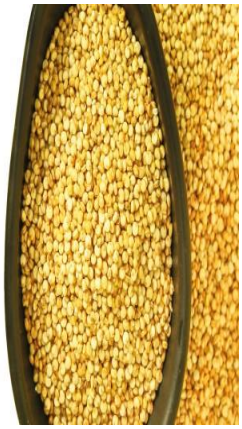
Strategies to include millet under mainstream agriculture

Coordinated intervention on the local, regional, and international levels is needed to promote millets worldwide with conducive policies, which calls for a multi-stakeholder approach. The framework for mainstreaming millets is centered around several dimensions from production, processing, packaging, and distribution to consumption. An insight into the various strategies undertaken by the government are summarized:

The year 2018 was proclaimed the National Year of Millets with the goal of greater marketing and demand generation. Millets were renamed "Nutri Cereals" in April 2018.

On the initiatives of Govt. of India and under the visionary leadership of the Prime Minister, the UN General Assembly has declared the year 2023 as the 'International Year of Millets' with support from over 70 nations across the globe to provide millets a new identity in the international market.

On March 2023, PM Narendra Modi inaugurated a two-day Global Millets (Shree Anna) Conference, Exhibition and Buyer-Seller meet to position India as the 'Global hub for millets'.



In 2012, the Initiative for Nutritional Security through Intensive Millets Promotion (INSIMP) was formulated with an allocation of Rs 300 crores as a part of the RKVY to improve production and post-harvest technologies in an integrated manner.

Department of Agriculture and Farmers' Welfare (DA&FW) has supported the establishment of three Centres of Excellence (CoE) on millets at IIMR, Hyderabad; CCSHAU, Hisar; and UAS, Bengaluru.

The GoI has enhanced the Minimum support price (MSP) for millet to promote millet cultivation substantially.

The government has funded 66 millet-focused start-ups with investments exceeding a cumulative Rs.6 crore.

To transition away from rice and wheat in the mid-day meal programme (now known as the PM POSHAN Scheme), NITI Ayog has been promoting the need to include millet.

FSSAI is actively spreading awareness of the health benefits of millets by celebrating 'Recipe Ravivar' every Sunday on social media platforms. FSSAI will soon formulate a guideline for schools, hospitals, government canteens etc, to incorporate millets, popularly known as 'wonder food' due to their numerous health benefits, as nutritional options in the food menu.

The Centre's Millet Mission will focus on developing farm-gate processing and empowering farmers through collectives while focusing on value-addition and aggregation of the produce.

The State governments, notably Karnataka and Orissa have initiated millet missions.

Conclusion

The combined initiatives of various Government departments, ministries, as well as states and UTs in India have ignited a momentum aimed at promoting millets and transforming them into a groundbreaking movement. Embracing millets is not just a dietary choice but a commitment to a healthier and more sustainable future for all.

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NEW AGE FERTILIZERS FOR RESPONSIBLE NUTRIENT MANAGEMENT SOLUTIONS

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Abstract
One of the high priority objectives of plant-nutrition will be ensuring a long-term sustainable nutrient management system for crop production, and developing more efficient mineral nutrient uptake by crop plants and improving intra and intercellular use of nutrients without detrimentally affecting the environment. This paper highlights the importance of New Age Fertilizers for smart agriculture.

Introduction
Agriculture plays an important role in economic development of India, and more than 50% of its population is dependent on agriculture. The rising population especially in developing countries such as India is anticipated to increase the demand for fertilizers. India ranks third in the world for food grain production after China and the U.S. Hence, increase in the demand for food production across the world is estimated to drive the demand for fertilizers market.

Fertilizers play an important role in enhancing the crop productivity by improving the soil fertility, they support the growth of crops. As fertilizers are food for plants, without the use of fertilizers, the crop yield and production would decrease significantly. All these aspects are estimated to drive the demand for fertilizer market during 2022-2030. Responsible nutrient management is indispensable in meeting food security needs of burgeoning population in the 21st century.

In the coming decades there will be increasing pressure on global food systems, and agriculture will have the challenge to provide food security for agro wing world population without impacting environmental security. Indian agriculture is now a days, generally based upon imbalanced and exploitative use of fertilizers and other agrochemicals putting the sustainability and productivity of agricultural systems into stake. Indiscriminate and imbalanced use of chemical fertilizers over the years has resulted environmental problems, depletion of organic carbon content, micro flora and fauna, and damage to soil fertility with deleterious effects on crop productivity. Accordingly, it will be necessary to use modern technologies in agroecosystems in order to supply sufficient food and decrease the negative impacts on the environment induced by chemical fertilization and by inadequate disposal or reuse of agricultural wastes. A combination of biotechnology, improved organic inputs, fully water soluble fertilizers, biofertilizers, bioenhancers and nano technology have the potential to revolutionize agricultural systems and provide solutions for current an future problems.

The fact that at least 60% of the presently cultivated soils globally have several mineral problems, like toxicities of Al, Mn and Na, and deficiencies of N, P, K, S, B, Fe and Zn, makes responsible plant

nutrient management is considered as most import major promising research area needed to meet the demand for massive increases in food production required to feed the growing world population. Current soil fertility scenario of Indian soils indicates that 85-90 %, 70-80 %, 42 %, 49 %, 33 %, 15 %, 7 %, 6 % and 4 % soils of India are deficient in N, P, S, Zn, B, Fe, Mo, Mn and Cu, respectively. This scenario of nutrient deficiency is not uniform over the regions but location, region, soil and crop specific. Zn deficiency is mainly associated with the states of Maharashtra (86%), Karnataka (72%) whereas, B deficiency is widespread in West Bengal (68%) and Bihar (38%) and most parts of Uttar Pradesh particularly in vegetable and fruit crops. Other micronutrients such as Fe are mainly deficient in Karnataka (35%), Himachal Pradesh (27%). Fertility imbalance requires management of macro, secondary and micronutrients deficiencies in view of stagnant/decline in productivity of most crops which is a cause of concern and requires immediate attention. Thus, there is need of more smart new age specialty fertilizers for site and location specific remedy of nutrient deficiency.

Speciality Fertilizers (SFs)

It must be recognized that the nutrient needs of Indian agriculture are now bigger and more varied. Fertilizers are a costly input and their availability is also limited. Indian fertilizer companies started the R&D work on specialty products in early 1980s. IFFCO developed urea super granule (USG), also were release nitrogenous fertilizer and conducted larges cale field demonstrations/trials to evaluate its agronomic efficacy. These demonstrations/trials established the superiority of US Gover the prilled urea and USG was included in the FCO in 1990. The absence of suitable applicator for placement of USG in soil was the main constraint in its adoption by the farmers. The National Fertilizers Limited (NFL) developed urea ammonium nitrate (UAN), a liquid nitrogenous fertilizer. Based on agronomic advantages, UAN was included in FCO in 1995. Again, the use of UAN could not be commercialized due to the transportation and storage problems.

The fertilizer industry faces a continuing challenge to improve its products to increase the efficiency of their use, particularly of nitrogenous fertilizers, and to minimize any possible adverse environmental impact. This is done either through improvement of fertilizers already in use, or through development of new specific fertilizer types. SFs are innovative sources of nutrients which applied in special condition of soil and plant for special action in plant for achieving higher recovery, efficiency and economy. SFs include an array of products ranging from low-end stabilized nitrogen fertilizer products for broad are a cropping systems, to high value premier products ranging from water soluble fertilizers (WSFs) for foliar fertilization an drip-fertigation to controlled release fertilizer products for turf and ornamental plants. They restrict the amount of moisture contact and help gradually release fertilizer nutrients, usually over a few weeks or a few months. SFs contribute to advanced fertilizer management programs and to innovative farming systems such as no-tillage farming. They significantly reduce possible loss of nutrients, particularly losses of nitrate nitrogen between applications, and uptake by the plant through gradual nutrient release. They also reduce loss of ammonia due to volatilization, which substantially decreases the risk of environmental pollution. Now-a-days, liquid fertilizer administration that is more effective and efficient guarantees that plants and crops get the nutrients they need at the correct time and in the right place, with minimal waste. As a result of the development of novel urease inhibitors and low-cost polymer coating technologies, highly

efficient fertilizers are rapidly developing in the agriculture business in numerous fields such as cereals and industrial crops.

There is no universal definition or category of specialty fertilizers. International Fertilizer Association (IFA) included controlled release fertilizers (CRFs), slow release fertilizers (SRFs), sulphur coated urea (SCU), stabilized nitrogen fertilizers (SNFs), WSFs, liquid NPKs, and chelated micronutrients and boron in the irassessment study of the global market for special products. In India, the specialty fertilizers are categorized broadly as water soluble fertilizers, neem coated urea, fortified fertilizers, customized fertilizers (CFs), micronutrient fertilizers, and liquid fertilizers. Mentioned below are the speciality fertilizers of IFFCO which are available all over the country through its robust marketing network ie. Pradhan Mantri Kisan Samriddhi Kendra, IFFCO eBazar, State Cooperative societies' agri-inputs centres, Agri-Junctions, IFFDC's fertilizer sale centres etc.

Water Soluble Fertilizers

Water soluble fertilizers (WSFs) are 100% water soluble materials and have very low salt index to minimize the potential for burning of plant tissue. WSFs were introduced in India way back in the late 1990s. Till 2005, their usage was restricted to Maharashtra. By 2011, adoption of WSFs had spread on to the states of Gujarat, Madhya Pradesh, erstwhile Andhra Pradesh, Tamil Nadu and Karnataka. From 2011 onwards, many states of North India started using WSFs.

The Government of India recognized the increasing need of 100% water soluble fertilizers for fertigation and created a separate category for WSFs in Fertilizer Control Order (FCO) in 2003. A number of grades of WSFs have been developed to meet the demand of crops on specific growth stages. The NPK combinations are starter grades (19:19:19; 20:20:20; 18:18:18), NK rich grade 13:5:26 for growth in middle stages; mono-potassium phosphate (0:52:34); mono-ammonium phosphate (12:61:0); potassium nitrate (13:0:45) for sugar conversion and disease resistance.

The market growth for micro-irrigation is showing increasing trend year after year. But the growth of water-soluble fertilizers is not maintaining the same pace as micro irrigation doing over the years. This is mainly due to higher cost and low awareness levels coupled with poor extension services which have restricted the speedy market growth. The market is currently showing a constant growth of 20-22% every year.

(b) Fully Water Soluble Fertilizers : Water soluble fertilizers are 100% water soluble solid fertilizers having high content of macronutrients with low salt index. Besides foliar feeding, they ensure simultaneous delivery of water and nutrients to the crop through subsurface drip irrigation system, ensures that plant nutrients are directed to the active rootzone. IFFCO is providing mono potassium phosphate, mono ammonium phosphate, potassium nitrate, calcium nitrate, potassium sulphate and 19:19:19 NPK fertilizer. (**Figure 1**).

Foliar application is efficient but sometimes availability of suitable water soluble fertilizer is limiting. High water soluble specialty fertilizers are exclusively useful for foliar application and fertigation. These fertilizers are having varying ratio of primary, secondary and micronutrient with low salt index and are compatible with other agrochemicals. Popular high water soluble specialty fertilizers are:

1. Mono Potassium Phosphate (0-52-34)
2. Mono Ammonium Phosphate (12-61-0)
3. Potassium Nitrate (13-0-45)

4. Sulphate of Potash
5. Calcium Nitrate
6. NPK 19:19:19

Figure 1. IFFCO speciality/fully water soluble fertilizers

Mono potassium phosphate (MKP) : MKP has an NPK ratio of 0:52:34. Application of MKP reduces premature flower dropping and fruit shedding. It gives a significant increase in yield when sprayed at the time of flowering, fruit formation, and grain filling stages. Monopotassium phosphate is produced by the action of phosphoric acid on potassium carbonate. Fertilizer-grade MKP powder contains the equivalent of 52% P_2O_5 and 34% K_2O, and is labelled NPK 0-52-34. MKP powder is often used as a nutrient source in the greenhouse and in hydroponics.

Mono Ammonium Phosphate (12-61-0) (MAP) : MAP is a completely water-soluble fertilizer. The NPK ratio of this fertilizer is 12:61:00. MAP is highly-concentrated source of phosphorus for plants (61% P_2O_5 / 27% P), free of chloride, sodium and other detrimental elements for plants, It has **d**ouble benefits. MAP contains nitrogen in ammoniacal form which offers more control over the amount of nitrogen that is available to crops when applied. The ammonium ($NH4^+$) form of nitrogen which lowers the pH in the root zone and thus enhances phosphorus availability. The high phosphorous content in MAP ensures the high immunity of the crops against unfavourable environmental conditions. MAP helps in flower setting and panicle emergence. As a highly efficient source of phosphorus and nitrogen for plants, recommended for use at the beginning of the growth season, when phosphorus availability is crucial for the establishment of the root system. MAP can be tank-mixed with other fertilizers to meet crop nutritional needs throughout the growth cycle. is suitable for preparation of fertilizer blends and for production of liquid fertilizers. MAP should not be mixed with calcium or magnesium fertilizers. MAP is moderately low pH (safer and less corrosive compared to urea phosphate), suitable for fertigation, foliar application and production of fertilizer blends and nutrient solutions.

Potassium Nitrate (13:0:45) : Potassium nitrate for healthier and stronger plants .The potassium present in potassium nitrate form helps to construct thicker cell walls, and increase the level of electrolytes in the cells, which, in turn, increases the plant's resistance to frost, drought and increases plant's resistance to pathologies, favours the initiation and ramification of the root system, prevents water loss and improves better water absorption by the plants. The potassium in

potassium nitrate is responsible for the opening and closing of the stomata, minimizes plant transpiration and thereby reduces its water requirements and prevents accumulation of salts.

It is highly water-soluble, dissolves rapidly and completely in water making it ideal for use in fertigation. It is compatible with other fertilizers. It does not generate insoluble precipitates that can clog drip irrigation or injectors, so it can be safely used in the production of different fertilizer solutions in mixing tanks.

Sulphate of Potash (0:0:50) (SOP) : Sulphate of Potash, a complete water soluble speciality fertilizer that contains chlorine free high quality Potash and Sulphur, the most important major and secondary plant nutrients. It is dominantly used as a fertilizer for crops which include tobacco, some vegetables, fruits and some other high value crops. SOP increases production, quality, nutritious value, resistance capacity, and storage of the crop. It is the best fertilizer for greenhouse and protected cultivation. It contains 50% K_2O and 17.5% Sulphur, suited for fertigation and foliar application.

Calcium nitrate (CN) : Calcium nitrate is an inorganic compound with the formula $Ca(NO_3)_2(H_2O)_x$.CN has been shown to stimulate root growth in plants, leading to healthier, more vigorous plants. The roots are essential for water and nutrient uptake, and by increasing the size and length of roots, the plant is better equipped to absorb these essential nutrients. It acts as a carrier of nitrate nitrogen within the plant, helps reducing calcium deficiency of the plant and increases crops growth with vigour, makes the plant healthy and sturdy through tolerance to pests, helps in neutralizing toxic chemicals within plants and increases fruit setting and improves rind quality of the produce.

NPK 19:19:19 : NPK 19:19:19 is a complete water soluble, ideal fertilizer which provides all major macronutrients N-P-K in a balanced ratio to the plants through foliar spray or fertigation at the time of maximum requirement with the lowest losses. It can fulfil any deficiency of one or all three major plant nutrients and minimizes the cost on basal fertilizers. NPK 19:19:19 increases net returns, lowers the cost of production per unit crop yield, minimizes the chemical load on the environment and enables to strengthen the fertilizer supplies in the event of their shortages or price escalation thereby ensuring a wiser and long lasting use.

(c) Secondary and Micronutrient Fertilizers

Secondary and micronutrient deficiencies particularly of S, Mg, Zn, B, Fe and Mn in India need attention from application viewpoint. IFFCO is serious to address this problem and providing farmers the needed fertilisers to correct these deficiencies by following fertilizers:

(i) IFFCO fertilizers containing secondary nutrients: Calcium nitrate, IFFCO Mag, IFFCO Sulphur-90.
(ii) IFFCO fertilizers containing micronutrients: Zinc fertilizer, Micro power (micronutrient mixture fertilizer), IFFCO Boron fertilizer (**Figure 2**).

Figure 2. IFFCO Secondary and Micronutrient Fertilizers

(d) Bioenhancers (Plant Growth Promoters)

Bioenhancers are plant growth promoters which are composite of Plant Bio-enzymes of pure natural origin and combination of naturally occurring growth promoter elements from different materials. Bioenhancers can be used in all the crops.

Sagarika- Liquid and Granular : Seaweed extracts (SEs) have been widely used as bio-stimulants in crop management due to their growth-promoting and stress-resistant effects. Preparations based on sea weed extract like *Sagarika* is playing a great role to boost crop growth and also mitigate extreme weather adversities and improve soil health (**Figure 3**). Sagarika works as a metabolic bio-enhancer, it stimulates internal growth and development processes in plants. It contains inherent nutrients, vitamins, plant growth hormones like auxin, cytokinin and gibberellins, betaines and mannitol etc. It enhances physiological efficiency of crops leading to more nutrient uptake from soil and improves quality - better shape, size, uniformity, colour and taste of fruits. Sagarika enhances stress tolerance ability of crops and resistance against pests & diseases. Previous studies have shown that the foliar application of seaweed extract promotes the absorption of nutrients by plants and increases the levels of macro- and micronutrients (such as N, P, K, Ca, Mg, Zn, Fe etc.) in the plants. This seaweed extract is naturally degradable and environmentally friendly, has become important components of organic fertilizers for agriculture and horticulture. In addition to enhancing stress tolerance, nutrient uptake, growth, and yield, seaweed-based bio-stimulants have also been shown to help reduce seed dormancy and enhance root systems, flowering, fruit quality, and taste, and even the quality of produce. Method of application of Sagarika is given below and Figure 3.

1. Foliar application: Dilution Details. 0.25 – 0.5 % or 2.5 - 5 ml of Sagarika Liquid in 1 liter of water.
2. Seed soaking / Seedling treatment: @ 0.1% or 1 ml of Sagarika Liquid in 1 liter of water.
3. Fertigation: Apply as per soil, crop growth stage and nutritional schedule.
4. Sagarika (granular) is applied at the time of sowing/planting of the crops as basal dose @10 kg/acre along with other fertilizers for rejuvenating soil health.

Table Composition of Sagarika

NUTRIENTS	RESULTS
Nitrogen (N)	0.25-0.30 g/100g
Phosphorous (P)	0.03-0.04 g/100g
Potassium (K)	14.0-18.0 g/100g
Sodium (Na)	1-1.5 g/100g
Calcium (Ca)	0.15-0.20 g/100g
Silica (Si)	0.2-0.25 g/100g
Magnesium (Mg)	0.35-0.45 g/100g
Iron (Fe)	0.02-0.03 g/100g
Sulphur (S)	0.1-0.15 g/100g
Copper (Cu)	50-70 ppm
Manganese (Mn)	15-20 ppm
Cobalt (Co)	5-10 ppm
Zinc (Zn)	5-12 ppm

Figure 3. IFFCO Sagarika for Smart Agriculture

In addition to Sagarika Granular and Liquid, several organic inputs are being made available to the farmers to improve productivity of organic agriculture (**Figure 4**). Some of the most common substances we collectively refer include:

Fulvic Acid, Humivic Power+, Humic acid and Hunin : Works as plant growth stimulant, promote root development and stimulate seed germination, enhances nutrient uptake by combining nutrients with humic acids and keep a well-balanced nutrition, resilience of crops such as cold, drought, pest, disease and toppling resistance, promotes healthier, stronger plants and enhances appearance by improving soil structure, ion exchange capacity of soil, resistance to stress for soil, especially reduce high salts in alkaline soils, nutrients uptake and increases the content of humus in soil, prevents soil from contamination of heavy metals as well as other harmful matters and enhances fertilizer use efficiency.

Figure 4. IFFCO organic inputs

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Biofertilizers : To reduce the dependence of nitrogen fertilizers, use of biofertilizers help cutting cost on fertilizers through benefits of symbiotic and a symbiotic nitrogen fixation. Many nutrient solubilizing bacteria, for example, P, K and Zn solubilizers are of great help. IFFCO's NPK consortia has been recognised as a potential input to boost crop yield and soil health. Biogas slurry can be used successfully to enhance NUE and minimize environmental problems. Now, we have several biofertilizers for example, IFFCO Liquid Bio-NPK, IFFCO Bio-decomposer, Acetobacter, Azospirillum, Phosphorus solubilizing bacteria, (PSB), potassium mobiliser, Trichoderma etc. (**Figure 5**).

Figure 5. IFFCO Biofertilizers

Nano-fertilizers (NFs) for Smart Agriculture

IFFCO has embarked on providing nano urea and nano DAP to the farmers and facilitate their use through these smart high-tech solutions (**Figure 6**). Nano-fertilizers (NFs) will be the Game Changer.

Figure 6. IFFCO Nano Urea and Nano DAP together will be the game changer

- NFs hold potential to offer numerous benefits for making the crop production more sustainable and eco-friendly that impart superiority over fertilizers by preventing 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 NUE and reduce the costs for environmental protection and save fertilizer resource.
- NFs intelligently control the release speed of nutrients that ensure slow, targeted, efficient release to ensure higher efficiency of nutrient uptake matching the uptake pattern of crop in a controlled manner in contradiction to rapid and spontaneous release of nutrients from conventional chemical fertilizers.
- Nutrients applied through NFs can be released over 40-50 days in a slow release fashion rather than 4-10 days by the conventional fertilizers.
- 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.
- NFs influence metabolic activities of the plant to different degrees compared to conventional materials and have the potential to mobilize native nutrients in the rhizosphere.
- NFs facilitate the crop plants to fight various biotic and abiotic stresses.
- 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.
- NFs required in small amount which reduce the cost of transportation.

Apart from nanotechnology-based fertilizers, IFFCO has introduced and invested in various path-breaking agro-technologies including promotion of agri-drones, rural e-commerce, digitally enabling farmers and farms and the Internet of Things (IoT). The society aims to be the flag-bearer of modern Indian agriculture, by being the brand resonating with innovators and progressive rural entrepreneurs aiming at climate resilient sustainable agriculture.

Future of New Age Fertilizers

The country has witnessed sharp increase in consumption of WSF sinrecenty ears reaching a level of 2,65,000 tin 2019-20. Expansion in area under horticulture and high value crops, and increased coverage under micro-irrigation have been the key drivers of growth in the consumption of WSFs. With a view to promote and regulate their use, Government of India (GOI) notified WSFs in FCO in 2003. The use of WSFs is largely concentrated in the horticulture-growing areas of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, and Uttar Pradesh. It may be mentioned here that there is no subsidy on WSFs. Farmers have accepted these fertilizers on merits in terms of increase in yield, quality of crop and net income. For the first time, 5 liquid fertilizers have been included in FCO last year. However, their acceptance by farmers is yet to be seen. Similarly, one product of nano-fertilizer *i.e.* IFFCO Nano-urea (liquid) and IFFCO Nano DAP (Liquid)have also been included in FCO. It is a noteworthy achievement in specialty nutrition and IFFCO has already started production of these fertilizers at commercial scale and earned credit to become the first country in the world to start commercial production and sale of nano-fertilizers. For future growth, fertilizer industry and research institutions (ICAR & SAUs) should pool their resources in R&D of specialty fertilizers. Fertilizer industry also needs to adopt a different marketing approach for new innovative specialty products. The marketers have to shift their focus from ‘selling product’ to‘ selling crop nutrition solutions’.

Conclusion

Enhancing nutrient use efficiency is a great challenge to boost crop productivity and protect environment in Indian agriculture. Introduction of several high efficiency fertilizers in Indian market is a right intervention at a right time. The new age fertilizers like 100% WSF, controlled release fertilizers, secondary and micronutrient fertilizers, biofertilizers, bioenhancers, organic fertilizers, customised fertilizers and super smart Nano-fertilizers would help enhancing crop productivity and protect environment through increased nutrient use efficiency. Technologies of these new age fertilizers are inseparable at the users end, therefore, greater awareness should be created among farmers about these fertilizers and educate them about 4Rs i.e. Right fertilizer, Right quantity, Right method and Right time of application to harness maximum use efficiency and the benefits. All stakeholders should join hands for promotion of these new age technologies. Concerted effort of line industries is going to help the farmers to manage the soil health more precisely and get benefited in long run.

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THE FERTILIZER : UREA GOLD

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Introduction

Urea Gold, a new urea coated with sulphur, was launched by Prime Minister Narendra Modi in Rajasthan's Sikar. This innovative fertilizer aims to address soil sulphur deficiencies and reduce input costs for farmers. It surpasses existing Neem-coated urea in terms of economic viability and efficiency, enhancing agricultural productivity. Urea Gold improves nitrogen use efficiency, reduces fertilizer consumption, and enhances crop quality. Introduced in collaboration with PM-PRANAM and MDA, Urea Gold is applied slowly, providing nutrients for long periods. The sulphur coating also provides nourishment, reducing urea use and increasing plant yield. The urea is coated with humic acid to enhance longevity and reduce fertilizer use. Urea Gold reduces urea consumption and improves crop quality by reducing consumption by 15 kg compared to 20 kg of conventional urea. The main function of Urea fertilizer (40% of Nitrogen content) is to provide the plants with nitrogen to promote green leafy growth. It also aids the photosynthesis process of plants. Since urea fertilizer can provide only nitrogen and not phosphorus or potassium, it's primarily used for bloom growth.

What is Neem-coated urea?

Urea is a commonly used nitrogen-based fertilizer that provides essential nutrients to plants to promote healthy growth.

Neem-coated urea is a specialized form of urea fertilizer that has been coated with neem oil.

Benefits of Neem-coated urea:

- The neem coating on urea slows down the release of nitrogen into the soil. This controlled release helps reduce nitrogen leaching and volatilization, leading to improved nitrogen use efficiency by plants.
- It would bring down the quantity of urea per acre and consequent reduction in input cost to farmers.
- The emission of nitrous oxide is also brought down significantly.
- Neem oil, derived from the neem tree (*Azadirachta indica*), has natural pesticidal properties.

How Urea Gold Is Better Than Others?

Nitrogen is more readily available to and more readily absorbed by crops when it is released gradually from urea that has been coated with sulphur. Urea Gold's usefulness as a fertiliser is

further increased by the addition of humic acid. This product not only replaces conventional urea consumption, but also lowers fertiliser demand in general. A Money Control analysis claims that 15 kg of Urea Gold offers equivalent advantages to 20 kg of regular urea, making it a more cost-effective and efficient option for farmers. According to the article, Urea Gold is intended to stop urea from being diverted. To stop the use of urea intended for agricultural use for industrial uses, the Centre has lately begun a statewide crackdown. Urea Gold is said to be better than conventional forms of Urea (including Neem coated urea)

- **Slow release:** Sulphur-coated urea facilitates a gradual release of nitrogen, thereby enhancing its availability and uptake by crops.
- **Extended Life:** The inclusion of humic acid in Urea Gold further extends its lifespan as a fertilizer.
- **Reduces overall fertilizer usage:** According to the report, 15 kg of Urea Gold provides comparable benefits to 20 kg of conventional urea, making it a more efficient and effective choice for farmers.

Will Govt. Provide Subsidy for Urea Gold?

Creating a high-level inter-ministerial group to solve numerous Urea Gold-related issues is something the government is exploring, according to a Money Control story from June. With regard to the product's pricing and subsidy requirements, this committee will be in charge of making key choices. It is important that farmers have access to Urea Gold in time for the *rabi* season so that their winter crops will be helped. A comprehensive set of cutting-edge agricultural programmes totaling Rs. 3,70,128.7 crores were authorized on June 28 by the Cabinet Committee on Economic Affairs (CCEA), which is led by Prime Minister Narendra Modi. A price of Rs. 242 per 45 kg bag of urea (excluding of taxes and neem coating charges). The government has allocated Rs. 3,68,676.7 crores for urea subsidy over the next three years (2022-23 to 2024-25), further supporting farmers and moderating their input costs.

Country on way to become *Atmanirbhar* in Urea by 2025-26

Since 2018, the establishment and reactivation of 6 urea manufacturing plants in the following locations: Chambal Fertilizers & Chemicals Limited, Gadepan District Kota, Rajasthan; Matix Fertilizers and Chemicals Limited in Panagarh, West Bengal; Gorakhpur, United Kingdom; Sindri, Jharkhand; and Barauni, Bihar. This has helped to make the nation *atmanirbhar* in terms of urea production and availability. From 225 LMT in 2014-15 to 250 LMT in 2021-2022, domestic urea output has grown. Production capability will reach 284 LMT in 2022-2023. By 2025-2026, this will help us become urea self-sufficient, together with nano urea plants, which would lessen our existing urea import dependence.

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REVOLUTIONIZING AGRICULTURE: THE INTERNET OF THINGS (IOT) IN FARMING

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Introduction

In recent years, technological advancements have swept across various industries, and agriculture is no exception. The Internet of Things (IoT) has emerged as a game-changer in modern farming practices, transforming traditional agriculture into a connected, efficient, and sustainable system. By seamlessly integrating technology into the heart of agriculture, the IoT is revolutionizing the way we grow, harvest, and manage crops. In this article, we'll explore how the IoT is reshaping the landscape of agriculture and the benefits it brings to farmers and the world.

What is the Internet of Things (IoT)?

The Internet of Things refers to the network of interconnected devices and sensors that can collect, exchange, and process data over the internet without requiring direct human intervention. These devices range from simple sensors to sophisticated machinery, all working in tandem to gather valuable data and facilitate smarter decision-making.

The IoT in Agriculture: A Connected Farming Ecosystem

1. Precision Farming

IoT-enabled precision farming has ushered in a new era of smart agriculture. By using sensors and data analytics, farmers can monitor and analyse critical factors such as soil moisture, temperature, humidity, and crop health in real-time. Armed with this information, they can make data-driven decisions, optimize resource allocation, and fine-tune irrigation and fertilization schedules, ultimately boosting crop yields while reducing waste.

2. Smart Irrigation

Water scarcity is a significant challenge faced by farmers worldwide. With IoT-powered smart irrigation systems, water usage can be optimized based on weather conditions, soil moisture levels, and crop requirements. This results in a more efficient water management system, reducing water waste and minimizing the overall environmental impact.

3. Crop Monitoring and Disease Detection

IoT sensors are deployed throughout fields to continuously monitor crop health and detect early signs of diseases or pest infestations. By spotting potential problems at their inception, farmers can implement targeted interventions, preventing large-scale crop losses and reducing the need for excessive pesticide usage.

4. Livestock Monitoring

IoT devices also play a crucial role in livestock farming. Wearable sensors on animals can provide real-time data on their health, location, and behaviour. This technology helps farmers detect signs

of illness, manage breeding programs more effectively, and optimize animal feeding schedules for better growth and production.

5. Autonomous Machinery

Autonomous farming machinery, equipped with IoT technology, is becoming increasingly common. Self-driving tractors and drones can handle tasks like planting, spraying, and harvesting with precision and consistency. This not only reduces the physical burden on farmers but also enhances overall efficiency and accuracy in the field.

Benefits of IoT in Agriculture

1. **Increased Productivity:** By leveraging IoT technologies, farmers can make informed decisions that maximize crop yields, leading to increased productivity and profitability.
2. **Resource Efficiency:** Smart agriculture optimizes resource usage, such as water, fertilizer, and energy, reducing waste and minimizing the environmental impact.
3. **Enhanced Sustainability:** IoT-enabled practices promote sustainable farming by conserving resources, reducing greenhouse gas emissions, and fostering responsible land management.
4. **Real-Time Data Analysis:** Access to real-time data empowers farmers to respond promptly to changing conditions, ensuring timely interventions and reducing potential losses.
5. **Cost Savings**: IoT technologies help farmers streamline operations, minimize manual labour, and prevent unnecessary expenses, ultimately improving the bottom line.

The future scope of the Internet of Things (IoT) in agriculture

The future scope of the Internet of Things (IoT) in agriculture is vast and holds immense potential for transforming the industry even further. As technology continues to evolve, we can expect to see the following exciting developments in IoT for agriculture:

1. **Advanced Data Analytics**: As more data is collected from various IoT devices, the focus will shift to advanced data analytics and artificial intelligence. Machine learning algorithms will enable predictive modelling, offering valuable insights into crop growth patterns, disease outbreaks, and weather forecasting. This will empower farmers to make even more informed decisions and optimize their farming practices further.
2. **Edge Computing**: Edge computing involves processing data closer to its source, reducing latency and dependence on the cloud. In agriculture, this means that IoT devices on the field can analyse data locally and take immediate actions without relying on a centralized server. This will enhance the responsiveness of IoT systems and enable real-time control over critical operations.
3. **5G Connectivity**: The widespread adoption of 5G networks will revolutionize the IoT landscape in agriculture. 5G offers ultra-low latency and high-speed connectivity, enabling seamless communication between a large number of IoT devices. This will improve the reliability and efficiency of data transmission, making IoT applications more robust and reliable on the farm.
4. **Drones and Robotics**: Drones equipped with IoT sensors will become more sophisticated, enabling highly accurate aerial surveys of crops and soil. These drones can spot early signs of stress or disease, allowing farmers to take prompt action. Additionally, robots integrated with IoT technology will take on more tasks, such as precision weeding, pruning, and harvesting, reducing the need for manual labor and increasing efficiency.

5. **Blockchain Integration:** Blockchain technology has the potential to enhance transparency and traceability in the agricultural supply chain. By integrating IoT data with blockchain, consumers will have access to verified information about the origin and quality of the produce they purchase, building trust and driving demand for sustainable and ethically sourced products.
6. **Livestock Monitoring Advancements**: IoT-based livestock monitoring will continue to evolve, providing even more detailed insights into animal health and behaviour. Advanced sensors will detect early signs of distress or illness, enabling timely veterinary care and improved overall livestock management.
7. **Climate Adaptation:** Climate change poses significant challenges for agriculture. IoT devices will play a crucial role in monitoring and mitigating climate-related risks. Smart irrigation systems will become even more adept at optimizing water usage during droughts, and IoT-powered greenhouses will enable precise climate control to protect crops from extreme weather conditions.
8. **Collaborative Farming Ecosystems:** IoT will facilitate the creation of collaborative farming ecosystems, where data is shared among farmers, researchers, and agricultural experts. This collective intelligence will foster innovation, allowing farmers to learn from each other's experiences and adopt best practices more effectively.
9. **Focus on Sustainability:** Sustainability will be at the forefront of future IoT applications in agriculture. From eco-friendly IoT sensors made from biodegradable materials to renewable energy-powered IoT devices, the focus will be on reducing the environmental footprint of smart farming practices.

Conclusion

The Internet of Things has transformed agriculture into a connected, data-driven ecosystem, revolutionizing the way we grow and manage crops. By leveraging IoT devices and data analytics, farmers can achieve increased productivity, resource efficiency, and sustainability while reducing operational costs. As the world's population continues to grow, smart agriculture will play a pivotal role in ensuring food security and meeting the global demand for food. Embracing IoT in agriculture is not just a technological trend; it is a sustainable solution for a brighter, more abundant future. The future of IoT in agriculture is brimming with exciting possibilities. As technology continues to advance, we can expect to witness an increasingly interconnected, data-driven, and sustainable agricultural sector. The integration of IoT devices with cutting-edge technologies like AI, 5G, and blockchain will drive efficiency, productivity, and responsible resource management, ensuring that agriculture remains at the forefront of meeting the world's growing demand for food while safeguarding the planet's resources.

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SOLAR TUNNEL DRYER: A BETTER ALTERNATIVE TO TRADITIONAL SUN DRYING

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Abstract
Drying is an ancient preservation method to increase the shelf life of products. Fossil fuel based dryer produce the carbon emission. Therefore, Solar Tunnel Dryer introduces a pioneering approach to drying practices with zero emissions through solar energy utilization. This novel concept harnesses the power of the sun to create a controlled drying environment, significantly reducing carbon footprints associated with traditional fossil fuel-dependent methods. With its eco-friendly operation, energy efficiency and adaptability. The Solar Tunnel Dryer emerges as a transformative solution for sustainable and environmentally responsible drying practices across various industries. This article delves into the principles, benefits and potential implications of this innovative technology, highlighting its role in promoting greener and more efficient drying processes.

Introduction
Solar drying is promising and most preferred method for drying agricultural products. Drying crops by solar energy is of great economic importance the world over. Solar energy being simple to use, free, renewable, clean, non-polluting and inexhaustible has received wide spread attention in recent times. It provides well abundant energy source if utilized efficiently. But this energy is time dependent energy source with an intermittent character. Most of the crops and grain harvests are lost to fungal and microbial attacks these wastages could be easily prevented by proper drying, which enhances storage of crops and grains over long periods of time. However, solar drying systems must be properly designed to match particular drying requirements of specific crops, which can increase the efficiency of a system.

Drying is an age-old preservation technique used to remove moisture from various products, ensuring their longevity and preventing spoilage. The percentage of fruits and vegetables lost due to the lack of proper drying can also vary based on several factors, such as the type of produce, local climate conditions and drying practices. Similar to grains, inadequate drying of fruits and vegetables can lead to spoilage, mould growth, and reduced shelf life, resulting in significant losses. The study was estimated the loss of product various agricultural produces like; cereal crops, roots crops, and fruit and vegetables account for about 19%, 20%, and 44% losses respectively (Gustavsson *et al.,* 2011; Lipinski *et al.,* 2013). However, traditional drying methods that heavily rely on fossil fuels for energy generation have significant environmental implications, contributing to greenhouse gas emissions and exacerbating climate change (Bassey and Schmidt, 1986).

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The drying of agricultural produce under the sun is a common practice most especially in developing countries like India where more than 3300 to 3700 hours of bright sunshine per year available in North-West and West coastal regions of the country and 2900 hour over central part of India except Kerala, Kashmir and Assam. In brief, there are nearly 250-300 days per year available to get useful sunshine (Mani, 1992). This method is characterized by a number of constraints like; lack of process control, non-uniformity in the drying rate, soaking by rain, theft and vandalism, contamination by dust, rodents, and other domestic animals. Also prolong open sun drying often caused deterioration of vital ingredients like vitamins, minerals and sensory characters of dried product and thus less market value Solar drying is alternative for drying varieties of agricultural produce at superior drying rate compared to open sun drying method with improved quality of dried product at a relative low cost.

In the pursuit of sustainable and eco-friendly practices, the concept of the Solar Tunnel Dryer has emerged as a groundbreaking solution. Harnessing the power of the sun, this innovative drying system offers zero-emission practices, minimizing environmental impact while promoting energy efficiency and cost savings. This article explored the working and principles of Solar Tunnel Dryer, its versatility and its potential to empower rural communities and industries to adopt sustainable and environmentally responsible drying practices. Several researchers have reported in favour of solar tunnel dryer.

Joy *et al.* (2001) studied on solar tunnel drying of red chillies. Wet samples of red chillies were dried in a tunnel dryer. Results of quality analyses of both tunnel-dried chilli samples and those dried by conventional open air sun drying were compared. A considerable reduction in drying time was noticed in tunnel-dried samples, which showed improved texture and hygienic quality over conventionally dried samples. Optimum conditions for solar tunnel drying of redchillies were described.

Arjoo *et al.* (2017) evaluated the performance of walk-in type solar tunnel dryer (10m × 3.75m x 1.98 m) for chili, garlic, fenugreek and aonla candy. A temperature of 15-30 ^{0}C higher than the atmospheric temperature was recorded inside the dryer The STD reduces the moisture content of chilli from77% to 7% (wb) in 7 days, garlic from 65% to 8.5% (wb) in 8 days, fenugreek from 86% to 7.2% (wb) in 5 days and aonla candy from 44% to 16% (wb).STD dried products were of good quality, hygienic and highly acceptable as compared to direct sun drying.

Understanding the Solar Tunnel Dryer

The Solar Tunnel Dryer is a type of solar dryer used for drying various agricultural products such as fruits, vegetables, grains, herbs, and even fish. The Solar Tunnel Dryer is a solar-powered drying system designed to harness the energy of the sun to dry various products efficiently. It consists of a tunnel-like structure covered with a transparent material, typically a greenhouse-grade polyethylene film or glass. The transparent cover allows sunlight to penetrate and create a greenhouse effect inside the tunnel that effectively trapping heat and creating a controlled drying environment. The principle of the Solar Tunnel Dryer is based on a combination of solar radiation, convective heat transfer, and proper airflow management. Jungadh Agricultural University, Junagadh has developed hybrid solar tunnel dryer with addition of solar flat plate collector as shown Fig. 1. The dimensions of the structure in length, width and ridge height are 10 m x 5 m x 2.6 m respectively in hemi cylindrical shape for 500 kg of chilli. The performance of the solar tunnel dryer was studied for the chilli, turmeric and ginger as shown Fig. 2. Here's an elaboration on its principles:

1. **Solar Radiation Absorption:** The fundamental principle of the Solar Tunnel Dryer revolves around the utilization of solar energy. The device consists of a long, tunnel-like structure covered with a transparent material such as glass or UV-resistant plastic. This covering allows sunlight to enter and be absorbed by the interior surfaces, including the drying racks and the products being dried.
2. **Greenhouse Effect:** The transparent covering creates a greenhouse effect within the tunnel. Sunlight enters through the transparent material and is absorbed by the surfaces inside. This absorption leads to an increase in temperature within the tunnel, creating a warmer environment compared to the outside ambient temperature.
3. **Convective Heat Transfer:** As the interior surfaces absorb solar radiation, they become heated. This heat is then transferred to the air within the tunnel through convection. Warm air has a lower density and tends to rise, creating a natural airflow within the tunnel. This convective heat transfer aids in removing moisture from the products placed on the drying racks.
4. **Airflow Management:** Proper airflow is crucial in the drying process. The Solar Tunnel Dryer is designed with inlets at one end and outlets at the other end of the tunnel. This creates a natural airflow path from the cooler inlet side to the warmer outlet side. The warm, moist air generated by the drying process is expelled from the tunnel, while fresh, drier air is drawn in from the other end. This continuous airflow helps carry away the evaporated moisture from the drying products.
5. **Drying Racks:** Inside the tunnel, racks or trays are placed to hold the products being dried. These racks are usually made from materials that can conduct heat efficiently, such as metal or wire mesh. The absorbed solar energy and the convective heat from the warm air help in directly drying the products on the racks.
6. **Product Quality Preservation:** One of the advantages of the Solar Tunnel Dryer is its ability to dry products gently while preserving their quality. The controlled environment minimizes the risk of spoilage, degradation of nutrients, and colour loss that can occur in open-air drying methods.
7. **Temperature and Moisture Control:** Some advanced Solar Tunnel Dryers include mechanisms to regulate temperature and humidity levels. This can involve automated ventilation systems or dampers that can be adjusted to control the airflow and optimize drying conditions.

Fig. 1 Solar tunnel dryer developed at REE Department, CAET, JAU, Junagadh

Salient features of Solar Tunnel Dryer over traditional sun drying

(Sharma *et al*., 1987; Sevda and Rathore, 2010)

1. Heat intensity is tremendously increase (18 to 26 ^{0}C) than open sun's heat enhance increase operational productivity with a reduced drying period (30 to 45 %).

2. It can be used even in early morning, evening or in cloudy weather also.
3. Products is kept in enclosed transparent structure (UV stabilized plastic cover) to protect from rain, dew, dust, dirt, rodents, birds, animals, pathogenic diseases, etc. minimizing to about 15 to 35 % PH losses as compared to sun drying.
4. Reduces the labour cost as compared to sun drying.
5. Farmers will get a better-quality of products ultimately results in better market values.
6. Reducing the operational cost and maintenance costs is very negligible.
7. It occupies less area even one can stake the products.
8. It could be used successfully for multiple crops, viz., spices, medicinal plants, horticultural produces, leafy vegetables, etc.
9. Solar tunnel dryers last longer and it is estimated that the average life is around 15-20 years.

Fig. 2 Solar tunnel drying of spices, viz., red chillies, turmeric and ginger

Harvesting of Solar Energy

The Solar Tunnel Dryer harnesses solar energy to generate heat required for the drying process. The sun's rays pass through the transparent cover, and the energy is absorbed by the products placed on drying trays or racks inside the tunnel. As the products absorb the solar energy, they release moisture, which is then carried away by natural convection or ventilation systems. The temperature inside the solar tunnel dryer was recorded as 55°C to 60°C.

Zero Emission Drying

Unlike traditional drying methods that rely on fossil fuels, the Solar Tunnel Dryer operates on renewable energy from the sun, making it a zero-emission drying practice. By eliminating the use of fossil fuels, the dryer significantly reduces carbon emissions and contributes to the fight against climate change. This eco-friendly approach aligns with global efforts to transition towards sustainable and low-carbon practices. Approximately 2267 kilojoules (kJ) or 540 kilocalories (kcal)required to remove 1 litre of water from fruits and vegetables for drying (Sevda and Rathore, 2010) (*i.e.*it is required 0.63 kwh of energy).The carbon emissions produced0.93 kg per Kwh (Mittal *et al.,* 2012)for electricity generation. The one litre of water might be removed mechanical dryer having with 70 % efficiency emits 0.83 kg of CO_2.

Energy Efficiency and Cost Savings

Solar energy is not only environmentally friendly but also cost-effective. Once the Solar Tunnel Dryer is set up, it operates with minimal operational costs, mainly for maintenance and occasional replacements of transparent covers. Furthermore, this energy-efficient drying method reduces the dependency on conventional energy sources, leading to long-term cost savings for industries and agricultural businesses.

Versatility and Adaptability

The Solar Tunnel Dryer is highly versatile and adaptable to different drying needs. It can be used for a wide range of products, including fruits, vegetables, grains, herbs, and even fish or meat. The drying temperature and humidity levels can be adjusted based on the specific requirements of the products being dried. Additionally, the system can be scaled up or down to accommodate varying production volumes.

Enhanced Drying Quality

The controlled environment of the Solar Tunnel Dryer ensures uniform drying and prevents product spoilage. The greenhouse effect created inside the tunnel maintains a stable temperature, reducing the risk of over-drying or under-drying. As a result, the dried products retain their nutritional value, color, flavor, and overall quality.

Empowering Rural Communities

The Solar Tunnel Dryer presents an opportunity for rural communities, particularly in developing regions, to enhance their agricultural practices and add value to their produce. By adopting this sustainable drying method, farmers can reduce post-harvest losses, increase the shelf life of their products, and access better market opportunities (Mada *et al.,* 2014).

Conclusion

Solar Tunnel Dryer operates on the principles of solar radiation absorption, convective heat transfer, and controlled airflow management. By leveraging these principles, it provides a more efficient and controlled environment for drying agricultural products compared to traditional open-air drying methods. The Solar Tunnel Dryer represents a groundbreaking innovation in the field of zero-emission drying practices. By harnessing solar energy, this system offers an environmentally friendly and cost-effective alternative to conventional drying methods that rely on fossil fuels. Its adaptability, enhanced drying quality, reduced drying time and empowerment of rural communities make it an attractive option for various industries and agricultural sectors. As the world seeks sustainable solutions to combat climate change and promote eco-friendly practices, the Solar Tunnel Dryer stands as a shining example of a novel concept driving us towards a greener and more sustainable future.

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MANAGEMENT PRACTICES FOR SUCCESSFUL TURKEY FARMING

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Abstract

The management of turkeys in a farm environment requires careful attention to various factors to ensure their well-being and productivity. Proper care during the incubation period, including maintaining a male-to-female ratio of 1:5 and a hatchability rate of 60-80%, is crucial for successful turkey farming. Debeaking, desnooding, and detoeing procedures are discussed as preventive measures against feather picking and cannibalism among turkeys. Proper handling techniques are essential to reduce stress and avoid injuries when catching and transporting turkeys. With good management practices, turkey mortality rates can be reduced to less than 5%, leading to healthier and more productive flocks.

Introduction

The effective management of turkeys in a farm environment is a multifaceted process that requires careful attention to various aspects to ensure their well-being and productivity.

Environmental Sensitivity : Turkeys are exquisitely sensitive creatures, and their behaviour is intricately linked to the environment they inhabit. Sudden changes or disturbances in their surroundings can induce panic responses that may lead to detrimental behaviours, putting the overall well-being of the flock at risk. To maintain a thriving and productive turkey farming operation, it is crucial to recognize and address these sensitivities. This involves creating a calm and stable environment, devoid of sudden loud noises, abrupt light changes, or intrusions by wild birds. By taking these precautions, farmers can significantly reduce the likelihood of panic-induced behaviors such as trampling, cornering, and smothering among the turkeys.

Incubation and Brooding : The foundation of successful turkey farming is laid during the critical stages of incubation and brooding. This includes maintaining the correct male-to-female ratio (1:5) to ensure fertile eggs and strictly adhering to the 28-day incubation period. During colder seasons, the brooding period may extend to 5-6 weeks, necessitating a gradual reduction of brooding temperature by 5°F per week. This temperature control is vital to provide poults with the ideal conditions for healthy development and comfort.

Care of Poults : Young turkey poults are delicate and exhibit timidity, making them prone to distress. Careful handling is essential, and their initial diet plays a critical role in their growth. To kickstart their development, poults are provided with a diet consisting of a mixture of milk and boiled eggs during the first 15 days of life. This mixture, comprised of 100ml of milk, 1 liter of water, and 1 boiled egg, supplies essential nutrients. To encourage proper feeding, feeders can be enriched with colorful or enticing items. High-intensity lighting at a rate of 3 watts per poult helps prevent "starve outs." Turkeys also have a strong preference for fresh green grasses, which can account for up to 50% of their total diet. Options like Lucerne, Berseem, and Stylo offer valuable nutrition and should be made available.

Health Management: Maintaining the health of young poults is paramount. Close monitoring during their initial days ensures they are feeding adequately. Adult turkeys have substantial dietary requirements, typically consuming around 200-250 grams of feed daily. Disease prevention is a key aspect of health management, with regular vaccinations against diseases such as RD and fowl pox being essential. Additionally, deworming using piperazine citrate at 16-week intervals helps combat roundworm infestations.

Debeaking, Desnooding, and Detoeing: Preventing aggressive behaviors like feather picking and cannibalism is crucial for maintaining a harmonious flock. Debeaking, usually performed at a young age, involves the careful removal of a portion of the beak to reduce harm potential. Desnooding, which prevents head injuries, can be carried out gently at day-old or at 3 weeks of age using sharp scissors. Detoeing, or toe clipping, enhances the safety of the turkey environment and is typically conducted at day-old by removing the tip of the toe just inside the outermost toe pad.

Debeaking

Desnooding

Detoeing

Catching and Handling : Effective handling techniques for turkeys require patience and gentleness. Strategies such as using a stick to drive turkeys and employing darkened rooms for catching help minimize stress and prevent potential injuries. Mature turkeys should not be kept hanging for extended periods (no more than 3-4 minutes) to avoid undue stress.

Feeding : Turkeys have distinct dietary requirements compared to chickens, necessitating a well-balanced diet rich in energy, protein, vitamins, and minerals. Proper feeding methods, such as mash and pellet feeding, ensure that feed remains clean and hygienic by being provided in feeders rather than on the ground. Transitioning between different diets should be gradual to prevent digestive issues. Turkeys require a constant and clean water supply, especially during the summer months when increased water availability is necessary. Additionally, providing shell grit at a rate of 30-40 grams per day per bird can help prevent leg weakness. Turkeys also benefit from green feeding, with fresh Lucerne being a favoured option that can constitute a significant portion (up to 50%) of their diet on a dry mash basis.

Prevention of cannibalism : Feather picking and cannibalism represent common challenges in turkey farming, particularly during the growth phase. Effective prevention strategies focus on addressing the root causes. This includes avoiding overcrowding in confinement, ensuring sufficient space for each turkey, and providing a well-balanced diet that meets the nutritional needs of the birds. By implementing these measures, farmers can significantly reduce the occurrence of these harmful behaviors and maintain the overall health and productivity of their turkey flock.

Conclusion

In summary, successful turkey management involves creating a stable and stress-free environment, proper incubation and brooding, attentive care of poults, health management, and preventive measures to combat cannibalism. Adhering to these practices will contribute to the overall well-being and productivity of turkey flocks in a farm setting.

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INFLUENCE OF ORGANIC MULCHING AND FERTILIZER APPLICATION ON THE VEGETATIVE GROWTH OF GUAVA CV. SARDAR (L-49)

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Abstract

The experiment was conducted to examine the response of organic mulching and fertilizer application on vegetative growth of guava plant at the ICAR-AICRP on fruits, BCKV, Mohanpur, Nadia, West Bengal during 2018 to 2019in Randomized Block Design with six treatments (T_1: Banana biomat mulch (BBM) @ 30 kg fresh m^{-2} Leguminous cover crop (LCC) @ 3g seeds m^{-2} + Recommended dose of fertilizer (RDF) @ 0 %, T_2: T_1 + 25% RDF, T_3: T_1 + 50% RDF, T_4: T_1 + 75% RDF, T_5: T_1 + 100 % RDF and T_6:Control RDF @ 100%) with 4 replications. The treatments consist of a banana biomat mulch and leguminous cover crops along with varying dose of fertilizers and the application of BBM (webbed leaf-sheath of banana @ 30 kg fresh m^{-2}), LCC (@ 3g m^{-2}; black gram cv. Kalindi in winter, mung bean cv. Samrat in summer) and RDF @ 75%, twice a year (August, 2018 & January, 2019), followed by incorporation of leguminous cover crops into the soil at 50-60 days after sowing showed better results with respect to vegetative growth.

Introduction

Guava *(Psidium guajava Linn)* is important fruit crop of tropicaland sub-tropical region, belongs to the myrtaceae family, having chromosome number 2n = 22 is grown in India. It is also known as "Poor man's Apple". It is originated from Tropical Central America and introduced in India in the early 17thcentuary. It is the most common and major fruit and considered the fifth most important fruit in terms of area and production. Guava is considered as one of the valuable fruits in terms of nutrition and also remunerative crops (Kumari and Choudhary, 2019). It is an ideal fruit for national security (Chadha, 2015). Guava has a higher proportion of 'shade' to 'sun' leaves and their leaves are found photo synthetically inactive under deeper shade and act as unproductive sink. Therefore, vegetative growth, fruit yield and quality are functions of light interception and translocation of light energy into chemical energy. Light interception was more in guava trees planted, at wider spacing and decrease significantly with the depth of the canopies inspective of the planting densities (Singh *et al.,* 2005). Guava growers in the Gangetic Alluvium region of West Bengal can increased the yield and quality of guava with the application of organic mulch and leguminous cover crops along with the recommended dose of fertilizers (Subba *et al*., 2023).

Methodology

The research was conducted at ICAR-AICRP on Fruits, Mohanpur, Nadia, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, during the year 2018-19. The trial was conducted at the 5 years old orchard of guava cv. Sardar (L-49) under high-density planting ($1111ha^{-1)}$ with a spacing of 3m × 3m in the square system. The recommended dose of fertilizer used in the guava experiment was

25 kg FYM, N-260gm + P2O5-320gm + K2O-260gm. The treatments consisted of application of banana biomat mulch (BBM), leguminous cover crop (LCC) and different level of fertilizer doses (T_1: BBM + LCC + 0% RDF, T_2: T_1 + 25% RDF, T_3: T_1 + 50% RDF, T_4: T1 + 75% RDF, T_5: T_1 + 100 % RDF and T_6: Control – conventional practices with 100% RDF).

Methods of treatment application

The orchard soil of guava was cultivated by power tiller and dose of fertilizer was applied to the guava field as per treatment layout. The overnight soaked seed of leguminous cover crop (LCC) was sown @ 3g/m^2 in the ground area of plants as per the treatment, about 48-36 hours after irrigation. Black gram var. Kalindi was sown during winter and spring months and moong bean var. Samrat was sown during summer and rainy months. The pseudostem of banana was collected from the harvested banana field. Strips were prepared by cutting the leaf sheath of pseudostem into 1.4-1.5 m in length and 10-15 cm in wide. The banana biomat mulch (BBM) was prepared by weaving the strips cross-wise and were spread onto the ground area of each plant @ 30 kg fresh/m^2. Pre-soaked moong bean seeds along with vermicompost was sown at 25-30 cm spacing in between the two banana strips of BBM. The grown up LCC was incorporated in soil during 50 to 60 days after sowing.

Application of treatments were imposed twice per year, i.e., between 2nd and 3rd week of August, 2018 and again between 2nd and 3rd week of January, 2019. Crop protection measures as recommended in crop calendar by BCKV and ICAR-AICRP on Fruits were followed as and when required. Observations were recorded on suppression of weed growth, weed control efficiency, soil moisture conservation, status of organic carbon content, bunch weight, finger weight, TSS and B: C ratio.

Table: Effect of organic mulching, leguminous cover crop and fertilizer application on canopy growth of guava plant (one year after application of treatment).

Treatment*	Canopy volume (m^3)							Avg. (m^3)
	Aug, 18	Oct, 18	Dec, 18	Feb, 19	April, 19	June, 19	Aug, 19	
T1: BBM+LCC+0% RDF	2.18	2.32	2.49	2.54	2.60	2.63	2.67	2.48
T2: T1+25% RDF	2.23	2.32	2.48	2.61	2.67	2.69	2.71	2.56
T3: T1 + 50% RDF	2.22	2.63	2.68	2.70	2.73	2.71	2.74	2.63
T4: T1 + 75% RDF	2.21	2.53	2.65	2.80	2.67	2.73	2.76	2.68
T5: T1 + 100% RDF	2.28	2.43	2.59	2.64	2.74	2.75	2.77	2.71
T6: Control	2.22	2.38	2.53	2.53	2.63	2.66	2.69	2.52
SEm (±)	0.109	0.105	0.102	0.113	0.060	0.014	0.02	-
C.D. at 5%	NS	NS	NS	NS	NS	0.031	0.05	-

Conclusion

The data presented in table revealed that all treatments with banana biomat mulch (BBM), leguminous cover crop (LCC) and varying dose of fertilizer on guava cv. Sardar caused non-significant variations in canopy volume of guava plant during the months of August 2018 to April 2019 and significant variations during the months of June 2019 to August 2019. So, it may be concluded that the guava growers in the Gangetic Alluvium areas of West Bengal may apply banana biomat mulch (webbed leaf-sheath of banana @ 30 kg fresh m^{-2}), leguminous cover crops

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(@ 3g m^{-2}; black gram cv. Kalindi in winter, mung bean cv. Samrat in summer) and 75% of recommended dose of fertilizer, twice a year in guava (August, 2018 & January, 2019), followed by incorporation of leguminous cover crops into the soil at 50-60 days after sowing for better management of vegetative growth (Canopy), orchard floors of guava, with beneficial effects of weeds growth suppression, soil moisture conservation, improvement of soil health (organic carbon and available nitrogen) and increased in fruit yield and quality.

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Photograph of treatment application

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ARTICHOKES: A NATURAL ALLY IN MANAGING DIABETES

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Abstract

The maxim, "Let food be thy medicine and medicine be thy food" has been acknowledged as one of the most renowned expressions associated with Hippocrates, who is often regarded as the progenitor of medicine. The prevalence of scientific inquiry into superfoods has witnessed a notable surge in recent years. These dietary items include both nutritional and pharmacological attributes, enabling them to effectively combat illnesses and mitigate instances of inadequate nutritional status. *Helianthus tuberosus* L., commonly known as Jerusalem artichoke, is a plant that exhibits potential as a superfood, offering various health benefits to the human body, particularly in relation to the digestive, gastrointestinal, and dermatological systems. Its high concentration of inulin makes it suitable for individuals with diabetes mellitus, while its complex carbohydrate content renders it a viable component of an optimal hypocaloric diet. Unfortunately, its usage and cultivation are not well recognised internationally.

Introduction

Diabetes mellitus, classified as a noncommunicable illness, is a significant public health concern in the contemporary era. Diabetes mellitus is characterised by the presence of insulin resistance, hyperinsulinemia, hyperglycemia, and biochemical changes in lipid metabolism. Type 2 diabetes is associated with a significantly increased risk of mortality mostly due to the development of cardiovascular disease (CVD). The incidence of cardiovascular disease (CVD) is significantly elevated, ranging from two to four times greater, in those with diabetes mellitus (DM) compared to those without diabetes. Dyslipidaemia has been identified as a recognised risk factor for cardiovascular problems in individuals with type 2 diabetes mellitus. Type 2 diabetes people commonly have lipid abnormalities characterised by reduced levels of high-density lipoprotein (HDL) cholesterol, elevated levels of triglycerides, and a prevalence of tiny, dense low-density lipoprotein (LDL) particles.

Figure 1: Aerial parts of Artichoke plant

In contemporary discourse, there is growing recognition of the potential role of functional foods in the management of type 2 diabetes and its associated problems. One example of an edible food that serves a purpose is Jerusalem artichokes, a root vegetable that is particularly rich in inulin-type fructans. These fructans are a form of carbohydrate that falls under the category of nonviscous, soluble, and fermentable fibres. This particular polysaccharide is furthermore present in several other dietary sources such as leek, wheat, onion, chicory root, garlic, and banana. The vegetable known as Jerusalem artichoke, technically classified as *Helianthus tuberosus*, has

garnered increasing attention in recent years due to its notable health and nutritional advantages. The artichoke is a member of the Asteraceae family, classified as a kind of sunflower. Contrary to its nomenclature, the Jerusalem artichoke lacks any botanical affiliation with the artichoke plant and does not possess any geographical association with the city of Jerusalem. It is, in reality, a constituent of the sunflower family that originates from the North American continent. The tuberous root vegetable commonly known as "sunchokes" possesses a rich assortment of nutrients, including vitamins, minerals, bioactive phenolic compounds such as caffeoylquinic, apigenin, and luteolin, as well as prebiotics like inulin and fructooligosaccharides. These constituents have been extensively utilised in the formulation of various dietary and pharmaceutical products over the past decade.

Over an extended period of time, this particular plant has been deliberately grown and nurtured due to its significant value as a consumable resource, including potent therapeutic attributes. Furthermore, it is inherently indigenous to the geographical region known as the Mediterranean Basin. The use of leaves in traditional medicine involves their application for the treatment of bone fractures and the alleviation of pain. The tubers represent the consumable component of the aforementioned plant. The tubers of *Helianthus tuberosus* possess a significant abundance of inulin, protein, and several bioactive constituents, rendering them suitable for the production of functional food components. Numerous bioactive chemicals have been extracted from the aerial components, exhibiting notable antifungal, antioxidant, and anti-cancer characteristics. Multiple clinical trials conducted by various researchers have indicated that extracts derived from artichoke had potential therapeutic qualities for the treatment of numerous disorders, including non-alcoholic fatty liver disease, hypocholesterolemia, metabolic syndrome, and hypertension. This investigation focuses on the Jerusalem artichoke, examining its nutritional composition, potential health advantages, and adaptability in cooking, so highlighting its suitability for inclusion in one's diet to promote overall wellness.

Figure 2: Tubers of Artichoke plant

Nutritional Value of *H. tuberosus*

The temporal factors of harvest time, measured in weeks following planting, and seasonal variations have the potential to influence alterations in nutritional constituents, including soluble carbohydrates. Inulin constitutes the primary nutritional constituent of *H. tuberosus*, with fresh tubers containing around 80% water, 15% sugar, and 2% protein. Jerusalem artichokes are rich in a diverse range of vitamins and minerals, including but not limited to iron, copper, magnesium, phosphorus, and potassium. In addition, getting plenty of vitamin C, a range of B vitamins, calcium, and several other essential nutrients are also present. The iron present in Jerusalem artichokes is classified as non-heme iron, which refers to iron derived from a non-animal origin. One notable distinction between *H. tuberosus* and other tubers, such as potatoes, is in their respective inulin content. Unlike potatoes, *H. tuberosus* exhibits a notable absence of starch and

sucrose, which are instead replaced by inulin. Research findings have provided evidence supporting the antibacterial and anti-inflammatory properties of inulin, as well as its potential to facilitate wound healing. Regrettably, the bioactive element in question has been undervalued as compared to those found in other agricultural commodities, such as wheat or rice.

Impact of Inulin on individuals with diabetes

Inulin consists of a series of fructose molecules that are connected by β-(2,1) glycosidic linkages, forming repeating units. Inulin is categorised as a soluble dietary fibre due to its ability to undergo dissolution in aqueous solutions. Soluble fibres have the ability to undergo gelation within the gastrointestinal system, hence exhibiting prebiotic properties by serving as a nutritive substrate for advantageous microorganisms residing in the gut. Upon ingestion, inulin remains intact as it traverses the digestive system and eventually reaches the colon. In this region, it undergoes fermentation by the resident bacteria. The fermentation process has the potential to enhance the proliferation and functionality of advantageous probiotic bacteria within the gastrointestinal tract, including bifidobacteria. Inulin exhibits a low glycemic index (GI), indicating its limited effect on postprandial blood glucose levels upon ingestion. This particular attribute can prove advantageous for persons diagnosed with diabetes or those seeking to regulate their blood glucose levels.

Applications of *H. tuberosus* in Human Health

Antioxidant capacity : The antioxidant capacity of Jerusalem artichokes is attributed to the presence of phytochemicals, including polyphenols, flavonoids, and inulin. These compounds possess antioxidant capabilities. Antioxidants play a crucial role in mitigating the detrimental effects of free radicals inside the human body, hence diminishing oxidative stress and lowering the susceptibility to chronic ailments.

Dermatological treatments : Sometimes involve the use of Jerusalem artichoke extracts for promoting skin health. The tubers possess antioxidants that have the potential to provide protection to the skin against UV damage and premature ageing. The use of topical treatments or the incorporation of certain substances into one's diet has the potential to enhance the health and condition of the skin.

Digestive system : The digestive system can benefit from the consumption of Jerusalem artichokes due to their high content of inulin, which is a form of dietary fibre. Inulin functions as a prebiotic agent, facilitating the proliferation of advantageous gastrointestinal microorganisms. An optimal gut flora has been correlated with enhanced digestive function and general well-being. The use of a daily dosage of 5-10g of inulin has been found to have a beneficial impact on gastrointestinal well-being.

Improvement of Biochemical Parameters : The consumption of Jerusalem artichokes has been associated with potential improvements in biochemical markers, including blood sugar levels and cholesterol profiles, according to many research. The potential health benefits of inulin found in Jerusalem artichokes include the regulation of blood sugar levels and the reduction of LDL cholesterol levels.

Superfood Potential : The Jerusalem artichoke possesses potential as a superfood due to its low caloric content and abundance of essential elements such as potassium, iron, and vitamin B6. The nutritional composition and possible health advantages of these items render them eligible for

classification as a "superfood." *Helianthus tuberosus*, often known as Jerusalem artichoke, possesses culinary versatility and may be used into various gourmet applications, including but not limited to the production of flour, chips, noodles, and pastries.

Adverse effects

The consumption of Jerusalem artichoke is often regarded as being safe. Nevertheless, certain individuals may have digestive pain due to the elevated inulin content of the vegetable, which has been associated with a propensity for inducing excessive flatulence. Moreover, due to its fructan content, individuals with fructan intolerance or those adhering to a low-FODMAP diet should refrain from consuming Jerusalem artichoke.

Conclusion

Helianthus tuberosus boasts multiple uses, including medical and health benefits. Jerusalem artichoke compounds, especially inulin and fructo-oligosaccharides, are versatile and might be considered renewable chemical raw resources. Industrial fructose and inulin production relies heavily on *Helianthus tuberosus* tubers. As a functional food additive and medicinal plant, this raw resource improves human health. *H. tuberosus* tubers stabilise blood sugar, lower “bad cholesterol,” regulate blood pressure and digestive function, protect the liver and kidneys, aid iron, calcium, and magnesium absorption, and eliminate blood alcohol. In diabetes, cardiovascular illness, nervous system disease, and cancer patients, it prevents and treats. This species' medicinal, nutritional, economic, and ecological relevance gives it a broad viewpoint.

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SYNERGY BETWEEN AGRONOMY AND AGRICULTURAL ECONOMICS: CULTIVATING SUSTAINABLE GROWTH

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Introduction

Sustainable development can be interpreted in economic terms as "development that lasts" (Pearce and Barbier, 2000) – i.e. a path along which the maximisation of human well-being for today's generations does not lead to declines in future well-being. The main purpose is to meet people's needs and aspirations while enhancing society's welfare. In essence, sustainable development aims to achieve an equitable distribution of development among the present and future generations. Agronomy and agricultural economics are two distinct yet interconnected fields that play crucial roles in ensuring the sustainability, productivity, and profitability of modern agriculture. While agronomy focuses on the science of crop production and soil management, agricultural economics delves into the financial, market, and policy aspects of agricultural systems. The synergy between these disciplines is vital for shaping efficient and sustainable agricultural practices in an ever-evolving global landscape.

1. The Intersection of Agronomy and Agricultural Economics

A. Optimal Crop Management:

Optimal crop management leads to better yields and in turn increase the income of the farmers (Stobart*et. al.,* 2015). Agronomists work to maximize crop yields and quality through the study of plant genetics, soil health, pest management, and efficient irrigation techniques (Silgram, 2015;Graeme, 2023). By integrating economic principles, agricultural economists assess the cost-effectiveness of these practices, ensuring that farmers' investments lead to improved profitability (White, 2016).

B. Market Dynamics:

Agricultural economists analyze supply and demand trends, price fluctuations, and consumer behavior within the agricultural sector. This information in-turn informs agronomists and farmers about which crops to produce, helping them align their production choices with market demand. This symbiotic relationship can work wonders in achieving the goal of sustainable development.

2. Sustainability in Agriculture

A. Conservation Practices:

The ecology has frequently suffered greatly as a result of boosting agricultural production and economic development. The Earth no longer has approximately fifty percent of the forests which previously covered it. Rapid groundwater depletion is occurring. Biodiversity has suffered severe decline. The combustion of fossil fuels releases billions of tonnes of greenhouse gases into the atmosphere each year, which cause global warming and climate change (FAO, 2017). Agronomists

develop and promote sustainable farming practices that prevent soil erosion, promote biodiversity, and conserve water resources. These practices have long-term economic benefits, including reduced input costs and increased land productivity.

B. Economic Viability:

Sustainability was mostly associated with environmental issues between the 1970s and the 1990s. Surprisingly, during the UN Conference on Environment and Development (UNCED) in 1992, a global action strategy for sustainable development was formed (Drexhage and Murphy, 2010). The need to transition to a sustainable economy and the economic implications of environmental challenges for many industries and businesses are key components of sustainability, an emerging and quickly expanding interdisciplinary topic of research (Pham*et. al.,* 2021). Agricultural economists evaluate the economic viability of adopting sustainable practices. Assessment of factors such as the potential costs of transitioning to new methods as well as the everlasting benefits with respect to reduced environmental impact and increased market access.

3. Technology and Innovation

A. Precision and Conservation Agriculture:

Precision Agriculture is a hopeful farm management strategy that is changing the way people farm. Agronomy embraces precision agriculture, which employs technology like GPS, sensors, and data analytics to tailor farming practices to specific field conditions. Socio-economic changes in developing countries, including India, are creating new scopes for appliance of precision agriculture (Meena *et. al.,* 2019). This optimization of inputs is not only environmentally friendly but also financially advantageous.

Conservation agriculture assists farmers to be successful when applying conservation agriculture by tailoring practices to local circumstances (Jerich, 2011). Conservation agriculture is defined by three simple principles:

i) Soil disturbance should be reduced as much as possible.
ii) Imbibing the different possible relevant crop rotations.
iii) Soil coverage with crop residues (Giller et al., 2011)

B. Investment Decisions:

Investment choices are those that an organisation renders about the allocation of various resources in an effort to achieve the highest returns for its investors. There are two types of investment decisions: long-term and short-term (Jain, 2023). The development of agriculture must be viewed in light of other global economic trends. Agriculture is impacted by trade liberalisation, agricultural policy reform, and globalisation. The way we approach agriculture is also influenced by increased public awareness and the focus on sustainable development (Viatte, 2001). Agricultural economists assist farmers in making informed decisions about adopting new technologies. Potential returns on investment is estimated in advance by different equipment or systems and the long-term economic impacts of technology adoption is also analysed.

4. Policy and Government Support

While a stable macroeconomic environment is essential for achieving continuous economic growth, it alone is not sufficient to guarantee such progress. In the case of developing nations, the process of economic diversification and structural transformation can significantly contribute to fostering growth and simultaneously mitigating the risks posed by external fluctuations. Similarly,

policy reforms aimed at improving infrastructure, human capital, financial expansion, and subsequently boosting productivity can also play a pivotal role in supporting growth and minimizing vulnerability to shocks from external sources (Fabrizio *et. al.,* 2015).

A. Subsidy Programs

In order to supply the rising population with food, food production is essential. The demand for food will rise by 50% globally by 2030 (Allaoui et al., 2018). Nations over the world have developed a variety of subsidy strategies to address major environmental issues in agriculture. (Zhang, 2021). Agricultural economics examines government subsidy programs and their impact on crop choices and production practices. Agronomists work in tandem by providing insight into the environmental consequences of these decisions. To address the issues of agricultural productivity and environmental preservation, several governments have developed specific policies for sustainable agricultural growth (Chen et al., 2020). A widespread and significant incentive method for the sustainable development of agriculture, in the meantime, is the subsidy policy. In order to encourage the development of agriculture, the Indian government offers farmers support for inputs, subsidies for prices, infrastructure subsidies, and incentives for exports (Fan et al., 2008).

B. Sustainable Policies

A range of government agencies, international organisations and groups in civil society are actively promoting the sustainable development. Both fields collaborate to design and advocate for policies that incentivize sustainable agricultural practices. Agronomists provide scientific evidence, while agricultural economists assess the potential economic outcomes of policy implementations. Both the economic and other policy communities must be heavily involved in the implementation of policies that support sustainable development, and continual efforts must be made to forge relationships between these communities.

A variety of policies that offer incentives or disincentives have an impact on the type and adoption of environmentally sustainable technologies:

- Environmental policies (limiting what farms can do); Agricultural policies (encouraging output growth or requiring environmental conditions in exchange for support);
- Trade policies (affecting the location and type of production, and the appropriate technology);
- Structural policy (affecting the scale of the farm, the type of technology applied, and the specialisation);
- Technology and R & D policy (encouraging research and dissemination of new technologies) (Viatte, 2001).

5. Future Challenges and Opportunities

A. Climate Change Resilience:

One of the biggest, longest-lasting, and most dynamic challenges society is currently experiencing is climate change (Birchall, 2020). The ability of a society to resist, absorb, as well as recover from the consequences of hazards while maintaining or regaining its fundamentally important basic structures, functions, and identity is known as resilience (CARE, 2021). Agronomists and agricultural economists are working together to develop climate-resilient crop varieties and systems. This collaboration aims to ensure food security while navigating the economic challenges posed by changing climatic conditions. There is a chance to incorporate climate resilience into

choices right away. To do this, proactive adaptation needs to be taken into account in development strategies and long-term expenditure plans. Adaptation plans must systematically identify these possibilities, or "entry points".

B. Data-Driven Decision Making

Better decision-making is facilitated by the combination of data science, agronomy, and agricultural economics. The massive volumes of data generated by the Internet of Things (IoT) can aid strategic decision-making by improving the generalisation and accuracy of models. Big data is prevalent in many industries, and it is increasingly used in agriculture, especially precision agriculture. Agronomic models will be used in data interpretation, but big data is changing agriculture from a model-driven to a data-driven industry. Significant potential will probably be discovered by learning from these enormous data collections (Coble et al., 2018; Rao, 2018). By utilising big data, machine learning and data mining techniques are anticipated to be crucial in overcoming the issues facing global agriculture. The analysis of large sets of data can help to provide deeper and more precise insights related to the optimization of resource allocation, improvements in yields as well as increasing the revenue generation.

Conclusion

The dynamic interrelationship between agronomy and agricultural economics emphasises the necessity of a comprehensive strategy for contemporary farming. The interaction between these two professions is vital because of the expanding global population and the serious environmental issues. Both these powerhouse departments of Agricultural sector have the potential to realise greater things with mutual co-operation. Agronomy and agricultural economics may spur innovation, promote sustainability, and open the door for a bright agricultural future by fusing scientific knowledge with economic ideas.

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INTEGRATED FARM TECHNOLOGIES FOR SUSTAINABLE SOIL HEALTH MANAGEMENTFOR FOOD, NUTRITION AND ENVIRONMENT SECURITY : IFFCO's EXPERIENCE

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Holistic measures like diversification and intensification of agriculture, pulse based cropping systems), site specific nutrient management, integrated nutrient management (INM) involving soil test based use of soil amendments and fertilizers,biofertilisers,nutrient enriched compost-PSNC,vermicompost, green manure, crop residue recycling, industrial wastes,amelioration of alkali and acid soils, use of specialty fertilizers(100 % water soluble fertilisers, bioenhancers etc.), smart fertilizers like IFFCO's Nanofertilizers for high nutrient use efficiency and use of secondary and micronutrientsto correct existing nutrient deficiencies need to be be encouraged for improving soil health and to ensure agriculture sustainability. IFFCO's initiative through "Save the Soil" Mission and the most recent policies of the Government have played key roles towards improving soil health, crop productivity and farmers income. through This paper aims at highlighting the importance of adoption of integrated farm technologies for sustainable soil health management for food, nutrition and environment security

Indian agriculture is facing the onslaught of reduction in soil fertility due to inadequate replenishment of nutrients removed by crops. The addition of nutrients from different sources vs. its removal show a deficit of approximately 10 million tonne annually. There is growing emphasis on meeting the nutrient needs of Indian agriculture through INM, and rightly so. This is primarily because (i) the nutrient needs of Indian agriculture and so large and continuously increasing that these cannot be met from a single type of source, be it mineral or organic and (ii) It is desirable to mate adequate and efficient use of all available sources of plant nutrients and other inputs to improve the health of soils so that the production systems can sustain increasing production goals. What are often dismissed as wastes can be effectively converted into valuable resources as for example through compositing. To address the issue of negative balance of nutrients in the soils, holistic measures like soil testing for judicious use of nutrients, soil amelioration for better nutrient availability through green manuring, use of nutrient enriched compost-PSNC, vermicompost, industrial wastes, biofertilizers, crop residues management, pulse based cropping system, specialty fertilizers for high nutrient use efficiency (100 % water soluble fertilizers etc.) should be encouraged. Judicious use of alternative nutrient sources will meet the need of the soil and crop subsequently over time. The instantaneous effect as well as high nutrient content of fertilizers have led reduced application of organic manures by farmers. For sustaining the agricultural production and crop productivity for future generations at least 25% of the nutrient

requirement should be met through organic sources. This will also address the multinutrient deficiencies of the soil leading balanced nutrient application.The technologies for improving soil health are given in the following columns:

IFFCO's Holistic Approaches for Sustainable Soil health Management

IFFCO initiated "SAVE THE SOIL MISSION" under which a flagship Pilot Project on "Soil Rejuvenation and Productivity Enhancement" was launched at Bighapur, Unnao. Based on very encouraging results of this Project the program was expanded on all India basis covering all the IFFCO adopted villages (over 600 villages) across the country. The program was carried out with main objective of improving soil health and crop productivity. The major components of this program are elucidated below:

1) *Soil testing:* For appraisal of the pattern of nutrient deficiencies including secondary and micronutrients.
2) Promotion of nutrient enriched compost, green manures and biofertilizers to improve soil health.
3) *Field Demonstrations for Balanced use of fertilizers for increased Fertilizer use efficiency:* Three plot demonstrations were conducted on farmers' fields. (i) farmer practice (ii) State recommended doses of nutrients and (iii) Improved doses of nutrients to achieve maximum economic yields.
4) A number of programs were organized to create awareness about emerging nutrient deficiencies and convincing the farmers to adopt integrated nutrient management practices based on soil tests to arrest increasing demand of fertilizers and also to improve soils chemical, physical and biological properties for better soil health and sustainable high yield agriculture.
5) *On-Farm Trials on increasing fertilizer use efficiency:* On-farm trials were conducted to demonstrate the superiority of neem-coated urea over uncoated pilled area, role of 100% water soluble fertilizers and secondary and micronutrients towards increasing fertilizer use efficiency and crop yield. Farmers were educated to adopt fertilizer best management practices and also for the adoption of improved farm technologies for achieving the goal of maximum economic yield.

Based on the findings of this flagship project following action strategies for Sustainable Soil health Management are suggested:

1. Diversification and Intensification of Agriculture : Due to continuous cultivation of the same crops in the same field, soil sickness can develop along with multiple nutrient deficiencies and incidence of new pest and diseases. All these adverse situations ultimately affect agriculture sustainability. The results of the experiments conducted under All India Coordinated Agronomic Research Project revealed that productivity, energy use efficiency and nutrient uptake in diversified cropping systems generally increased with increasing cropping intensity as compared to mono cropping with rice-wheat system. The total productivity of rice-wheat system could be increased to 81.7, 17.4, 80.0, 68.9 and 120.8% in maize-potato-groundnut (TGP, Ludhiana), rice-vegetable pea-wheat/rice-wheat -green-gram (UGP, Pantnagar), maize-potato-wheat (UGP, Kanpur), rice- potato-green-gram (UGP, Varanasi) and rice-potato-sunflower (MGP, Sabour), respectively. Resource use efficiency and relative economic efficiency in diversified/intensified

cropping systems was above 200% compared to the existing rice-wheat system. After the high productivity trend in rice-wheat cropping system in the IGPs during green revolution era, a declining trend was observed in later years. This was mostly because of imbalanced use of fertilizers and over exploitation of the natural resources, including water. A major consequence of this was soil degradation. The sustainability of this important cropping system is now under threat and major emphasis should be paid on improving soil health/soil quality. In this regard, appropriate soil health indicators should be developed to assess various soil functions.

2. Importance of Legumes in Soil Health Management : Legumes have a long-standing history of being soil fertility restorers due to their ability to obtain N from the atmosphere in symbiosis with Rhizobia. Legumes can form an important component of INM when grown for grain or fodder in a cropping system, or when introduced as a green manuring crop in cropping system. Legumes grown as green manure, forage or grain crops improve the productivity of RWCS and regenerate soil fertility.

2.1 Legumes grown in rotation : Different legumes have the capacity to leave behind different amounts of N for use by the succeeding crop. Further, fodder legumes contribute more N than grain legumes. A number of leguminous crops have been evaluated for the contribution which they make in meeting the N requirement of the succeeding crop, and it has been found that as much as 50 to 60 kg N/ha may be made available. The carryover of N for succeeding cereal crop may vary from 50 to 120 kg/ha depending on legume species. Grain yield of succeeding crop also increases markedly with preceding legume than a preceding cereal crop. In general, pulse crops do leave a residual amount of as much as 30 to 50 kg N/ha for utilization by the succeeding crop.

2.2 Increasing Efficiency of N-Fixation through Legumes: Pulse crops can be made more effective by inoculation with proper species of *Rhizobia*. Nitrogen fixation by rhizobia is of great importance in agriculture in several ways. Legumes help to feed the human through protein rich grains as well as meat-producing animals through protein rich feed and fodders. The nodulation and crop yields of legumes can be greatly by correcting existing nutrient deficiencies, for example, P, K, S, Zn and B in neutral to alkaline soils and P, K, S, Zn, B and Mo in acid soils.

Legumes grow well on poor soils where other crops cannot be grown successfully. After harvest legume roots left in the soil decay, releasing organic nitrogen compounds for uptake by the next generation of plants. Farmers take advantage of this natural fertilization by rotating a leguminous crop with a non-leguminous one. Nitrogen fixation by natural means cuts down on the use of artificial fertilizers. This not only saves money but helps to prevent the many problems brought about by excessive use of commercial nitrogen and ammonia fertilizers such as eutrophication of rivers and lakes, generation of acid rain, and overgrowth of agricultural land by non-food crops. Besides enhancing the efficiency of rhizobia as nitrogen fixers in legumes, researches on genetic engineering to bring about nitrogen fixation in other crops is very much needed. In a country where the average consumption of plant nutrients from chemical fertilizers on national basis is very low, the residual fertility build-up due to legumes is obviously a major contribution, which must be fully exploited.

1. NUTRIENT ENRICHED COMPOST

Composting has been traditionally practised by farmers of the country. Neglect of scientific composting techniques results in poor quality and farmers are loosing interest in composting. Scientific methods of preparation of composts are given in the following columns.

3.1 Phospho-Sulpho- Nitro Compost : Phospho- Sulpho- Nitro Compost is an enriched compost due to higher nutrient content, thus its application @ 2 MT /ha can lead to substantial nutrient supply and increase in crop yields. The general technique for preparation of PSNC is as follows:

Guidelines for Pit or Heap Method :

1. Location of compost pit should be fully exposed to sunlight.
2. Dimension of Pit and heap:
    a. Pit method – 10 X 5 X 3 feet
    b. Heap method – 7.5 X 6 X 3 feet

*About 500 kg undigested materials (250 kg crop residues + 250 kg dung) can be decomposed.

3. For 3 feet depth of pit, there will be total 16 layers (i.e height of each layer 2.25 inches)
4. Total quantity of material for 16 layers
    a. 143 kg indigenous rock phosphate or 25 kg damaged DAP or 35 – 40 kg damaged 10:26:26 / 12:32:16
    b. 100 kg Phosphogyspum / Gypsum
    c. 5.5 kg urea
    d. 24 kg soil
5. Phosphogypsum is added to the dung slurry to make the mixture acidic to reduce N – volatilisation losses and increase phosphorus solubility while urea is added to increase microbial activity.
6. Mix all the material with fresh dung in 1:1 ratio that is equal part of dung with material to be composted.

Steps for preparation of PSNC

1. Preparation of each layer as mentioned below : (Total 16 layers)
    a. Put a uniform layer of 15 kg crop residue. Spread 15 kg dung solution / slurry on this layer.
    b. Mix 330 gm of urea in 1 litre of water and spray uniformly.
    c. Put a uniform layer of 8.6 kg rock phosphate.
    d. Put a uniform layer of 6.25 kg phosphogypsum / gypsum.
    e. Finally cover the layer by applying 1.5 kg soil.
2. Repeat the process till the formation of 16 layers. Insert 5 bamboo pieces (4 corner and 1 middle) to facilitate application of water and aeration. Plaster the top portion of pit /heap with dung slurry and cover with polythene sheet for protection against heavy rains, air etc to maintain moisture and temperature.
3. After 3-4 weeks, turn the material for better decomposition. Apply water frequently to maintain 60-70 % moisture.
4. After 110 days , 500 kg of PSN compost would be available from 775 kg of material used. The nutrient content depends on type of crop residue used for composting.
5. Biofertilizers like PSB @ 1 kg/500 kg compost should be mixed before application of compost in the field.
6. Use of waste (Bio) decomposer accelerates the process of decomposition.

Application of nutrient enriched compost i.e @ 2MT PSNC/ha will improve the physical, chemical and biological properties of soil leading to overall improvement in soil health, crop yields and income of farmers.

3.2 Vermicompost: In vermi-composting earthworm or "Nature's ploughman" are added to composting site for efficient utilization / value addition to decomposed organic matter. They can practically consume all kinds of organic matter as much as their own weight per day; the excreta or "casting" thus produced is rich in nutrients (N, P, K and Mg) and also in bacteria and actinomycetes population. The collection of vermicast along with microbial degraded organic compost is called vermicompost.

Benefits:

1. Rich in essential plant nutrients / beneficial microorganisms.
2. Improves soil health and encourages growth of new shoots and leaves.
3. Increases use efficiency of fertilizers
4. Provides excellent effect on overall plant growth and improves the quality and shelf life of produce.

Methodology:

1. *Selection of earthworm species* : Two exotic species i.e*Eisenia*foetida and *Eudriluseugeniae* and one indigenous species i.e. *Perionyxexcavatus* (found under cool places like cattle sheds, irrigated orchards, kitchen gardens etc) having characteristics of prolific breeding / higher multiplication rate / shorter life cycle / lesser mortality and voracious feeding habit are most suitable. They are easy to handle, have life span of 1- 1.5 years, sturdy and survive well under varying climates.
2. *Adequate availability of food*: Any well decomposed organic waste having C/N ratio of 20 to 40 are considered as suitable feed for earthworms.
3. *Adequate moisture:* Earthworms contain 85 % water in their body. It has no protective body cover and respiration is done through body wall only. It constantly secretes mucus to keep the body wet. At least 35 % water must be present in the earthworm feed and at least 60 % moisture must be maintained in the composting medium.
4. *Suitable temperature and light:* Temperature in the range of 20^0 C to 35^0 C is suitable as > 45^0 C results in moisture stress while below 0^0 C stops earthworm activities. Because of their nocturnal habit adequate shade must be provided in composting site.
5. *pH:* For effective multiplication of earthworms, pH near neutral level is desirable. It is better to use equal part of green and dry biomass to get ideal pH.
6. *Location for earthworm multiplication:* Earthworms can be multiplied well in pit and raised beds or on heaps of 2 feet height filled ready food of decomposed or partially decomposed organic waste.
7. *Compost structure dimensions:*
    a. Compost pit or Tank: 2 m X 1m X 0.45-1m. Made of brick and mortar with proper water outlets.
    b. Plastic crate : 60 cm X 30 cm X 30 cm with holes drilled at bottom.
    c. Empty wooden crates (drilled wood boxes) or Well rings (75 cm dia, 30 – 45 cm height).

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Picture 1. A view of Vermicompost Promotion Program by IFFCO

Preparation of Organic biomass/Predigested organic biomass: Pile the biomass (dry agricultural wastes, green biomass, leaf falls, cuttings of hedge plants) in systematic layers underneath a tree. Soak well in water/cowdung slurry (cowdung 1 – 2 % to the wight of green biomass and 10-20 % in case of dry biomass)/ biogas slurry. Cover the heap with black polythene sheet. Two turnings are given at an interval of 15 days. After 30-40 days when temperature of heap is around 25 – 30^0 C transfer in to vermi-bed or alternatively a cow dung heap (3 m X 1.5 m X 1.5m) having 50 -60 % moisture can also be maintained under shade for about 30 days and turned twice at 15 days for getting predigested biomass.

Vermi-bed preparation

d. Vermi-bed of size 3 m X 0.9 -1.2 m X 45 cm can be prepared under shade.

e. Bottom layer should be loosely lined with brick pieces, pebbles or twigs for aeration (approx – 11cm) followed by sand layer of 2 cm. Then dry and hard agriculture biomass can be used. Cover the bed with neem leaves / wheat – paddy straw / dry grass or line with wood or charcoal ash for protection against red ants.

f. Middle layer (9" – 12 ") consist of half decomposed biomass or green biomass and animal dung in combination leads to good quality of compost

g. 2000 single/mixed variety earthworms are inoculated in one bed. They are first introduced into the bed or tank containing half decomposed material and enter downwards from layer to layer in search of food. Fine granular vermicompost is ready within 40 – 45 days.

Compost Recovery

h. Every kg of earthworms feeds on 5 kg of waste with 40 – 50 % moisture, around 50-60 % of compost will be recovered from the original material weight by volume.

i. Watering to the bed should be stopped once vermicast is visible on the top layer. Then earthworms move downward. After 2-3 days, small heaps of compost are prepared on the vermi-bed and kept open. The harvested compost is sieved through 4 -5 mm sieves after 2- 3 days while fresh material is added in the vermi-bed.

j. Small earthworms /juveniles, sub –adults or other escaped cocoons if seen in the compost are aggregated by burying small balls of cow dung. These balls are removed after 15 days.

k. Frequent harvesting of earthworms is essential to bring down population pressure. Addition of wheat bran, gram husk or grain powder, neem cake lead to better earthworm population.

l. Composting units should be well covered with wire mesh or with thorny leaves to protect from predators.

Application Rates: A pit of size: 2 m X 1 m X 1 m can hold 20-40 thousand worms giving 1 tonne manure per month. Nutrient content of vermicompost: 1 – 1.5 % N, 0.75 % P and 1.5 % K along with secondary and micronutrients. It is spread @ 5 – 6 t / ha in the field before sowing of crops; 1 -10 kg / fruit tree depending on the size of trees and 3 kg per $10m^2$ of lawn.

4. City Compost : Fertiliser industries will now involve themselves to promote use of city compost as the scheme is mandatory and important for improving soil health. IFFCO has already initiated this program in the interest of farmers.

5. Green Manuring : With increasing use of fertilizers in intensive cropping the practice of green manuring and also the use of organic manure has became less popular leading to fall in organic matter status of soil and emergence of multi nutrient deficiency. The physical and biological properties of the soils have also deteriorated. Organic matter status is directly linked with the soil quality as it helps improving soil structure and moisture holding capacity of soil along with soil aeration and temperature. Green manuring can help in improving organic matter status of soil through the addition of substantial quantities of biomass, adds N to the soil and enhance availability of all the nutrients essential to crop plants.

Benefits of green manuring

1. Green manuring adds organic matter to soil.

2. It produces green biomass of narrow C:N ratio which is readily decomposable and improves the nutrient availability.

3. Ploughing or turning green biomass improves soil physical and biological properties.

4. Green manuring brings atmospheric nitrogen to the soil through biological fixation and other nutrients of deeper layer to upper layer.

5. Through decomposition of biomass better availability of other nutrients is ensured.

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Important tips

- Preference should be given to leguminous crops. Along with their ability to supply nitrogen, they are used as a forage crop also.
- Legumes leave a large proportion of easily decomposable root residues compared to cereals.
- A leguminous green manure crop producing 10-25 MT of green matter / ha will add about 60 to 90 Kg N / ha besides improving availability of other nutrients.
- In wide spaced crops like sugarcane, the initial crop growth period can be utilized for growing green manuring crops.
- Summer legumes like black gram and green gram intercropped with spring planted sugarcane increased the cane yield markedly besides producing yield of 4-5 q / ha.
- Long duration green manure crops help restoring soil structure, control weeds, serves the purpose of mulching, composting and provide fodder for feeding livestock.

Types of Green manuring Practice

1. ***Green Manuring in situ (Northern India) :*** Green manure crop grown as pure or intercrops are buried in the same field to be green manured.
    a. Crop should be fast growing and succulent with narrow C:N ratio.
    b. Best stage is the flowering stage.
    c. Green manure crops should be tolerant to alkalinity, acidity, water logging, drought etc.
2. ***Green Leaf Manuring (Eastern and Central India) :*** Turning of green leaves and tender green twigs collected from shrubs and trees grown on bunds, unutilized, marginal lands e.g. *Glyricidia* / *Sesbania*/ *Karanj*etc

Management of Green Manuring

- Second fortnight of May is the best suited time for sowing of green manure crops.
- Proper seed rate (16 - 20 kg/ acre) is required to get higher biomass production.
- Can also be grown as mixed crops e.g. Green manure crops like Indigo and Pulses (Black gram) in the ratio of 1:3, Intercropping of *Sesbania* and Rice, Border planting of *Sebania speciosa* on the bunds of rice fields, Application of phosphatic fertilizer @ 50- 60 kg P2O5 / ha to enhance nodulation and nitrogen fixation and green manuring in rotation as catch crop.

Green manure crop should be ploughed in at 6 week. Rice can be transplanted immediately after puddling but 2 week decomposition time is needed for other crops. Rotavator can be effectively used for incorporating the green manure crop to hasten decomposition of biomass. Details of important green manure crops are provided in **Table 1**.

Table 1. Green manure crops

S. No.	Crop	Sowing Time	Seed rate (kg/ acre)	Turning Age (Days)	N content (%)	Available N* (Kg/acre)
1	Dhaincha	April-July	15-20	45-60	0.42	34-40
2	Sunnhemp	April –July	30-35	45-60	0.43	24-40
3	Guar	April –July	20-25	55-60	0.34	23-30
4	Cowpea	April –July	12-15	55-60	0.49	26-36

S. No.	Crop	Sowing Time	Seed rate (kg/ acre)	Turning Age (Days)	N content (%)	Available N* (Kg/acre)
5	Moong	June –July	8-10	60-90	0.48	15-20
6	Senji	Oct -Dec	20-25	60-90	0.51	50-55
7	Berseem	Oct-Dec	20-25	60-90	0.43	25-30

* Besides nitrogen addition, green manure helps improving availability of all other nutrients.

6. Biofertilizers : Biofertilizers are microbial inoculants consisting of living cells of microorganisms like *Rhizobium, Azotobacter, Azospirillium, Pseudomonas* etc. which either alone or in combination can be applied to composting area for helping in biological nitrogen fixation, phosphorus solubilisation, decomposition of crop residue etc.

Benefits : Supplement nitrogen and phosphorus, stimulate plant growth, increase crop yield, activate the soil biologically, help restore soil fertility, cost effective supplement to chemical fertilizers and eco-friendly.

Types of Biofertilizers : ***(1)*** *For Nitrogen: (a)* Rhizobium for legume crops (b) Azotobacter/ Azospirillum for non legume crops (c) Acetobacter for sugarcane only and (d) Blue –Green Algae (BGA) and Azolla for low land paddy; (2) *For NPK:* IFFCO NPK Consortia; (3)*For Phosphorous, potassium, Sulphur and Zinc :* PSB should be applied with Rhizobium or IFFCO NPK Consortia in pulses and other crops and with Azotobacter, Azospirillum and Acetobacter in other crops.(4) *For enriched compost* : Add Cellulolytic fungal culture/ PSB and Azotobacter culture.

Method of application

A. Seed Treatment
   a. Add 200 gm each of nitrogen fixer and PSB biofertilizers to 1 litre of water.
   b. Pour solution on 10-15 Kg of seed and mix gently under shade.
   c. Treated seeds after drying in shade. should be sown *immediately.*

B. Root Treatment
   a. Root treatment is useful for crops to be transplanted.
   b. Add 4 Kg of biofertilizers (2 Kg each of nitrogen fixer and PSB) to 20 - 25 litres of water in a shallow vessel and make solution properly for root treatment of seedlings for an area of 1 acre.
   c. Dip the roots of seedlings in solution for 20 - 30 minutes.
   d. Nursery may be transplanted after drying roots in shade.

C. Soil Treatment
   a. 4 Kg of Biofertilizers (2 Kg each of nitrogen fixer and PSB) is required for application in 1 acre area.
   b. Mix 4 Kg of biofertilizers in 50 Kg. of soil + 50 Kg. of good quality of compost thoroughly.
   c. Prepared mixture of biofertilizers should be applied in field either in furrow or by broadcasting it before sowing.

D. Foliar Application
   a. Application of liquid biofertilizers at early vegetative stage promotes crop growth.
   b. 500 ml of liquid biofertilizers (250 ml Azotobacter + 250 ml PSB) is required for foliar application in an area of 1 acre.

c. Mix 500 ml of liquid biofertilizers in 500 ltrs. of drinking water in container.
d. Prepared solution of liquid biofertilizers should be applied as foliar application on different field crops (at early vegetative stage) 2-3 times at 7 days interval.

7. Promotion of 100% Water Soluble Fertilizers: Water and nutrients are the major factors that contribute significantly for sustaining crop productivity. Fertilizers being costly and their availability becoming scarce they need to be utilized efficiently in conjunction with water. This aspect is more important under rainfed agriculture where water availability is limited. Water soluble fertilizers are the need of the day to address the issue of decreasing nutrient use efficiency due to deterioration in soil health in consequence to imprudent use of fertilizers. Foliar application of water soluble fertilizers at critical growth stages such as tillering, panicle initiation stage/flowering, fruit setting etc. in addition to basal application of fertilizers and manures provides quick result in case of multi-nutrient deficiencies. Various grades of water soluble fertilizers are available in the market. Given in **Table 5** are the IFFCO water soluble fertilizers being promoted for higher nutrient use efficiency through promotional activities are displayed in **Pictures 4** and **5**.

Table: 5. Generally used 100 % water soluble fertilizers

Sl. No.	Name	Grades (N-P / N-P-K / N-K)
1	Potassium Nitrate	13-00-45
2	Sulphate of Potash (SOP)	00-00-50
3	Mono Ammonium Phosphate (MAP)	12-61-00
4	Mono Potassium Phosphate (MKP)	00-52-34
5	NPK Blends	19-19-19/20-20-20
6	Urea Phosphate	17-44-00
7	19:19:19 NPK	19:19:19

Picture 4. Generally used 100 % water soluble fertilizers of IFFCO

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Picture 5. A view of Promotion of 100% Water Soluble Fertilizers through Fertigation by IFFCO

Fertigation : In this process, concept of fertilizer application and irrigation is united that provides nitrogen, phosphorus, potassium as well as the secondary and micronutrients (Mg, Fe, Zn, Cu, MO, Mn) directly to the plants through active root zone, thus minimizing losses of expensive nutrients, which ultimately help improving productivity and quality of produce. It ensures high yield and economize use of fertilizer and water (40-60%) and save time and labour. The focus crops may be:

Fruit crops: Grapes, pomegranate, banana, citrus, papaya, mango, melon etc.; *(b) Vegetables*: Tomato, capsicum, cucurbits, cucumber, gourd, onion, garlic, bhindi, cabbage; *(c) Flowers:* Rose, gerbera, carnation, lilium etc. *(d)* Plantation crops: Coconut etc.*(e) Others:* Sugarcane, cotton, chilly, maize etc.

Application of WSF under drip irrigation system i.e. pressurized and low pressurized drip system under open field and protected cultivation (called as fertigation) have the potential to increase productivity of crop under limited water availability. Increasing area under horticultural crops along with increase in drip irrigation area to cope up with water scarcity both due to scanty rainfall as well as availability of quality water has brought alternate way of input use. Fertigation has assumed great importance in high value crops like fruits (35 %), vegetables, plantations (18.5%), flowers, sugarcane etc. Among the fruit crops the maximum coverage is under citrus (24%) followed by grapes (19%). Other major fruit crops covered are banana, pomegranate, mango and sapota. There is a growing awareness about drip irrigation even for closely spaced crops. Ensured availability of water soluble fertilizers is important for successful fertigation.

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Fertilizer use efficiency through Micro-irrigation : The benefits of micro-irrigation are given in **Tables 3** and **4**.

Table 3. Fertilizer use efficiency in different methods of fertilizer application (%)

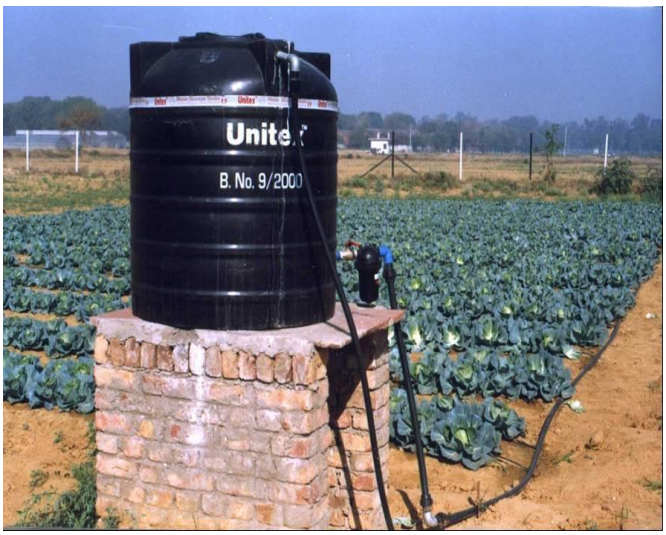
Nutrient	Soil application (Conventional method)	Drip + Soil application (Conventional method)	Fertigation (Fertilizer + Water)
Nitrogen	30-50	65	95
Phosphorus	20	30	45
Potassium	60	60	60

Table 4. Fertilizer use efficiency through Micro-irrigation

Crop	Saving in fertilizer, %	Increase in Yield, %
Sugarcane	50	40
Banana	20	11
Onion	40	16
Cotton	30	20
Potato	40	30
Tomato	40	33
Castor	60	32
Okra	40	18
Broccoli	40	10
Source: NCPAH (2001) National Commission on Plasticulture Applications in Horticulture.		

Low cost drip irrigation systems can bring significant change regardless of size of farm holdings. This will effectively improve use of water and nutrients and bring more area under fertigation.100 % water soluble fertilizer for fertigation should have High nutrient content / Fully soluble at field temperature / Fast dissolution in irrigation water / Fine grade, flowable / No clogging of filters and emmiters / Low content of insoluble /Minimum content of conditioning agents/Compatible with other fertilizers / No drastic changes of water pH /Low corrosivity for control head and system.

Picture 2. Micro irrigation unit for open well with
Storage tank and Filter tank



Picture 3. Low pressure drip irrigation system

IFFCO's Nano Fertilizers : Nano fertilizers like Nano Urea – Liquid (Nano N), Nano Zinc and Nano Copper were manufactured by IFFCO with indigenous research and development. Nanofertilizers were characterized and diluted with an effective concentration of nano nitrogen as 100 ppm, nano zinc as 20 ppm and nano copper as 10 ppm. The diluted nano formulations were mixed just before the use. The nano formulations were foliar sprayed on the plant leaves 2-3 times during the life cycle of the plant at critical growth stages.

IFFCO Nano Urea and Nano DAP (Liquid) : IFFCO Nano Urea (Liquid) and Nano DAP (Liquid) have been notified under Fertiliser Control Order (FCO, 1985), govt. of India and farmers are already using these fertilizers. Nano Urea is sprayed @ 4 ml per liter of water and Nano DAP @ 2 ml/litre water which may vary depending on the crop nitrogen and phosphorus requirements, crop canopy development and amount of water required for a standing crop. It is sprayed at critical crop growth stages when crop canopy is good to uptake the nutrients. First spray of nano urea is done 30-35 days after germination/transplantation and the second spray at least one week before flowering. Number of sprays and spray concentration increases or decreases as per crop nitrogen requirement. Nano DAP is used for seed and seedling treatment @5 ml/kg seed or 5 ml/litre water for seedling treatment. Then after one month one foliar spray of Nano DAP is done @ 2 ml/litre water.

Epilogue

Agriculture sustainability needs holistic transformation in the face of emerging problems in the field. Soil health problems such as deterioration in chemical, physical and biological properties and emergence of multi-nutrient deficiencies emphasize the need for integrated nutrient management and 4R initiative which has positive impact on nutrient use efficiency and soil health. There is still a need for adoption of recommended package of practices which so far have been adopted in piecemeal. Practices that protect soil and crops and also non-renewable natural resource should invariably be adopted. In particular, reduction in tillage and recycling of crop residues on the fields would play a key role towards improving soil properties as well as increasing yields. Wider adoption of these practices should be supported by better information. Indigenous knowledge and practices need to be well blended with modern improved farm technologies to minimize cost of cultivation and also to ensure agriculture sustainability. Cultivation of crops on

the ridges in rainfed areas and on contours in hilly region will protect soil from wind and water erosion. Along with these, growing of cover crops would help minimize soil erosion problem. Summer ploughing through disc harrow will minimize/control weeds. Crop residue recycling and INM would be important for increasing soil organic carbon content. Use of PSNC, vermicompost, tank silt, crop residue recycling and mulching and composting INM, SSNM and green leaf manuring are some of the useful technologies for maintaining soil health not only in irrigated areas but also in rainfed/dryland areas. Problem soils (Alkali soils) need integrated nutrient supply not only for improving soil health but also for amelioration of such soils. Use of gypsum/phosphogypsum would help increasing fertilizer use efficiency. Similarly, the acid soils which cover about 30% of the cultivated area of the country can contribute towards enhancing crop productivity to their achievable potential. Application of soil amendments should precede fertilizer application. Liming acid soils can bring significant benefits from BNF as it creates a more favorable environment for multiplication and improved activity of soil microbes. Much of the technologies for improving health of the alkali, acid soils and slopy lands are available which need to be promoted and adopted on a large scale or say on each and every piece of holding for sustainable soil health and sustainable high agriculture.

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