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AN INSIGHT INTO THE APPLICATION SECTORS OF MICROALGAE

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Abstract
Sophistication and advancement in technology alongwith urbanization, and population boom have prompted the implication of microalgae at the industrial scale for fulfilling human needs. The microalgae industry occupies a vast scale in the market. Although its involvement has many potential benefits butinclusion of microalgae biomass at an industrial scale also suffers from certain shortcomings such as lesser yield, higher energy consumption rate, and high maintenance of culturesand products.However, they can be handled effectively by the development of newer tools and technologies. Microalgae also has a wide application sector. This article provides a brief overview of the application of microalgae in different areas.

Keywords : Application, Industrial, Microalgae, Sectors, Biomass.

Introduction

The rising population and advanced technologies have prompted ever-increasing demands for food products, beverages, supplements, pharmaceuticals, and cosmetics all over the globe (Rahman 2020). To fulfill these demands, there is a continuous exploration search for feasibleoptions. Microalgae are one of the most versatile and promising resources and have occupied a substantial market space. In 2020, the industry based on microalgae bioproducts was US$3.4 billion which is anticipated to escalate to US$ 4.6 billion in 2027. However, to exploit this field to its full potential further studies are mandatory for amelioration in yield and cost (Zhuang *et al*., 2022).

Employment of microalgae at an industrial scale has certain limitations such as lower yield, high power consumption, cultures, and product maintenance which could be easily handled by the ongoing technological advancements shortly. They are contemplated as the most promising source ofhigh-value compounds because of the development of genetic and metabolic engineering, and nanotechnology (Harun *et al.*, 2011).

Microalgae are ubiquitous, micro-organisms that can endure extremely harsh environments. Algae have been employed for human benefits since years ago. Their application will provide a sustainable pathway for the progress of the industrial sector.Microalgae are versatile and sustainablebioresources that can adapt to a wider range of environmental fluctuations with the capability of autotrophic, heterotrophic, and mixotrophically growth (Daneshwar *et al* 2019). Temperature, luminosity, pH, nutrients, and salinity concentration are some crucial cultural conditions for microalgae growth (Singh and Dhar 2011).

Benefits of using microalgae for value-added compound production

Due to their bewildering capacity of photosynthesis, they can fix atmospheric CO_2, and significantly reduce the greenhouse effect, thereby warranting the ecosystem health

(Liyanaarachchi *et al*., 2021). Moreover, microalgae require only simple nutrients to sustain its growth. Additionally, they can grow on marginal land space excluding the need for cultivable land, and generate massive biomass as compared to terrestrial plants (Russell *et al*., 2022).

Moreover, microalgae provide the simpler and easier extraction of the bioactive compounds than complex protocols required in the case of higher plants. Value-added products from microalgae are not only eco-friendly but also havea higher nutrient profile as compared to usual supplements. Pigments from microalgae also have applications in the cosmeceuticals and nutraceuticals sector (Zhuang *et al.,* 2022).

There isan endless list of microalgae application areas. Among them main ones are represented under the following subheads:

Application areas of microalgae

Cosmetics

The termcosmeceutical is used for formulations carrying bioactive components having medicine-like characteristics. Recently, natural ingredients prevailing in algae havegained great interest among the general public as a safer option against chemical-containing synthetic cosmetics. Microalgae produce secondary natural compounds performing a variety of functions such as anti-microbial, free radical scavenging activity, anti-senescence, anti-inflammatory, and anticancerous which establish them as amazing creatures in the cosmetics sector for manufacturing skin care products, lotions, and sunscreens. For example, AlgaPür Algae Oils and GoldenChlorella are two commercial algal products that are used for skin and hair treatments (Wang *et al.*, 2017).

Pharmaceuticals

The Vogueness of algal products lies in their anticancerous, antihyperglycaemic, and antimicrobial properties. They are an inexpensive bioresource for several pharmaceutical compounds such as antibodies, and recombined proteins.α-amylase, α-glucosidase, *N*-acetyl-glucosaminidase, aldose reductase, hexokinase, glucose-6-phosphatase, dipeptidyl peptidase IV, glucose transporter 4 and glycogen synthase kinase-3β from *Chlorella* sp. *Nitzschia laevis*, *Isochrysis galbana*, *Chaetoceros furcellatus*, *Skeletonema marinoi,*and *Porosira glacidis* species are some examples of the enzymes from algae (Abo-Shady *et al*., 2023). Microalgal PUFAs such as DHA and EPA have anti-inflammatory properties effective in reducing hypertension, stroke, and arthritis and for the proper growth of the nervous system (Mutanda *et al.*,2020).

Nutraceuticals

High levels oflipids, proteins, sugars, pigments, vitamins, minerals, phenols, *etc.* in microalgal biomass make them an effective option for functional food or nutraceuticals. Microalgae can synthesize polyunsaturated fatty acids such as linoleic acid, γ-linolenic acid (GLA), arachidonic acid (ARA), linolenic acid, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) which have many benefits in ailments such ascardiac diseases, arthritis, and arterial hypertension. They bring down the triglyceride levels in the body and enhance high-density lipoprotein cholesterolthrough their hypolipidemic function and brain development (Jacob-Lopes *et al*., 2018). Pigments present in microalgae besides being used as food colorants have anti-inflammatory, antitumor, free radical scavenging, antidepressant, and antisenescence attributes (Camacho *et al*., 2019).

Feed

Animalfeed fortified with microalgae contributes synergistic and significant improvement in the physiology and immunity of the animal by providing resistanceagainst diseases, improving the performance of the reproductive system, and weight gain (Madeira *et al*., 2017).*Arthrospira, Chlorella,* and *Dunaliella*are the most employed genera for inclusion in animal feed.Theinculcation of *Chlorella vulgaris*in cattlefeed enhances the DHA content and reduces the saturated fatty acids in animal milk (Kouˇrimská *et al*.,2014). Microalgae addition to lamb and horse feed and pig and poultry feed horses increases the fatty acids concentration of themeat (Hess *et al*., 2012) and mass gain, respectively (Simkus *et al*., 2013).An example of the inculcation of microalgae feed in the aquaculture sectoris the use of astaxanthin for enhancing seafood production and fish and shrimp color (Yaakob *et al*., 2014).

Biofertilizers

After extraction of value-added compounds from microalgal biomass, residual biomass containing remaining nutrients can be employed as biofertilizer. Biofertilizers can be employed to boostcrop growth and yield (Ali *et al*., 2022). Plant growth hormones such as cytokinins, auxins, gibberellins, abscisic acid, ethylene, betaine, and polyamines are embedded in the algal biomass (Ammar *et al*., 2022). Microalgae extracts can be used as growth stimulants and as amendments in crop plants (Ronga *et al*., 2019).

Conclusions

Microalgae are the most sustainable and valuable bioresources gaining worldwide attention and have applications in several sectors such asnutraceuticals, pharmaceuticals, biofuels, agriculture, *etc*.They can synthesize biomolecules namely proteins, sugars, lipids,vitamins, pigments, *etc.* exhibitingendless activities such asantioxidant, antimicrobial, anticarcinogenic, antihypertensive, neuroprotective,and immunomodulatory.

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CULTIVATING TOMORROW'S HARVEST: HARNESSING THE POTENTIAL OF AEROPONICS FOR SUSTAINABLE AGRICULTURE IN A GROWING WORLD

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Abstract

As Earth's population surges, traditional agriculture faces challenges in meeting growing food demand. This paper explores the potential of aeroponics, an innovative soil-less cultivation method, addressing water and nutrient efficiency. Aeroponics benefits include uniform crop growth, rapid seed multiplication, and enhanced nutrient uptake. Despite advantages, challenges like cost and maintenance exist.

Introduction

Earth Population is expected to rise by 3 billion people. It is estimated that approximately 109 hectares of additional traditional land will be needed to feed them, among them only 80% of the Earth’s arable land is suitable for farming now. A greater quantity of hectares with optimum inputs is needed every day to feed the rising population. To solve the problems mentioned, new farming methods have been searched, one of them being aeroponics.

An aeroponic system is medium-less in that the roots of the plant are free hanging inside an open root-zone atmosphere. Aeroponics structure supplies optimum levels of water, nutrients and air to the growing chamber. Aeroponics is the process of growing plants in an air or mist environment without use of soil or an aggregate media. This was widely used in horticultural species including potato, tomato, lettuce, cucumber etc.

Importance of Aeroponics in Vegetable Crops

1. Water use efficiency - Almost 99% of the water is used by the plant. Since pesticides and soil compatible fertilizers are not used, vegetables obtained are pure and doesn’t need to be washed before use.
2. Nutrient use efficiency - Delivers nutrients directly to the plant roots, which results in a faster growth of crops. Vegetables obtained from an aeroponics-based greenhouse are healthy, nutritious, pure, rich, fresh and tasteful. Aeroponics system uses nutrient solution recirculation. Aeroponics system also allows the measurement of nutrient uptake over time under varying conditions.
3. Uniform growth of crops was also observed. It comparatively offers lower water and energy inputs per unit growing area.
4. Optimizes root aeration - because the plant is totally suspended in air, giving the plant stem and root systems access to 100% of the available oxygen in the air which promotes root growth. Such environment also gives plants 100% access to the carbon dioxide concentrations ranging from 450 to 780 ppm for photosynthesis hence, plants in an aeroponics environment grow faster and absorb more nutrients than regular hydroponics plants.

5. Aeroponics method of propagation is one of the most rapid methods of seed multiplication. Another advantage of aeroponics system is that of easy monitoring of nutrients and pH. Aeroponics system also allows the measurement of nutrient uptake over time under varying conditions.
6. Aeroponics production system is very space efficient, with plants taking up minimal room.

Nutrients Used in Aeroponics System
Carbon, oxygen and hydrogen are present in air and water. Water may contain a variety of elements with primary nutrients such as nitrogen, phosphorus, potassium and secondary nutrients *viz*., calcium, magnesium, and sulphur, micro-nutrients are iron, zinc molybdenum, manganese, boron, copper, cobalt and chlorine.

The optimal pH for plant growth is between 5.8 and 6.3. In aeroponic system where water and nutrients are recycled, it is important to measure the acid/base or pH measurement to allow plants to absorb nutrients. Aeroponic using spray to nourish roots use much less liquid resulting in easier management of nutrient concentration with greater pH stability.

Components of Aeroponics System
Spray misters: Automization is achieved by pumping water through nozzles at high pressure. Nozzels come in different spray patterns and orifices. Larger nozzles and orifices reduce the chance of clogging but need pressure to operate and have high flow rates. Droplet size in a given spray may vary from sub microns to thousands of microns.

Droplet size: The ideal droplet size range for most plant species is 20 - 100 microns. Within this range the smaller droplets saturate the air, maintaining humidity levels within the growth chamber. The larger droplets 30 - 100 microns make the most contact with the roots. Spray droplets less than 30 microns tend to remain in the air as a fog. While any droplets over 100 microns tend to fall out of the air before containing any roots. Too large of a water droplet means less oxygen is available to the root system.

High pressure water pump: High pressure aeroponics requires a pump that can produce enough to pressurize the water to produce the ideal droplet size of 20 to 50 microns. These pumps are generally diaphragm pumps or reverse osmosis booster pumps. The pump must produce a steady 80 PSI with required nutrient flow.

Light and Temperature: Replacement for Sun light is very essential. It can be replaced by fluorescent tubes of required Intensity. 15000-20000 lux – for vegetative growth, 35000-40000 lux –for flowering and fruiting. The optimum temperature for all plants is 150C – 250C. Misting Frequency and Nutrient Reservoir.

Crop Production
Potato: The International Potato Center (CIP) has recently developed and promoted mini-tuber production based on a novel, rustic and publically available aeroponics system. Results showed that the aeroponics system is a viable technological alternative for the potato minituber production component within a potato tuber seed system producing a greater number of tubers, high tuber yield tuber weight. Thus, aeroponic system, has potential to increase income and reduce cost of production of quality seed, thereby, making it more accessible to growers in developing countries where potato production is heavily constrained by the use of poor-quality seed tubers.

Yams: The aeroponics technology should be considered as an effective yam propagation method. Genotypes of both *D. rotundata*and *D. alata*were successfully propagated in it using both pre-rooted and fresh vine cuttings. Results of these studies revealed that vines cutting from five months old plants rooted successfully (95%) within 14 days in aeroponics. Other vegetables like lettuce, tomato and leafy greens are also cultivated through aeroponics.

Leafy vegetables: A comparison of the product yield, total phenolics, total flavonoids, and antioxidant properties was done in different leafy vegetables/herbs (basil, chard, parsley, and red kale) and fruit crops (bell pepper, cherry tomatoes, cucumber, and squash) grown in aeroponic growing systems and in the field. An average increase of about 19%, 8%, 65%, 21%, 53%, 35%, 7%, and 50% in the yield was recorded for basil, chard, red kale, parsley, bell pepper, cherry tomatoes, cucumber, and squash, respectively, when grown in aeroponic systems, compared to that grown in the soil.

Advantages

1. Reduction in fertilizer use - Since all the nutrients are contained, they don't end up in groundwater or sinking too deep into the soil to be of any help.
2. Reduction in water use - Very important for space travel and those in arid climates. Much of the water lost in traditional gardening is from water evaporating out of the soil. The rest of it just sinks past the roots and the plants never get a chance to drink it.
3. More Cost Effective - Since less nutrient solution is needed as compared to hydroponics the costs to operate an aeroponic garden are less than to operate a hydroponic garden. There are also fewer moving parts and complicated systems involved.
4. Reduced Disease Damage - Because the plants are separated from each other and not sharing the same soil, an infection in one plant has a much lower chance of spreading to the rest of your plants.
5. Faster and healthier growth since it has enough oxygen (in the root region) Increased harvest rate is 45–70% faster than conventional agricultural techniques.
6. Studies has shown that plants grown via the aeroponic system have an increase in flavonoids.

Disadvantages

1. More expensive for long scale production.
2. Ordinary farmers will struggle to manage all these sophisticated instruments
3. Mister spray heads may also have a tendency to clog and not produce mist when needed.
4. Many consumers believe that aeroponically grown plants are not as nutritious as other grown plants.
5. Maintenance of an aeroponics farm is very expensive.

Conclusion

Aeroponics emerges as a promising solution to address the impending global food crisis. Its benefits, such as water and nutrient efficiency, rapid seed multiplication, and faster crop growth, underscore its potential. However, challenges like cost and maintenance need consideration to ensure widespread adoption and maximize its impact on sustainable agriculture.

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GREEN HORIZONS: MEETING CHALLENGES AND UNLEASHING OPPORTUNITIES IN CLIMATE-SMART AGRICULTURE

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Abstract

Global agriculture is facing previously unheard-of difficulties as a result of climate change, which calls for creative solutions to ensure food security and sustainable farming. This study delves into the intricate notion of Climate-Smart Agriculture (CSA), which is a complete framework that aims to improve agricultural productivity, enhance climate resilience, and lower greenhouse gas emissions. Productivity, adaptation, and mitigation—the three pillars of CSA—are broken down to give a more complex picture of the approach.In light of climate change, the importance of CSA is emphasized, underscoring its critical function in building agricultural systems' resilience. It is discussed how important it is to modify agricultural techniques to resist shocks brought on by climate change, such as harsh weather and changing precipitation patterns. Additionally, by highlighting productivity improvements through cutting-edge methods and technology, CSA is positioned as a major actor in resolving concerns about global food security.The explanation of the CSA conceptual framework highlights its three main tenets: adaptation, mitigation, and sustainable intensification. Precision farming, remote sensing, and agroecological techniques are examples of technological integration that is examined as being essential to improving resilience and sustainability in agriculture.Prospects for CSA advancement are examined, emphasizing biotechnology, data analytics, policy assistance, and public-private collaborations. Successful CSA deployments are highlighted in case studies from China, Kenya, and Colombia, offering insightful analysis and best practices.Research gaps and future prospects in CSA are explored, with a focus on the need for studies on ecosystem-based techniques, big data and artificial intelligence applications, social and economic factors, and climate-resilient crop breeding. The conclusion emphasizes how critical it is to support and prioritize CSA in order to encourage broader adoption and adaptation and guarantee a resilient and sustainable future for international agriculture in the face of climate change.

Keywords : Agriculture, Climate Change, CSA, Climate-smart, Challenges

I. Introduction

Global agriculture faces enormous problems as a result of climate change, which calls for creative solutions to guarantee food security and sustainable farming methods. Climate-Smart Agriculture (CSA), a notion that has gained popularity recently, is one such strategy. The triple aims of improving agricultural output, strengthening resistance to climate change, and lowering greenhouse gas emissions are addressed by the CSA, which is an integrated and comprehensive framework (FAO, 2010).

The three pillars of climate-smart agriculture—productivity, adaptation, and mitigation must be broken down in order to fully understand the concept. Utilizing cutting-edge techniques and technology to maximize production while reducing resource inputs is what productivity entails. The goal of adaptation is to build agricultural systems that can withstand the effects of climate change, including extreme weather events, changes in temperature, and altered precipitation patterns. By using sustainable practices and technology, mitigation seeks to lower greenhouse gas emissions associated with agriculture (Lipper et al., 2014).The complexity of CSA necessitates a thorough comprehension of its tenets and methods. This essay delves into the complexities of Climate-Smart Agriculture, offering a sophisticated examination of its definition, constituent parts, and the wider framework in which it functions.

Climate-Smart Agriculture's (CSA) Significance in the Framework of Climate Change

With its unpredictable and intense weather events, changed precipitation patterns, and rising temperatures, climate change poses a serious threat to world agriculture (IPCC, 2014). Climate-smart agriculture (CSA) becomes extremely important in this environment. In order to minimize the negative effects of climate change on agricultural systems and promote sustainable growth, CSA provides a calculated and flexible solution.Enhancing agricultural practices' resilience is one of the main reasons that CSA is important. In order to ensure that agricultural systems can withstand and recover from climatic shocks, CSA emphasizes the adoption of resilient crop varieties, improved water management techniques, and sustainable soil conservation methods (Lipper et al., 2014). This is because climate change introduces uncertainties and vulnerabilities. CSA supports the long-term sustainability of food production by enhancing adaptive capacity.

In addition, CSA is essential in tackling issues related to food security in the context of climate change. There is an immediate need to raise agricultural output due to changes in climate and an increasing global population. By combining cutting-edge techniques and technologies that maximize resource use and raise yield, CSA does this (FAO, 2010). In the face of climate-related uncertainty, CSA helps to ensure a stable and sufficient food supply by concentrating on productivity gains.Climate-smart agriculture (CSA) plays a key role in reducing the environmental impact of agriculture on climate change, in addition to providing food security and adaptability. Methane and nitrous oxide emissions from agricultural operations are the main sources of greenhouse gas emissions (Smith et al., 2014). According to Lipper et al. (2014), the Conservation Science Association (CSA) advocates for sustainable land management, agroforestry, and conservation agriculture as means of mitigating climate change. These practices not only absorb carbon but also lower emissions.In conclusion, in the backdrop of climate change, the significance of climate-smart agriculture cannot be emphasized. Because of its comprehensive strategy that addresses productivity, adaptation, and mitigation, CSA is seen as a vital tool for ensuring the sustainability, productivity, and resilience of global agricultural systems in the face of climate change.

A comprehensive strategy for tackling the problems caused by climate change in agriculture is called Climate-Smart Agriculture (CSA). With a broad emphasis, CSA aims to reduce environmental impact, boost production, and improve resilience. The "triple win" goals include adopting creative behaviours, optimizing resource consumption, and increasing production through climate-resilient technology. To overcome climate uncertainty, CSA promotes robust agricultural types, sustainable water management, and soil conservation. Additionally, via techniques like agroforestry and better livestock management, CSA lowers greenhouse gas emissions and helps mitigate the effects of climate change. Establishing a resilient and sustainable agricultural system is the main objective, and it will be accomplished by incorporating climate concerns into research, regulations, and on-farm practices for a comprehensive and flexible strategy.

Conceptual Framework of Climate-Smart Agriculture

Climate-Smart Agriculture (CSA) operates on core principles that integrate adaptation strategies, mitigation measures, and sustainable intensification, providing a comprehensive framework to address climate change challenges in agriculture.Adaptation techniques within CSA entail strengthening the resilience of agricultural systems to climate change impacts. This entails encouraging crop types that are robust to climate change, putting sustainable water management policies into effect, and utilizing conservation agricultural methods (FAO, 2010). Through the integration of these measures, CSA hopes to assist farmers in adapting to the effects of a changing climate, including modified patterns of precipitation and a rise in the frequency of extreme weather events.in the context of the CSA, mitigation techniques work to lower greenhouse gas emissions from agriculture while advancing sustainable production. techniques including agroforestry, cover crops, and better livestock management can sequester carbon and reduce emissions. These steps address the environmental impact of agricultural practices and are in line with global climate mitigation targets.A key tenet of CSA is sustainable intensification, which emphasizes the need to raise agricultural output while reducing adverse environmental effects. To increase output without jeopardizing the ecological balance, this entails implementing precision agriculture, maximizing the use of resources, and using cutting-edge technology (Pretty et al., 2018). Sustainable intensification lowers resource input requirements and increases efficiency, ensuring the long-term sustainability of agricultural systems.

Enhancing the sustainability and resilience of agricultural systems in the face of climate change is largely dependent on the incorporation of technology into Climate-Smart Agriculture (CSA). Precision farming, remote sensing, and agroecological techniques are just a few examples of the sophisticated instruments and techniques that are strategically used in this integration process.One important technology aspect of CSA is precision farming, which aims to increase agricultural techniques' efficiency and optimize resource utilization. With this method, inputs like water, fertilizer, and pesticides are carefully managed via the use of sensors, GPS technology, and data analytics. With the use of real-time data, precision farming enables farmers to make well-informed decisions that maximize output while minimizing waste and its negative effects on the environment (Lobell et al., 2009).Applications of remote sensing make major contributions to CSA by giving useful information for managing and keeping an eye on agricultural environments. Crop health, soil conditions, and land use patterns may all be evaluated with the use of drones, satellite photography, and other remote sensing technology. According to Thenkabail et al. (2019), this data promotes the adoption of adaptive techniques in response to changing climatic circumstances, makes decision-making easier, and helps identify any problems early.The incorporation of ecological concepts into agricultural systems is emphasized by agroecological techniques.

Agroecology in CSA refers to the use of resilient and varied cropping systems, incorporation of cover crops, and encouragement of natural pest management techniques. This strategy increases soil health, boosts biodiversity, and increases agricultural ecosystems' overall tolerance to climatic unpredictability (Altieri, 1995).These technical elements work together in CSA to increase agriculture's resilience while also supporting sustainability objectives. In the context of climate change, farmers may monitor environmental conditions, optimize resource usage, and promote resilient and sustainable agricultural systems by utilizing agroecological practices, precision farming, and remote sensing technologies.

II. Challenges in Implementing Climate-Smart Agriculture

Crop yields, water availability, and overall farm production are all impacted by climate variability and unpredictability, which provide major difficulties to agriculture. Natural variations in climatic patterns, such as variations in temperature, precipitation, and extreme weather occurrences, are referred to as climate variability. Conversely, unpredictability describes the challenge of precisely predicting particular weather conditions.Climate variability makes resource restrictions worse for farmers. Variations in the weather can cause unpredictable water supply, which can affect crop management and irrigation. Furthermore, severe weather events like floods or droughts might interfere with planting and harvesting schedules, which can lower overall agricultural productivity (Sivakumar & Stefanski, 2010).

One important component of resource limitations in agriculture is financial difficulties. Farmers frequently lack the resources to invest in climate variability-mitigating adaptive technology and practices. Weather fluctuations can lead to higher production risks, which makes it harder for farmers to get insurance or financing (Antle & Capalbo, 2010).Farmers have a difficult time responding to the unpredictable nature of the environment since they have little access to technology. Precision farming and crop types resistant to climate change are examples of advanced technology that can improve resilience and production. The impact of climatic variability on farmers' livelihoods may be exacerbated by their inability to use these technologies if they have low financial resources (World Bank, 2010).

Agriculture faces additional difficulties in adjusting to climatic unpredictability due to institutional and policy obstacles. Climate-smart activities are difficult to execute when there are no enabling policies in place. The implementation of adaptation measures may be hampered by policies that fail to take into account the unique demands of farmers in the face of climate change.The reaction to climatic variability is further complicated by challenges with institutional coordination. The creation of context-specific adaptation techniques and the transmission of climate information are impeded by the lack of efficient communication and collaboration among research institutions, governmental agencies, and local people (Fernandez &Sutz, 2011).The success of Climate-Smart Agriculture (CSA) is largely dependent on socioeconomic variables, with farmer knowledge, education, and gender concerns playing major roles. By raising farmers' knowledge of the dangers associated with climate change and encouraging the use of cutting-edge CSA methods, education initiatives help to build their resilience and production. Women's access to resources and decision-making in agriculture are frequently restricted by gender inequality.(FAO, 2013).

Gender-sensitive CSA techniques are used to recognize the achievements of women and to ensure their empowerment via involvement and education. The distribution of CSA expertise is facilitated by farmer groups and cooperatives, which encourage teamwork and improve scalability and sustainability in local communities. The successful implementation of CSA requires a comprehensive strategy that considers socioeconomic dynamics, prioritizes education, and tackles gender imbalances. This will help agricultural systems remain resilient and sustainable in the face of climate change concerns.(Birner et al., 2018).

III.Opportunities for Advancing Climate-Smart Agriculture

By utilizing biotechnology, data analytics, decision support systems, policy and institutional assistance, technical improvements, public-private partnerships, climate financing mechanisms, and financial incentives, Climate-Smart Agriculture (CSA) presents a multitude of advancement potential.Innovations in technology are essential to CSA, emerging technologies like sensor networks, drones, and precision farming allow for more adaptable capacity, input optimization, and accurate resource management. To provide sustainable harvests in the face of changing climatic circumstances, biotechnology and genetic advancements help to generate crops with higher resistance to abiotic stressors, pests, and diseases (Tester & Langridge, 2010).Decision support systems and data analytics offer up-to-date information for well-informed agricultural decision-making. The efficiency of CSA techniques is increased when farmers anticipate and adapt to climatic variability via the use of satellite images, climate models, and big data analytics (Thenkabail et al., 2019).

The development of policy and institutional support are essential avenues for CSA progress. Widespread implementation of CSA principles is made possible by national and international policy frameworks that include them into agricultural policies (FAO, 2010). Implementing CSA methods is made easier by strengthening extension services, which guarantee efficient information transfer and capacity building among farmers (Birner et al., 2018).Decision support systems and data analytics offer up-to-date information for well-informed agricultural decision-making. The efficiency of CSA techniques is increased when farmers anticipate and adapt to climatic variability via the use of satellite images, climate models, and big data analytics. The development of policy and institutional support are essential avenues for CSA progress. Widespread implementation of CSA principles is made possible by national and international policy frameworks that include them into agricultural policies (FAO, 2010). Implementing CSA methods is made easier by strengthening extension services, which guarantee efficient information transfer and capacity building among farmers (Birner et al., 2018).

IV. Case Studies and Success Stories

Climate-Smart Agriculture has been effectively implemented in several areas and nations, offering insightful insights, creative solutions, and best practices that support the development of sustainable agriculture. Analysing situations demonstrates the variety of approaches used to mitigate the effects of climate change and improve resilience.

China's Agro-Ecological Zoning: This method, which is based on soil and climate characteristics, assigns particular regions agricultural techniques, is applied. As a result, there has been a decrease in environmental impact and an increase in production (Zhang et al., 2018).

Kenya's Climate-Smart Villages: This project combines sustainable land practices, water management, and climate-resilient agriculture. According to Rurinda et al. (2018), this all-encompassing strategy has improved community livelihoods and increased food security.

Colombia's Sustainable Intensification: Colombia's adoption of sustainable intensification practices, including agroforestry and conservation agriculture, has improved resilience to climate variability and increased agricultural productivity (Fischer et al., 2018).

The effectiveness of these implementations highlights important lessons, such as how Climate-Smart Agriculture practices should be customized to local contexts, how multiple components, such as crop management, water use, and soil conservation, must be integrated, and how community involvement and engagement are crucial to the success and sustainability of CSA initiatives.The adoption of eco-compensation policies, which provide financial incentives to farmers who adopt CSA practices, is an example of an innovative approach and best practice in Climate-Smart Agriculture. Other examples include the use of digital agriculture platforms for weather information, market access, and farm management (Hobbs et al., 2017; Zhang et al., 2018). These examples highlight how crucial it is to use context-specific solutions, include the community, and integrate cutting-edge technologies to make sure that Climate-Smart Agriculture programs succeed.

V. Future Directions and Research Gaps

Breeding Crops to Resist the Climate:

Further studies are necessary to create crops that are more resilient to abiotic stressors and pests, which will guarantee consistent yields even when weather patterns change (Tester & Langridge, 2010).

Big Data and Artificial Intelligence (AI) in CSA:

A chance to use cutting-edge instruments for forecasting climatic trends, streamlining resource management, and enhancing agricultural decision support systems is provided by the integration of big data analytics and artificial intelligence (AI) into climatic-Smart Agriculture research (Lobell et al., 2019).

Approaches Based on Ecosystems:

A thorough investigation of ecosystem-based methodologies, such as agroecology and sustainable intensification, ought to be part of the future course of CSA research. According to Perfecto et al. (2009), these methods can improve ecosystem services, biodiversity, and resilience in agricultural landscapes, which will support climate-smart and sustainable practices.

Topics Needing Additional Research:

Social and Economic Dimensions: Further study is required to comprehend the socioeconomic elements, such as farmer awareness, education, and gender concerns, that impact CSA adoption (Birner et al., 2018).

Impact Assessment: In order to determine the efficacy of CSA procedures and pinpoint areas in need of improvement, thorough evaluations of the global economic, social, and environmental implications of these practices are important (Lipper et al., 2014).

Precision farming with remote sensing:

The persistent progress in remote sensing technology and precision agriculture approaches has the capacity to greatly enhance agricultural system monitoring and management by providing accurate solutions to the problems presented by climatic variability (Thenkabail et al., 2019).

Blockchain-Based Traceability Technology:

The implementation of blockchain technology presents a viable approach to establish transparent and traceable supply chains in the agricultural sector. In the field of climate-smart agriculture, this invention guarantees the authenticity and sustainability of goods, adding to the entire integrity of the supply chain (Janssen et al., 2019).

VI. Conclusion

In conclusion, research into Climate-Smart Agriculture (CSA) demonstrates a diverse strategy meant to lessen and adjust to the effects of climate change on agricultural systems. The combination of strategies addressing resilience, productivity, and environmental sustainability is emphasized in the concept of CSA. Context-specific solutions are crucial, as demonstrated by lessons learned from successful implementations, which include community participation, integrating numerous components, and customizing techniques to local settings. In addition, creative methods such as eco-compensation laws and digital agriculture platforms demonstrate how flexible CSA is, allowing it to adjust to new developments in technology and legislation.Prospective avenues for sustainable agriculture are presented by the developing trends in climate-resilient crop breeding, big data and AI applications, and ecosystem-based techniques, which are highlighted in the research directions for CSA. Technological developments such as blockchain and remote sensing augment the validity, traceability, and monitoring of climate-smart agriculture methods.

There are significant implications for agriculture's future in a changing environment. A approach to promote resilience, guarantee food security, and lessen the negative effects of agriculture on the environment is through CSA. Nonetheless, issues like resource scarcity, social inequality, and climatic unpredictability require thorough consideration. It is therefore essential that stakeholders and legislators issue a call to action to prioritize and fund CSA. of encourage wider adoption and adaption of CSA techniques, this entails coordinating CSA principles with national and international policy frameworks, offering financial incentives, bolstering extension services, and supporting research.

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DNA BARCODING: A GENOMIC TOOLS FOR SWIFT AND ACCURATE SPECIES IDENTIFICATION

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Abstract
DNA barcoding is a swift and accurate technique for identifying species, relying on the analysis of a short DNA sequence rather than the entire genome. Each species, akin to a fingerprint, possesses a unique barcode. This DNA barcode sequence is then compared to a reference library containing information about various species linked to their respective barcodes. The technique has crucial applications in biodiversity conservation, playing a vital role in preserving endangered species and promoting sustainable natural resource management. In botanical studies, it proves invaluable for accurate categorization of medicinal plants. Agriculture benefits significantly from DNA barcoding, particularly in pest management, providing insights for effective agricultural practices by identifying both beneficial insects and harmful pests. Beyond taxonomy and conservation, DNA barcoding extends its utility into diverse fields, emerging as an indispensable tool in contemporary biological research.

Keywords : DNA barcoding, barcode, Identification**,** taxonomy, CO1, BOLD, BLAST

Introduction

Insects are the most abundant life form on Earth, have evolved into an astonishing array of shapes and sizes. Despite the discovery of one million insect species, many more remain unknown. The task of identifying insects is daunting, requiring an increased number of specialists and funding. To tackle this challenge, naturalists devised taxonomy, a scientific discipline that categorizes living organisms based on their morphological features. After 250 years since the time of Darwin and Linnaeus, a novel approach called DNA barcoding has emerged. This method, a cornerstone of DNA-based taxonomy, identifies both known and unknown species by analysing the unique arrangement of nucleotides in a fragment of DNA specific to each species. Widely embraced from seasoned taxonomists to graduate molecular biologists, DNA barcoding is endorsed by governmental and non-governmental organizations worldwide for cataloguing Earth's biodiversity**.**
In 2003, Paul Hebert and his research team at the University of Guelph in Ontario, Canada, introduced DNA barcoding as a taxonomic approach. This method employs a concise genetic marker or DNA sequence to ascertain the identity of organisms or particular species. Their publication, titled "Biological identifications through DNA barcodes," introduced a novel system for identifying and discovering species employing a short DNA segment from a standardized genomic region (Antil et al., 2023). This DNA sequence functions similarly to a supermarket scanner, utilizing the familiar black stripes of the UPC barcode to identify purchased items. The advent of molecular biology and its tools has revolutionized the identification of life forms, including insects, making it faster, more accurate, and simpler. The Barcode of Life Data Systems (BOLD) houses approximately 19,961,360 insect species barcodes, facilitating global research efforts.

Over time, DNA Barcoding has evolved with advancements like next-generation sequencing, third-generation sequencing, and Nano tracer, making it more precise and rapid. However, a notable limitation islack of a universal primer or gene applicable to all types of life forms, hindering effective species differentiation. Challenges include a lack of a comprehensive reference DNA barcode library and the loss of quantitative information due to biases in primers and polymerases. Despite these limitations, DNA barcoding addresses issues beyond research, aiding in pest control, food safety, resource management, biodiversity conservation, and education. Its significance lies in providing precise and cost-effective biodiversity characterization, particularly crucial amid ongoing threats and rising extinction rates.

DNA BARCODING MARKERS

This approach is versatile, applicable to both prokaryotes and eukaryotes, and employs specific markers tailored for distinct species. The barcoding of various organisms involves the utilization of different genes or markers.

Table 2: Barcoding markers for different organisms

ORGANISMS	MARKER
Animals	The 648-base-pairfragment located in the mitochondrial cytochrome c oxidase 1 gene, known as "CO1," has proven to be exceptionally effective in the identification of various animal groups, including birds, insects, spiders, fish, collembolans, bats, fishes, reptiles, musk deer, and many others.The key advantage of using COI lies in its optimal length – short enough for quick and cost-effective sequencing, yet long enough to discern variations among different species (Wilson et al.,2017).
Plants	In 2009, the Plant Working Group of the Consortium for Barcode of Life (CBOL) proposed seven potential DNA barcodes for plants. These include rbcL (large subunit of ribulose 1, 5 bisphosphate carboxylase), matK (maturase K), psbA-trnH (intergenic spacer region), rpoC1 (RNA polymerase C1), rpoB (RNA polymerase B), atpF-atpH (encodes for ATP synthase subunits CFO I and CFO III), and psbK-psbI (encodes for polypeptide K and L of photosystem II).
Fungi	Internal Transcribed Spacer (ITS), the D1-D2 region of the large subunit of ribosomal RNA gene, RPB1, and RPB2 of the large subunit of RNA polymerase II, γ-actin (ACT), β-tubulin II (TUB2), translation elongation factor 1-α (TEF/α), DNA topoisomerase I (TOPI), and phosphoglycerate kinase (PKG serve as barcodes for identifying fungal species
Archae	The he 16S rRNA gene is widely utilized as a barcode to evaluate the diversity of archaea.
Bacteria	The 16S rRNA gene serves as a universal marker due to its high conservation across all bacterial species. The assessment of bacterial diversity can also be accomplished by employing other genes as barcodes, such as COI, rpoB, cpn60 (encoding chaperonin protein), RIF (Replication initiation factor), tuf (elongation factor) and gnd (Gluconate-6-phosphate dehydrogenase) gene.
Virus	No universally standardized barcode fragment specifically assigned for virus detection.
Protist	Several DNA barcode candidates have been proposed, including COI, ITS, rbcL, 18S rRNA geneand the 28S rRNA gene region.

Procedure

While the technologies employed in DNA barcoding research have seen continuous growth and evolution, the fundamental process has remained largely unchanged. Table 1 outlines a step-by-step procedure for DNA barcoding.

Table 1: Procedure for DNA barcoding

Step 1: Extraction of DNA	To acquire DNA from an individual specimen, a small tissue sample, such as an insect leg, hair/feathers, or a mouth swab, is collected. For bulk analysis, DNA is extracted from a collective sample comprising multiple specimens.
Step 2: Amplify	By employing suitable primers and the polymerase chain reaction (PCR), the particular barcode region of the specimen's DNA is replicated millions of times, preparing it for subsequent sequencing.
Step 3: Sequence	The amplified DNA sample is introduced into a DNA sequencing platform, where the unknown tissue sample's nucleic acid sequence, representing its DNA barcode, is determined. This sequence is denoted by a series of letters (CATG), corresponding to the nucleic acids cytosine, adenine, thymine, and guanine.
Step 4: Comparison	The amplified DNA is sequenced on a platform or compared to the Barcode of Life Data Systems (BOLD) database, a comprehensive reference for identifying unknown specimens. This translates the tissue sample into a unique DNA barcode sequence.BOLD serves as a valuable resource for DNA barcoding, facilitating data storage, retrieval, and analysis by researchers.

After successful DNA extraction and barcode amplification with primers, a single gel band per sample signals readiness for sequencing. Upon obtaining the DNA sequence, the Basic Local Alignment Search Tool (BLAST) on the NCBI website identifies the closest species match in its extensive database, offering valuable insights into the specimen's genetic makeup and potential species identification.

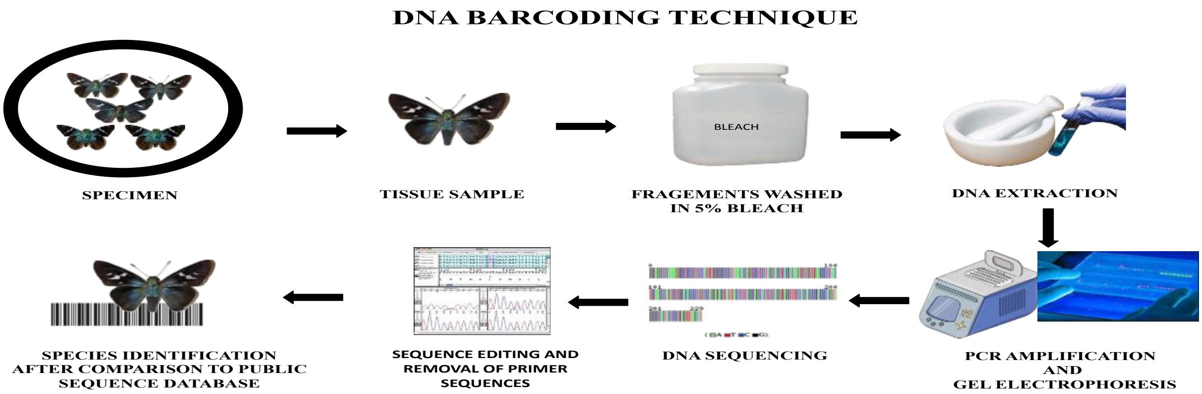

Figure 1: DNA Barcoding procedure (Source, Aquiny)

Applictions

DNA barcoding benefits scientists in various fields, including biotechnology, forensic science, extending beyond taxonomists. Its applications are diverse, crucial for scientific advancements, human well-being, and environmental health (Frézal et al.,2008;Wilson et al.,2017). It serves as a universally accessible tool for exploring and identifying multicellular life forms globally.

1. Exotic Species Detection: This method enables monitoring and early detection of invasive species, safeguarding ecosystems from potential threats.
2. Nature Conservation and Predictive Analysis: DNA barcoding contributes to understanding biodiversity and assessing the impact of human-induced changes, facilitating predictions for species survival and the future of our planet.
3. Unveiling Cryptic Species: DNA barcoding plays a pivotal role in differentiating cryptic species—those that appear identical but possess distinct genetic differences. This has profound implications for biodiversity, wildlife management, and disease control.
4. Food Safety Assurance: DNA barcoding is a critical tool for ensuring food safety by verifying proper labeling and confirming the authenticity of food products.
5. DNA barcoding proves highly beneficial in forensic science. Certain plant species, like Datura sp., possess toxic properties, leading to severe health complications in humans and animals upon ingestion.

Conclusion

DNA barcoding, recognized as a simple and accurate method, is increasingly considered as an integrated approach alongside classical taxonomy for species identification and authentication in the post-genomics era. The BOLD system, currently housing over 19,961,360 records, serves as the official repository for DNA barcode data. In the foreseeable future, DNA barcoding is expected to evolve into a standard identification protocol for diverse organisms. With the integration of identification support systems, DNA barcoding is poised to become a pivotal keyword in exploring biodiversity. It will function as a bridge between research in the fields of biodiversity and genomics, playing a crucial role in advancing our understanding of the living world.

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SILK FARMING

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INTRODUCTION

Silk farming or Sericulture is rearing or domestication of silkworms. The word Sericulture is derived from Greek word “Sericos” which means “Silk” and English word “culture” meaning “Rearing”. The Silkworm belongs to order lepidoptera. It has bipectinate type of antennae. It was first domesticated during 4700 BC.The most pervasive domesticated silkworm in India is Mulberry silkworm. Silk is composedof two fibroin filaments which held together by a cementing layer of sericin. The percentagecomposition of fibroin and sericin in Raw Silk by weight is 75% and 25% respectively. It isthe secretion from the modified labial salivary gland which are present on both sides ofalimentary canal of silkworm larvae. The glands are ectodermal in origin. The fibroin is chieflycomposed of three major Amino acids, they are Alanine, Glycine and Serine.

HISTORY AND IMPORTANCE

The story of sericulture dates back to ancient China, where the discovery of silk isattributed to Empress Lotzu of Kwang Ti in 2697 B.C. Legend has it that she found silkworms and their cocoons when sipping tea in her garden. Intrigued, she observed the silk-producing process andintroduced it to the Chinese people.The cultivation of silkworms and the extraction of silk became closely guarded secrets inChina. The Chinese monopoly on silk production was a valuable asset, leading to theestablishment of the Silk Road—a network of trade routes connecting the East to theWest. Silk became a highly sought-after commodity, symbolizing wealth and luxury.

The Silk Road was a network of ancient trade routes that connected the East and West, facilitating the exchange of goods, cultures, and ideas. It spanned several continents, including Asia, Europe, and Africa. The name “Silk Road” reflects the significant trade insilk that occurred along these routes, especially during the Han Dynasty in China. TheSilk Road was not a single, fixed path but a complex web of interconnected routes thatevolved over centuries. It played a crucial role in the development of civilizations, fostering economic, cultural, and technological exchanges between diverse cultures. Thetrade routes fell into decline with the rise of maritime routes, but the Silk Road’shistorical legacy persists in shaping global interactions.

Over time, the knowledge of sericulture spread beyond China. Silk productiontechniques reached regions like India, Persia, and eventually Europe, influencing tradeand cultural exchanges along the Silk Road. Japan also embraced sericulture, contributing to the global diffusion of silk cultivation.
Today, sericulture is a widespread industry, with advancements in breeding, technology, and global trade shaping the production of this luxurious and historically significantfabric.

Silk is a natural protein fibre and one of the expensive fibre. It is one of those valuable products which we get frominsects. It is mainly used for making clothes.Beside this, the parachuteare also prepared from this which are used during war.Oils are also prepared byextractionfrom the cocoons of tasar silkworm which are used as preparation of some importantmedicines. It is used in screening of anti microbial drugs in pest control and used inEnvironmental monitoring.Sericulture helps in pollution control, soil preservation, Manures and fuel resources etc.Women constitution about 60% of sericulture employees in India. It is one of the best occupations for weaker section of the society.

TYPES OF SILK

There are two types of silki.e, Mulberry silk and Non-Mulberry silk and on the basis of itsrearing it is known as Mulberry sericulture or Non Mulberry Sericulture.

Mulberry Silk : *Bombyxmori*; BombycidaeThe major portion of silk produced in world's come from thisvariety about 90%.The Silk is white or creamy colour. The adult moth are 2.5 cm long, creamywhite in colour, with feeble wings that do not permit flight.Adult life spanis about 2 to 3days after emergence and mating occurs in the period.In natural condition egglaying is onthe upper surface of Mulberry leaves. There are approximately 20 species of Mulberry ofwhich 4 are more common;*Morus alba, Morusindica,Morus serrata and Morus latyfolia*.Themajor states of India producing Mulberry silk are Karnataka and Andhra Pradesh.

Non-MulberrySilk

Tasar Silk : *Antheraea mylitta*; Saturniidae

Tasar Silk is coperish in colour. There are commonly three varieties of tasar silkworm - Chinese tasarsilkworm (*Antheraea pernyi* Guerin) which is largest producer of non mulberry silk. Indian tasar silkworm (*Antheraea mylitta* Dury) and Japanese silkworm (*Antheraea yamamai* Querin) specific to japan and it produces green silk thread. Tasar moths are basically large insects, female is larger and yellowish brown while male is smaller and brick coloured.Both have prominent eye spot on their wings.The Chinese and Japanese tasar silkworm feed on oak leaves (*Quercus species*).The Indian tasar silkworm feed on Asan(*Terminalia tomentosa*), Arjun (Terminalia Arjuna), Sal (*Shorea robusta*) and Ber (*Zizyphus jujuba*). The major states of India producing tasar silk is Jharkhand, Orissa, Chhattisgarh, Maharashtra, West Bengal and Andhra Pradesh.

Eri Silk : *Samia Cynthia, Samia ricini and Phylosamiaricini, Samia enthia*; Saturniidae

Eri Silk isalso known as Endi or Errandi Silk. The Silk is white colour.The malemoth is a smallerthan female.Both have brown or chocolate and black or green coloured wings with whitecrescent marking and wolly white abdomen.The host plant of silkworm is castor (*Ricinuscommunis*). The major states of India producingeri silk are Bihar, West Bengal and Orissa.

Muga silk : *Antheraea assamensis*; Saturniidae

This Silk is golden yellow in colour and is very strong and attractive.In Assamese language Muga meaning Brown or Amber.The male moths are copper brown coloured and females are yellowish to brown and both pair of wingshave eye spot. The host plant of Muga silkworm is Som (*Persia Bombycina*), Sualu (*Litsea Polyantha*). The major state producing Muga Silk is Assam.

LIFECYCLE OF SILKWORM

Silkworm belongs to the Class: Insecta, Division: Endopterygota, Subclass: Pterygota which are Holometabolous, it means it undergoes complete metamorphosis includes egg, larva, pupa and adult in their lifecycle. The silkworm generally under goes one lifecycle per year or two lifecycles per year or more than two lifecycles per year which are called univoltine or bivoltine or multivoltine respectively. The duration of lifecycle a Silkworm univoltine is longer compared to a multivoltine.

Egg: The eggs of silkworm are called seeds as the as they resemble the size of small seeds. The color, size, shape and weight of egg vary from species to species, environmental conditions, mother moth nutrition etc. The eggs B. mori is initially pale white in color when laid later turns to blue color 48 hours before hatching and at this stage black boxing is done followed by exposure to sunlight for uniform hatching of all eggs. Black boxing stops the hatching of fully developed eggs and simultaneously fastens the growth of slowly developing embryo. These eggs are later exposed to sunlight for stimulus and hatch uniformly.

Larva: The larva immediately after hatching are so tiny with size of 3mm and are called ants /kengo / kegs chawki. These are Eruciform or polypod larva with thoracic and abdominal legs, they also have a horny appendage on the dorsal side of 8^{th} abdominal segment. The larva undergoes 3,4,5 moultings has 4,5,6 instars respectively based on type of silkworm. Most of the silkworms undergo 4 moultings and has 5 instars in their in their lifecycle. Sex differentiation can be done with the fully developed sexual markings in 4^{th} and 5^{th} instars. The female larva has pair of sex markings on 8^{th} and 9^{th} abdominal segments on ventral side and these are called Ishwata's fore glands which are on 8th segment and Ishwata hind glands on 9th segment. In later stages the fore glands are modified into Bursa copulatrix and hind glands modified into oviduct andaccessory glands in adults. In case of male the sexual marking is at the joining position of 8^{th} and 9^{th} abdominal segments and are called Herold's glands which later modified into seminal duct & ejaculatory duct in adults. The final instar larva is fully grown with creamy white color and stops feeding and spins the cocoon of silk around itself. The entire larval period if 30-35 days and silk is produced at its final larval stage from labial salivary glands.

Pupa: The stage at which the final larva which instar larva spun the silk around itself called pupae. After spinning the cocoon, it moults inside and becomes pupa which is reddish- brown in color and the cocoon is generally white in color in Bombyx mori species and this cocoon color varies from species to species. This pupal stage of silkworm is non-feeding and inactive. The cocoon is oval in Shape with 3.8 cm x1.9cm in dimensions. Sex is determined by the presence of X Shaped line in female on the central portion of the 8^{th} abdominal segment ventrally and a small round spot-on ventral side of 9^{th} abdominal segment male. The good quality of silk is extracted after 10 days of cocoon formation by boiling cocoon and this process is called stiffling. The weight of single cocoon is 1.8 g to 2 g. We require 7 to 8 kg of cocoons to produce 1kg of raw silk.

Adult: The adult silkworms have short lifecycle i.e., 2-3 days and it does not feed during this period. The entire body is of adult is covered with scales and has hypognathous head, with paired a pair of compound eyes, antennae are bipectinate and has a coiled proboscis. The female of silkworm is large, less active and pale in color. In contrast males are small, more active and darker in color and male bears a pair of hooks called "Harpens" at caudal end which helps in copulation.

DISEASES AND ENEMIES OF SILKWORM

The species of Bombyx mori are mostly affected by Pebrine, Flacherie, Grasserie and Muscardine diseases.

Pebrine disease is caused by Nosema bombycis which is a protozoan. Pebrine disease is also called Pepper disease or Corpuscule disease because the larva affected with this disease shows dark pepper like spots on its body. This disease shows different symptoms in different stages. Eggs detach from egg card due to lack of adhesiveness and eggs overlap each other egg laying instead of side by side and egg hatching is also poor in infected eggs. Larva in initial stages do not produce

any symptoms but in later stages the larva becomes sluggish and dull. Dark or black spots appear on the body of larva and also shows irregular moulting. In pupal stage the abdominal area becomes soft, swollen and black spots are also present on either side of abdomen. In Adult the scales on wings become patchless. Wings and antennae are deformed and also has low fecundity.
Management: As this disease spreads through contact, ingestion, spores and by transovarial transmission of which the disease spread through transovarial transmission holds major portion of disease spread so mother moth examination is more important for production of disease free layings and destruction of infected moths and eggs. Sterilization of eggs, equipment and rearing area with the disinfectants of which 2% of formalin is most effective.

Flacheriedisease is caused Bacillus bomby septicus. The larval stage is more susceptible for this disease the whitening of the midgut, excreta is laid in the form of chain with beads and the of larva becomes flaccid and later gets putrification and emits foul smell.

Management: All the infected larva, faecal matter and rearing beds should be removed and burnt and disinfecting all the equipment with disinfectants like RKO for beds and 2-4% formalin for rearing room.

Grasserie disease is caused by Borrelia Virus and larval stage is more susceptible for this disease. Symptoms are the body fluid of larva becomes thick and the body segments become swollen and body gets ruptured easily emitting fluids outside and then die.

Management: Proper hygienic rearing conditions without injury and providing good quality mulberry leaves prevents the disease.

Muscardine disease is caused by different muscardine species like White muscardine (Beauveria bassiana), Green muscardine (Spicaria prasina), Yellow muscardine (Isaria farinosa). Larval, pupal and adult stages are very susceptible for the disease. Symptoms include projection of fungal hyphae from larval intersegmental membranes, vomit, diarrhoea and the body of the larva becomes hard and mummified in later stages.

Management: Ensuring proper sterilization and rearing conditions can prevent the disease.

Uzi fly (Tricholyga bombycis), these are parasites of the silkworm larva, they lay eggs and the maggots hatch and feed on the larvae. Black spots can be observed and intersegmental surface of larva from where maggots enter into the larval body.

Prevention: Nylon net can be used in the rearing house to prevent entry Uzi fly. The affected silkworms, Uzi fly maggots and pupae should be collected from rearing stands and destroyed. During spinning levigated china clay is dusted with muslin cloth @3g/100 should be done to prevent Uzi fly attack.

Beetles (Dermestes cadererinus) Both the grubs and adults of this beetle attack cocoons and eat the cocoons enclosed in pupae as they are attracted to the smell of cocoons in storage.

Prevention: All the cervices of the rearing room must be properly concealed to prevent laying of eggs in cervices. Proper sterilization and fumigation with methyl Bromide (CH_3Br) is also done occasionally.

Ants, lizards, Birds, Rats and squirrels are other enemies in the Sericulture which feed on silkworms. These can be prevented by keeping the rearing room free from these creatures, proper sanitation with insecticides. Legs of rearing stands must be arranged in ant wells filled with insecticide and water to prevent ants. Birds should be scared away from rearing rooms and traps for rats should be arranged in the rearing room.

Global Production: The major silk producing countries are China, India, Uzbekistan, Brazil, Japan, Republic ofKorea, Thailand, Vietnam, DPR Korea, Iran and etc. The major Silk consuming countriesare USA, Italy, Japan, India, France, China, UK, Switzerland, Germany, UAE, Korea, Vietnametc. Total silkworms reelable production reached 414,788 in 2022 in the world according to Faostat. This is 4.85% less than in the previous year and -40.9% less than 10 years.

Institutes

Central Tasar Research and Training Institute, Ranchi, Jharkhand
Central Silk Board, Bangalore
Central Sericulture Research and training institute, Mysore
Central Sericulture Research Station, Behrampur, Orissa
Central Muga Eri Research and Training Institute, Titibar, Assam
Central Sericulture GermplasmResources Centre Hosur, Tamilnadu
Seri Biotech Research Laboratory, Bengalaru

Indian Journals

Indian Journal of Sericulture published by CSR & TI, Srirampur, Mysore, Biannual
Indian Silk published by CSB, Bengalaru, Monthly.

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AI CULTIVATION: TRANSFORMING AGRICULTURE THROUGH SMART TECHNOLOGIES IN FOOD PRODUCTION

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Abstract

This article explores the transformative potential of artificial intelligence (AI) in the food manufacturing industry, detailing its role in enhancing efficiency, reducing costs, and increasing overall output. From precision agriculture to supply chain optimization, AI is reshaping every aspect of food production. The essay delves into specific applications of AI in agriculture, highlighting its contributions to precision farming, crop monitoring, predictive analytics, autonomous machinery, farm management systems, supply chain optimization, robotics, and smart irrigation. While showcasing the manifold benefits, the article also addresses challenges, such as the initial implementation costs and the need for skilled personnel to operate and maintain AI systems. The discourse aims to provide a comprehensive understanding of the current landscape and future prospects of AI in the food manufacturing sector.

Introduction

Artificial intelligence (AI) has the potential to transform the food manufacturing industry by enhancing efficiency, lowering prices, and increasing output. AI is being utilised to alter every part of food production, from farming and harvesting to processing and distribution. In this essay, we will look at the function of artificial intelligence (AI) in the food manufacturing industry and its benefits. Some of the ways it is useful in agriculture are:

1. **Precision Agriculture:** AI technologies, such as machine learning and computer vision, are used to analyze data from various sources, including satellite imagery, drones, and sensors. This data is then used to make informed decisions about crop management, irrigation, and fertilization, optimizing resource usage and maximizing yields.
2. **Crop Monitoring and Disease Detection:** AI-powered image recognition and computer vision systems can analyze images of crops to identify signs of diseases, pests, or nutrient deficiencies. This early detection allows farmers to take corrective measures promptly, reducing crop losses.
3. **Predictive Analytics:** AI algorithms can analyze historical data, weather patterns, and other relevant factors to make predictions about crop yields, optimal planting times, and potential pest outbreaks. This information helps farmers plan their activities more effectively.
4. **Autonomous Machinery:** AI is integrated into agricultural machinery to enable autonomous operation. For example, AI-driven tractors and harvesters can navigate fields, perform tasks, and optimize routes without constant human intervention, leading to increased efficiency and reduced labor requirements.
5. **Farm Management Systems:** AI-powered farm management platforms help farmers monitor and control various aspects of their operations. These systems can provide insights

into resource utilization, crop health, and financial performance, allowing for more informed decision-making.

6. **Supply Chain Optimization:** AI is used to optimize the agricultural supply chain by predicting demand, managing inventory, and improving logistics. This ensures that agricultural products reach their destination efficiently, reducing waste and costs.
7. **Robotics in Agriculture:** AI is integrated into robotic systems that can perform tasks such as weeding, harvesting, and sorting. These robotic systems can operate autonomously or with minimal human intervention, improving efficiency and addressing labor shortages.
8. **Smart Irrigation:** AI is applied to analyze soil moisture levels, weather conditions, and crop water requirements to optimize irrigation schedules. This helps conserve water, reduce costs, and prevent overwatering or underwatering.

AI's Challenges in Food Production

Despite the numerous advantages of AI in food production, there are certain drawbacks. The expense of implementation is one issue. AI technology can be costly, and it may take some time for businesses to return their investment. Another issue is the shortage of competent employees to operate and maintain AI systems. To work with AI systems, businesses may need to invest in training and employing new staff.

Conclusion

In conclusion, the integration of artificial intelligence in the food manufacturing industry represents a monumental shift towards a more efficient, sustainable, and economically viable agricultural landscape. The showcased applications of AI in precision agriculture, predictive analytics, and autonomous machinery underscore the tangible benefits in optimizing resource utilization, reducing crop losses, and enhancing overall productivity. Despite the promising advantages, it is crucial to acknowledge the challenges, particularly the financial investment required for AI implementation and the need for a skilled workforce. As the industry navigates these challenges, the continued exploration and adoption of AI technologies promise to revolutionize food production, ensuring a resilient and technologically advanced agricultural sector for the future.

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HARVEST FLAMES: THE STUBBLE BURNING DILEMMA

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Abstract

Stubble burning refers to the practice of in-situ burning of crop residues after harvest, especially that of paddy, and is widely adopted by farmers that adopt the rice-wheat cropping pattern. It contributes significantly to air pollution and soil degradation. Efforts to curb stubble burning have faced challenges, with no definitive solution yet. Alternatives like conservationagriculture and the Happy Seeder offer promising avenues, supported by government subsidies and incentives. Nonetheless, awareness among farmers remains crucial for widespread adoption. This article provides a brief background on why stubble burning is practiced, its effects and potential solutions, highlighting the importance of awareness campaigns in fostering sustainable agricultural practicesto tackle this 'burning' issue.

Introduction

In the 1960s, the Green Revolution dawned as a beacon of hope, promising food security through the cultivation of high-yielding varieties of the staple cereal crops, rice and wheat. This led to widespread adoption of the rice-wheat cropping system by farmers in the fertile belts of our nation, particularly in the Indo-Gangetic Plains. However, this guarantee of sustenance also ushered in a host of challenges, the management of paddy crop residue being one of them.

Stubble burning

Stubble burning or crop residue burning involves intentionally burning the leftover straw residue from crops, especially rice, to swiftly clear the field for land preparation and planting of the subsequent crop.

Reasons for stubble burning

- Kharif paddy is planted during the months of May or June and harvested in October or November. So, there is a short time gap of around 10-15 days between the harvesting of paddy and the sowing of wheat, which should preferably be sown during November or early December. So, in order to prepare the land for wheat, the most convenient and cheap method for the farmer to get rid of the rice residues is by burning the stubbles.
- The use of combine harvestersis common in the states of Punjab, Haryana and Uttar Pradesh. These machines combine three tasks, namely, reaping, threshing and winnowing, which usually leave the residues scattered all over the field, thereby making it difficult to manage the residues in alternative ways.

The burning scenario

A study conducted by Khan *et al*. (2023) examined data from the period spanning 2020 to 2022, utilizing information derived from the satellite-based system called the Fire Information Resource Management System (FIRMS). The findings revealed that Punjab alone accounted for90%of stubble burning incidents. Shedding a ray of light, there has been a decreasing trend in fire occurrences over the years as evidenced by the data from Punjab and Haryana, which registered the highest number of active fire counts in 2021 (80,505), followed by 2020 (75,428) and 2022 (49,194). According to the most recent report from the Press Information Bureau (PIB), this figure has further decreased to 36,663 as of 2023.

Notable effects of stubble burning

1. Air pollution

The repercussions of this practice on air pollution are very evident as a thick haze of smog, which is a combination of smoke and fog, envelops Delhi-NCR during October to November every year. An Air Quality Index (AQI) greater than 100 is considered harmful. Consequently, an AQI of 999 recorded in November 2017 in Delhi raised frantic concerns among both the government authorities and the general public.

- Stubble burning significantly contributes to air pollution by releasing a cocktail of harmful pollutants, including carbon monoxide (CO), nitrogen oxides (NOx), sulphur dioxide (SO_2) and volatile organic compounds (VOCs) as well as greenhouse gases like carbon dioxide (CO_2) and methane (CH_4). These pollutants have major consequences forhuman health.
- The key pollutant is particulate matter which posesa health concern when levels in the air are high. These tiny particles can get trapped inside the lungs and increase the risk of lung cancer. Stubble burning reportedly raises PM 2.5 upto50 to 75%, while an increment of 40 to 45% in the concentration of PM 10is observed (Khan *et al*., 2023).

2. Soil health decline

The implications of stubble burning on the soil may or may not be apparentbut studies have shown that it has highlyconsiderable effects on soil health.

- Organic matter helps improve soil moisture retention, nutrient availability and microbial activity, all of which are vital for healthy plant growth. Stubble burning leads to the loss of organic matter present in crop residues, which is essential for the maintenance of soil fertility and structure.Ademe (2015) revealed that the depletion of soil organic carbon and total nitrogen from crop residue burned fields were up to 83%. These were more pronounced in the top 30 cm depth of soil but significant changes were also witnessed upto 60 cm.
- The macronutrients, nitrogen and phosphorus, have low thresholds and are drastically affected by burning. Micronutrient fractions are also bound to decrease in the soil due to burning.
- A change in the microclimate after burning impacts the population of organisms that live in the soil since they thrive at a particular temperature. The bacterial and fungal population decrease by 50% by repeated burning (Manjeet *et al*., 2019).

Ground report

In a documentary by the Business Standard, a farmer was heard lamenting, “While we acknowledge that stubble (parali) burning adversely impacts the environment and poses health risks, I find myself compelled to burn the stubble in my field. The lack of financial resources to acquire machinery for stubble management leaves me with no alternative. Furthermore, the stubble I had set aside for fodder has been rendered unusable due to dampness.” This poignant statement underscores the complex trade-offs faced by farmers in their struggle to balance agricultural practices with environmental concerns. Another distraught farmer reiterated that there is no provision to collect the stubbles and transport them for various purposes, leading the farmers to resort to burning.

Viable alternatives to stubble burning

Many trials have been put in place since then to abate this problem but none very successfully because even up to this day, a concrete solution is yet to be identified. The failure of the Pusa Decomposer, a microbial spray designed to decompose the residues quickly, is one such example, as the residues took long periods of 20 to 30 days to get decomposed, which did not serve the needs of the farmers. A step in the right direction needs to be met with precision.

Considering the present scenario, a conservation agriculture-based residue management system is the most feasible option as it involves minimum soil disturbance and practices that restore organic matter to the soil through residue incorporation or residue retention.This can be achieved in conjunction with government subsidies for the necessary equipment. In the latest report by the Union Ministry, it was revealed that as compared to 2022, Punjab and Haryana farm fires have dipped by 27% and 37%, respectively. This may have been possible since governmentsboth at the central and state levels, have introduced financial incentives and subsidies to encourage farmers to adopt alternative methods of managing crop residues and keeping the environment clean.

Happy Seeder

The HappySeeder is an agricultural implement, towed behind a tractor, designed to sowcropswhile evenly incorporating the crop residues in the field. Since the new crops are sown directly into the stubble of the previous crop, without disturbing the soil, this makes it the ideal solution to tackle the stubble burning issue. The residues serve as natural mulch, thereby enhancing the soil's fertility.The government of Punjab offers a subsidy of 50% to individual farmers on the purchase of Happy Seeder, while farmer groups and cooperatives get a subsidy of 80%.

Baler

Balers are agricultural machines designed to efficiently collect, compress and bind crop residues into compact bales. These bales can then be stored, transported or utilized for various purposes. If the farmers can avail a good price for their baled residues, it would effectively mitigate the need for crop residue burning. This implement is also given at a subsidy of 50% to the farmers in Punjab.

Cash incentive

The government of Haryana offers financial incentives to promote the management of paddy crop residue. Panchayats that achieve near-zero-burning targets in designated "red zones" (five or more farm fires daily) receive rewards of₹1 lakh, while those in "yellow zones" (upto two farm fires daily) receive ₹50,000 as an incentive.A cash prize of ₹1000 per acreis given.The Haryana government also adopted stringent measures and issued over 939 challans and imposed fines of over ₹25.12 lakh on farmers practicing stubble burning in 2023 as stated by a news report.

Raising awareness

A comprehensive awareness campaign is essential to educate farmers about the environmental and economic advantages of adopting alternative methods for crop stubble management. Challenges such as insufficient labour, lack of government incentives, and farmers' unawareness of cost-effective and eco-friendly alternatives hinder widespread adoption. Many farmerswho did not explore alternative approaches lacked government support and access to necessary materials and machinery. To address this, awareness programs should be strategically designed, utilizing effective communication channels, including modern mass media.

Conclusion

The prevalence of stubble burning presents a complex challenge at the intersection of agricultural practices, environmental concernsand socioeconomic factors. While efforts to mitigate this practice have shown some progress, such as the adoption of conservation agriculture methods and the promotion of implements like the Happy Seeder, more comprehensive strategies are needed. Government initiatives offering subsidies and incentives demonstrate a commitment to change, but success ultimately hinges on the engagement of farmers. Raising awareness about the environmental and economic benefits of alternative stubble management methods is paramount. This necessitates targeted educational campaigns addressing the barriers to adoption, including access to resources and knowledge gaps. By empowering farmers with information and support, we can pave the way for a sustainable agricultural future, mitigating the adverse effects of stubble burning while ensuring food security and environmental sustainability.

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COMPOSTING: TRANSFORMING ORGANIC WASTE INTO SUSTAINABLE AGRICULTURE

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Abstract
Composting, a natural process catalyzed by microorganisms, offers a sustainable solution for converting organic waste into nutrient-rich fertilizer. This overview explores composting principles, techniques (cold and hot composting), materials required, methods (Coimbatore, Indore, Bangalore, Nadep), and advantages. Composting enhances soil fertility, reduces waste volume, and minimizes environmental impact. However, challenges such as transportation costs, nutrient variability, and contamination concerns must be addressed for widespread agricultural adoption. Despite these challenges, composting emerges as a promising practice, promoting ecological balance, reducing pollution risks, and fostering agricultural productivity.

Composting - An Overview
Composting is the natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions. Raw organic materials such as crop residues, animal wastes, food garbage, some municipal wastes and suitable industrial wastes, enhance their suitability for application to the soil as a fertilizing resource, after having undergone composting.
Composting is essentially a microbiological decomposition of organic residues collected from rural area (rural compost) or urban area (urban compost.

Principles of Composting
1. Narrowing down of the carbon: nitrogen ratio to a satisfactory level.
2. Total destruction of harmful pathogen and weed seeds ensured by high temperature evolved during decomposition and stabilization.
3. At the optimum temperature of 60-65 degree Celsius required for decomposing all harmful pathogen are destroyed.

Technique of Composting
Cold Composting:
a. Cold composting is one of the easiest forms of composting.
b. Many beneficial nutrients in cold compost remain uncompromised by high temperatures.
c. The process is slower.
d. Once established, the cold composting bins will provide you with a continuous supply of lawn and **garden** food.

Hot composting:
a. A hot pile requires enough high-nitrogen materials to get the pile to heat up.
b. Microbial activity within the compost pile is at its optimum level, which results in finished compost in a much shorter period of time.
c. It requires some special equipment, as well as time and diligence.

d. Temperatures rising in a hot-compost pile come from the activity of numerous organisms breaking down organic matter.

Material Required for Composting

1. Farm refuse:

a. Weeds
b. Stubbles
c. Crop residues
d. Remnants of fodder.

2. Animal dung:

a. Cow dung
b. Buffalo dung
c. Poultry dung.

3. Town refuse:

a. Night soil
b. Street refuse
c. Municipal fuse.

Types of Composting

Aerobic composting:

a. This means to compost with air.
b. Organic waste will break down quickly and is not prone to smell.
c. This type of composting is high maintenance, since it will need to be turned every couple day to keep air in the system and your temperatures up.
d. It is also likely to require accurate moisture monitoring
e. This type of compost is good for large volumes of compost.

Anaerobic composting:

a. This is composting without air.
b. Anaerobic composting is low maintenance since you simply throw it in a pile and wait a couple years.
c. Compost may take years to break down.
d. Anaerobic composts create the awful smell most people associate with composting.
e. The bacteria break down the organic materials into harmful compounds like ammonia and methane.

Method of Composting

In Coimbatore method, composting is done in pits of different sizes depending on the waste material available. A layer of waste materials is first laid in the pit. It is moistened with a suspension of 5-10 kg cow dung in 2.5 to 5.0 l of water and 0.5 to 1.0 kg fine bone meal sprinkled over it uniformly. Similar layers are laid one over the other till the material rises 0.75 m above the ground level. It is finally plastered with wet mud and left undisturbed for 8 to 10 weeks. Plaster is then removed, material moistened with water, given a turning and made into a rectangular heap under a shade. It is left undisturbed till its use.

Indore Method: In the Indore method of composting, organic wastes are spread in the cattle shed to serve as bedding. Urine-soaked material along with dung is removed every day and formed into a layer of about 15 cm thick at suitable sites. Urine-soaked earth, scraped from cattle sheds is mixed with water and sprinkled over the layer of wastes twice or thrice a day. Layering process continued for about a fortnight. A thin layer of well decomposed compost is sprinkled over top and the heap given a turning and reformed. Old compost acts as inoculum for decomposing the material. The heap is left undisturbed for about a month.

Bangalore method of composting, dry waste material of 25 cm thick is spread in a pit and a thick suspension of cow dung in water is sprinkled over for moistening. A thin layer of dry waste is laid over the moistened layer. The pit is filled alternately with dry layers of material and cow dung suspension till it rises 0.5 m above ground level. It is left exposed without covering for 15 days. It is given a turning, plastered with wet mud and left undisturbed for about 5 months or till require thoroughly moistened and given a turning. The compost is ready for application in another month.

NADEP Method:

This method of making compost involved the construction of a simple, rectangular brick tank with enough spaces maintained between the bricks for necessary aeration. The recommended size of the tank is 10 ft(length), 5 ft(breadth), 3 ft(height). All the four walls of NADEP tank are provided with 6 vents by removing every alternate brick after the height of 1 ft from bottom for aeration. Tank can be constructed in mud mortar or cement mortar.

Method of Filling Tank

1. Slurry made of cow dung and water should be sprinkled on the floor and the walls of tank. The filling of tank follows these step
2. FIRST LAYER
3. Vegetable residue are spread evenely in layer up to 6 inches (5 to 100 kg) in tank.
4. SECOND LAYER
5. 4 to 5 kg Cattle dung of gobber gas- slurry in 70 litres of water should be apply on the first layer
6. THIRD LAYER
7. 50 to 60 kg sieved soil added on the second layer of tank.
8. In this way, the tank is filled layer by layer up to 1.5 feet above the bricks level of taank.
9. Filled tank should be covered and sealed by 3-inch layer of soil (300 to 400 kg)
10. It should also be pasted with a mixture of dung and soil.

Advantages of Composting

1. Volume reduction of waste.
2. Final weight of compost is very less.
3. Composting temperature kill pathogen, weed seeds and seeds.
4. Matured compost comes into equilibrium with the soil.
5. During composting number of wastes from several sources are blended together.
6. Excellent soil conditioner
7. Saleable product Improves manure handling
8. Reduces the risk of pollution
9. Pathogen reduction
10. Additional revenue.
11. Suppress plant diseases and pests.

Disadvantages of Composting

Agricultural use of composts remains low for several reasons:

1. The product is weighty and bulky, making it expensive to transport.
2. The nutrient value of compost is low compared with that of chemical fertilizers, and the rate of nutrient release is slow so that it cannot usually meet the nutrient requirement of crops in a short time, thus resulting in some nutrient deficiency
3. The nutrient composition of compost is highly variable compared to chemical fertilizers.
4. Agricultural users might have concerns regarding potential levels of heavy metals and other possible contaminants in compost, particularly mixed municipal solid wastes. The potential for contamination becomes an important issue when compost is used on food crops.
5. Long-term and/or heavy application of composts to agricultural soils has been found to result in salt, nutrient, or heavy metal accumulation and may adversely affect plant growth, soil organisms, water quality, and animal and human health.

Conclusion

In conclusion, composting stands as a pivotal practice in sustainable waste management and agriculture. While challenges persist, the benefits, including waste volume reduction, pathogen elimination, and soil enrichment, make composting a valuable asset. The diverse composting methods showcased, from the Coimbatore technique to the Nadep method, offer flexibility for various waste streams. Addressing concerns like nutrient variability and transportation costs will be crucial for widespread adoption. As we strive for eco-friendly practices, composting emerges as a beacon, contributing to healthier soils, reduced pollution, and a more resilient agricultural ecosystem.

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INDIGENOUS BREEDS OF POULTRY FOR BACKYARD FARMING IN INDIA

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Abstract

Developing countries like India keeping poultry is primarily done in backyard.Backyard poultry farming is one of the important segment of rural people for their livelihood. They serve as an essential component of a well-balanced farming system which offers rural households with high-quality animal-based protein, emergency financial support and a major boost to women's empowerment and the cultural and social life of the community.With this regard, we are going to discuss some indigenous breeds of chicken which are the best for backyard farming in India.

Introduction

One of the rising sectorof agricultural economyin Indiais Poultry production. India now occupies the second place for egg production and fifth place in the world for poultry meat production in the world. As per 20^{th} livestock census poultry population of India is 851.81 million, which has increased by 16.8% over previous census. Out of the that backyard poultry is 317.07 million, whereas commercial poultry population is 534.74 million.According to estimates backyard and commercial poultry has increased over 45.78 and 4.5 % by previous year respectively. The per capita supply of eggs has reached 95 eggs and meat has achieved 6.82 kg per annum (BAHS, 2022), which are far away from recommendation as by ICMR 180 eggs and 11 kg meat per year. Therefore, there is ample scope for development of poultry in India. Backyard chickens can aid states in closing the gap between the supply and demand for chicken meat and eggs. Moreover, backyard poultry in one hand would help alleviate the nutritional status of rural people, get residue free birds on other hand.Hence, many Indigenous chicken breed and its crosses were developed to meet demand of backyard poultry farming and to fulfil need of people as per the region.Following are the Indigenous breeds of poultry –

Breeds	Characteristics	Photo
Giriraja	• Dual purpose bird developed by Karnataka Veterinry, Animal and Fishery Sciences University • Age at sexul maturity – 155-160 days • Egg production – 180 – 190 eggs /annum	
Satpuda	• Developed by Yashwant AgritechPvt. lim., Jalgoan • Dual purpose bird • Annual egg production – 110-120 eggs • Body weight –1120-1400 gm	

Breeds	Characteristics	Photo
		
Kadaknath	• Home tract – Madhya Pradesh • Eggs Production – 150-170 eggs/year (Farm) • Body wt – 1.4 -1.6 kg at 5 month	
Chittagong (Malay)	• Dual purpose bird • Red ear lobes, over-hanging prominent eyebrows, • fether-less shank • Comb– Pea type	
Aseel	• Home tract – Andhra Pradesh and Madhya Pradesh • Small pea comb • Feathers Colour–Black, Red or mixed • Age at sexual maturity – 196 days • Eggs Production – 60-70 eggs/year (Farm) • Body wt – 1.8 -2.0 kg at 5 month • Mostly farmers kept for cockfightinhgas well asornamental purposes.	
Ghagus	• Home tract – Andhra Pradesh and Karnataka • Eggs Production – 110-118 eggs/year • Body wt – 1.8 -2.0 kg at 5 month	

Breeds	Characteristics	Photo
Kalinga Brown	• Cross of White Leghorn layer and RIR • Egg production – 252-265 eggs /annum	
Kaveri	• Developed by Central Poultry Development Organisation and Training Institute, Banglore • Egg type rural bird • Multi coloured plumage • Egg production – 180 eggs /annum • Body weight at 20 weeks– 1600-2200 gm • Good scavenging bird	
Pratapdhan	• Dual purpose coloured bird • Home tract – Rajsthan • Age at sexual maturity – 170 days • Egg production – 165 eggs • Body weight at 20 weeks– Male – 1478 to 3020 gm Female – 1283 to 2736 gm	
Swarnadhara	• Dual purpose chicken • Developed at Dept. of Avian Production and Management, Hebbal, Banglore • Swarnadhara is cross of Vanaraja and Giriraja breeds • Plumage – Golden brown • Red comb and wattles • Egg production – 180-190 eggs/annum • Body weight – 1800-2000 gm	
Narmadanidhi	• Dual purpose poultry breed produced by Veterinary College, Jabalpur • Body weight at 20 weeks - Male – 1500-2000 gm Female – 1300-1700 gm • Annual egg production – 181 eggs	

Breeds	Characteristics	Photo
Nandanam Chicken-1	• Developed atTamilnaduVeterinary and Animal Science Vidyapeeth, Chennai • Develped from Sterling strain of Rhode Islnd Red breed • Medium sizeddual purpose breed having dark red plumage • Body weight at 12 weeks -900-1000 gm • Annual egg production -180	
Nandanam Chicken-II	• Multi coloured vroiler breed • Body weight at 8 week –1440 gm • Feed efficiency – 2.66 • Good disease resistance, Adaptability to sub standard managemental conditions	
Nandanam Chicken-IV	• Coloured breed developed for egg and meat purpose • Annual egg production – 225 eggs • Egg colour – Brown • Fightiness to evade predation • Good survivability	 
Kamrupa	• Multi-coloured dual purpose breed developed by Assam Agricultural University, Guwahati • Highe disease resistance power • Body weight at 20 weeks–1500-1800 gm • Age at firat egg – 150-180 days • Annual egg production – 130-150 eggs • Dressing percentage –65-70 %	
Jharim	• Home tract – Jharkhand • Jharim is derived from Jhar for Jharkhand and sim meaning hen in tribal dialect • Plumage – Multi-coloured • Age at first egg laying – 175-180 dyas • Egg production – 165-170 eggs • Body weight – 1600-1800 gm	

Breeds	Characteristics	Photo
Punjab Brown	• Utilized for meat and egg purpose • Home tract – Haryana and Punjab • Plumage colour – Brown • Pea – Single type Red in colour • Males have black stripes/spots on neck, wings and tail • Average age at first egg – 5-6 months • Annual egg production – 60-80 eggs • Body weight – 1400-2200 gm	
Mewari	• Distributed in Central and Southern part of Rajasthan • Plumage – Multi coloured • Comb type -Single • Annual egg production – 35-55 eggs • Egg colour - Brown • Body weight – 1200-1900 gm	
Danki	• Local names- Dinki, Khaki or Sanwla, Dega, Parla, Satua and Pingle • Home tract – Vizianagram, Srikakulam, Vishakapatnam (A.P) • Reared for game and meat purpoe • Birds can fight continuously for 1-1.5 hrs • Plumage – brown followed by black, Sometime Red, white or golden yellow are also seen. • Wattles – absent • Comb – Pea type, Red colooured and compressed • Cocks having shinning bluish black feathers on wings, breast, thighs and tail. • Age at first egg laying – 180-245 days • Egg production – 25-35 eggs • Body weight – 2200 -3100 gm	

<table>
<tr><th>Breeds</th><th>Characteristics</th><th>Photo</th></tr>
<tr><td>Ankleshwar</td><td>Small and medium sized bird reared for both egg and meat purpose
Origin- Around Bharuch and Narmada district of Gujrat
Comb type – Single and Rose
Age at first egg – 179 days
Egg production – 75-90 eggs/annum
Egg weight – 35 gm
Dressing ercentage – 62.44 %
Body weight – 1480-1755 gm</td><td></td></tr>
<tr><td>Busra</td><td>Distriibution – Maharashtra and Gujrat
Name Busra comes from busrawal-a tree
Frizzle character is common
Age at first egg – 150-210 days
Annual egg production – 40-55 eggs
Egg colour – Light brown
Dressing percentage – 65-70%
Body weight –
Male- 850-1250 gm
Female – 800-1200 gm</td><td></td></tr>
<tr><td>Daothigir</td><td>Distribution – Bodoland region of Assam and Nothern banks of Brahmaputra river reared by Bodo community.
Daothigir name comes from Thigir plant because the plumage of chicken is similar to flower of that plant.
Dual purpose breed
Plumage – Black interspersed with white feathers
Comb – Single type
Age at first egg – 180 days
Annual egg production – 60-70 days
Body weight – 1630 –1790 gm</td><td></td></tr>
</table>

Breeds	Characteristics	Photo
Miri	• Local name – Porog • Mainly found around Sibsagar, Dhimaji, Dibrugarh and adjoining districts of Assam • Reared for both egg and meat type • Miri name derived after tribe i.e. Miri/ Mising rearing them • Age at first egg – 6-8 months • Annual egg production – 30-35 eggs • Body weight – 1320-1525 gm	
Kaunayen	• Local name- Kwakman/Koman • Home tract – Manipur • Birds are energetic, alert and prized for its Martial qualities • Birds have elongated body with long neck and long legs • Comb – Pea type red coloured • Plumage colour – Black followed by brown (red) • Age at first egg – 5-7 months • Annual egg production – 35 eggs • Body weight – 2400-3800 gm	
Harringhata Black	• Native to West Bengal • Reared for egg and meat purpose • Average age at first egg – 4 months • Annual egg production – 100-120 eggs • Body weight – 1200-1500 gm	
Hansli	• Home tract – Mayurbhanj and Koenijhar district of Odisha • Hansli breed males are very aggressive with high stamina and dogged fighting qualities • Comb – Pea type, Red • Plumage - Black • Age at first egg – 180 days • Annnual egg production – 50-70 eggs • Body weight – 2500-3800 gm	
Kalasthi	• Distributed in Nellore, Chitoor and Cuddapah districts of Andhra Pradesh	

Breeds	Characteristics	Photo
	• Named after sriKalahastri area of chitoor district where these birds originated • Reared formainlyfor meat and egg purpose. Sometime utilized as game bird • Plumage – Bluish black and brown coloured • Colour pattern – Patchy in male and spotted in females • Comb – Pea type and Red • Legs are longer • Age at first egg – 5-9 months • Annual egg production – 30-40 eggs • Body weight – 1250-2480 gm	
Tellichery	• Native to Kannur and Malappuram districts of Kerala and Puducherry • Birds are fast mover • Also birds have medicinal value as its soap is beneficial for anemia and worm infestations • Plumage colour – Black with a shinning bluish tinge on hackle, back and tail feathers • Comb – Single, large sized Red in colour • Average age at first egg – 5-8 months • Annual egg production- 60-80 eggs • Eggs with tint • Body weight – 1240-1625 gm	
Nicobari	• Locally known as **Takniethyum** reared by Nicobari tribe of Andaman and Nicobar Island • Mainly reared for egg purpose • Average age at first egg – 5-9 months • Annual egg production – 110-240 eggs • Body weight – 900-1200 gm	

Breeds	Characteristics	Photo
Kashmir Favrolla	• Locally called Kashir Kukkar birds can survive in subzero temperature • Found in Baramula, Anantnag, Kupwara, Budgam, Srinagar and Pulawana districts of Jammu and Kashmir • Age at first egg – 6-8 months • Annual egg production – 60-85 eggs • Body weight – 1400-1800 gm	
Uttara	• Home tract – Uttarakhand • Birds evolved through natural selection, blck in colour and have crest/crown type structure on the head • Specific character- feathered shank • Annual egg production – 125-160 eggs • Dressing percentage – 70-72 %	
Himsamridhi	• Dual purpose chicken distributed in hilly region of Himachal Pradesh • Multi coloured plumage • Well adopted to local agro-ecosystem • Body weight – At 8 weeks –350-550 gm At 20 weeks – 1250-1850 gm • Age at first egg –145-165 days • Annual egg production – 150-180 eggs	
ICAR – Directorate of Poultry Research Rajendranagar, Hyderabad		
Vanaraja	• Dual • Eggs Production – 100-110 eggs/year • Egg colour – Brown • Body weight – 1.8 -2.0 kg at 3 month • Disease resistance and better survival rate	

Breeds	Characteristics	Photo
Srinidhi	• Dual • Multi coloured plumage and Longer shanks • Early maturing (175 days) • Eggs Production – 140-150 eggs/year • Egg colour – Brown • Body weight – 1.7 -2.0 kg at 3 month	
Janapriya	• Dual purpose • Eggs Production – 140-150 eggs/year • Egg colour – Brown • Body weight – 1.2 -1.5 kg at 3 month	
Gramapriya	• Attractive brown feather colour pattern • Eggs Production – 160-180 eggs/year • Egg colour – Brown • Body weight – At 6 weeks – 550 gm At 3 month – 1600-1800 gm • Better survivability and adaptability to backyard/free range rearing	
Shwetpriya	• Cross of P.B. 1 and Naked Neck • Annual egg production – 200 eggs	
Krishilayer	• Layer • Eggs Production – 270-290 eggs/year (Farm) • Egg colour – White • Body wt – 1.8 -2.0 kg at 3 month • Feed consumption - 1.8-2.0 kg feed / dozen egg	
Vanashree	• Layer (Improved) • Eggs Production – 170-180 eggs/year • Egg colour - brown • Body wt – 1.8 -2.2 kg at 5 month • Attractive golden yellow colourde feather pattern • Longer shank help to run fast	

Breeds	Characteristics	Photo
Krishibro	• Colourful Broiler bird (Meat) • Body weight – 1.4-1.5 kg at 6 week • FCR – 2.0 • High disease resistance	
Central Avian Research Institute, Izzatnagar (U.P)		
CARI SONALI	• Developed in the year 1992 using White Leghorn as male line and Rhole Island Red as female line • 50% Egg production – 155 days • Eggs Production – 280-283 eggs/year • Eggs colour - Brown • Body wt – 1.8 -2.2 kg at 5 month • Feed consumption- 2.3 kg feed per dozen of eggs	
CARI PRIYA (ILI-80)	• Developed by crossing superior male and female strains of White Leghorn • 50 % egg production – 150 days • Egg production – 290-301 eggs • Feed consumption – 1.77 kg per dozen of eggs • High positive return over feed cost	
CARL DEBENDRA	• Medium-sized dual-purpose bird • Produced by crossing coloured synthetic broiler line as male line and Rhode Island Red as female line • Have attractive bright plumage colour • Body weight: 8 weeks -1100-1200 g 12 weeks -1700-1800 g • Feed conversion ratio (0-8 weeks) - 2.5 -2.6 • Age at sexual maturity – 155 -160 days • Egg production – 190-200 eggs	

Breeds	Characteristics	Photo
CARI SHYAMA	• Improved indigenous fowl developed by crossing Kadaknath breed and CARI Red • Plumage – coloured dominted by black • Beak, skin, shank, toes and soles – dark grey coloured • Age at sexul maturity – 170 days • Egg production – 210 eggs/ annum • Body weight at 20 weeks – Male- 1460 g Female- 1120 g • Meat colour – Black • Eggs and meat contain high amount of iron. Therefore, it considered as medicinal.	
CARI NIRBHEEK	• Produced by crossing native breed Aseel with CARI Red • Birds are active, pugnacious in nature with high stamina and majestic gait • Age at sexul maturity – 176 days • Egg production – 190-200 eggs/ annum • Body weight at 20 weeks – Male- 1840-1850 g Female- 1325-1350g • Adapted to all climatic zones of country	
HITCARI	• It is a cross of Indian native Naked neck with CARI Red. • Suitable for hot humid coastal region • Age at sexul maturity – 178 days • Egg production – 175-200 eggs/ annum • Egg weight at 40 weeks – 60 gm • Fertility - 92 % • Body weight at 20 weeks – Male- 1745-1760 g Female- 1300-1320 g	

Breeds	Characteristics	Photo
UPKARI	• For development of Upcari birds Indian native breewith Frizzle plumage has been crossed with CARI Red. • Medium sized multicoilourd chicken have single comb • Better adopted to tropical climate • Age at sexul maturity – 165 days • Egg production – 180-220 eggs/ annum • Egg weight at 40 weeks – 60 gm • Fertility - 90 % • Body weight at 20 weeks – Male- 1685-1690 g Female- 1280-1290g	
CARIBRO VISHAL	• High disease resistance • Superior growth rate • Body weight – At day old – 43 gm At 6 weeks – 1650 to 1700 gm At 7 weeks – 2000 to 2150 gm • Dressing percentage – 75-80 % • Feed conversion ratio at 6 weeks – 1.85 • Livability percentage – 97-98	
CARIBRO DHANRAJA	• Multicoloured broier developed by crossing coloured synthetic male and female lines • Multicoloured plumage with single comb • Body weight - At day old – 46 gm- At 6 weeks – 1500 to 1700 gm At 7 weeks – 2000 to 2125 gm • Dressing percentage – 73-75 % • Feed conversion ratio at 6 weeks – 1.92 • Livability percentage – 96-98	
CARIBRO MRITYUNJAY	• Developed by introgression of naked neck gene into coloured and white synthetic broiler lines by repeated backcrossing • Plumage – coloured and white	

Breeds	Characteristics	Photo
	• Suitable for hot and dry region • Body weight - At day old – 32-42 gm At 6 weeks – 1400 to 1500 gm At 7 weeks – 1800 to 2000 gm • Dressing percentage – 75-77 % • Feed conversion ratio at 6 weeks – 1.95	
CARIBRO TROPICANA	• For hot and humid region • Cross of broiler and Naked neck frizzle birds • Body weight - At 6 weeks – 1300 gm At 7 weeks – 1800 gm • Dressing percentage – 74 % • Feed conversion ratio- 1.90 (at 6 weeks) • Most suitable for tropical poultry production	

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CULTIVATING GREEN CITIES: A COMPREHENSIVE OVERVIEW OF URBAN GARDENING AND ITS GLOBAL IMPLICATIONS

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Abstract

Urban gardening, the practice of growing plants in city environments, is experiencing a surge in popularity worldwide. This paper explores the global and Indian urban farming scenarios, emphasizing its economic, environmental, and social advantages. The study reveals a rising demand for fresh, local produce and highlights the positive impacts of urban gardening on food security, community building, and sustainable practices. As cities grapple with environmental challenges, urban gardening emerges as a transformative solution, offering economic benefits, reducing environmental footprints, and fostering community resilience.

Introduction

Urban gardening refers to growing plants, fruits and vegetables in an urban environment such as a city or town. Small plots, containers, or other types of horticultural methods are used to grow plants in areas not normally used for agriculture. Urban gardening is growing in popularity as more and more people seek to grow their own food, connect with nature and improve the urban environment. Urban gardening also helps build communities by allowing individuals and groups to work together to create shared green spaces and encourage sustainable practices. In recent years, urban farming has become more popular as people have become more interested in locally grown and sustainable food sources.

Urban Farming Scenario in World

The global urban farming market is projected to grow at a CAGR (Compound Annual Growth Rate) of 6.8% from 2021 to 2028. The market is driven by growing demand for fresh, healthy, local produce. In the United States, the number of urban farms increased by 30 between 2008 and 2016, with an estimated 25,000 urban farms operating nationwide. According to a report by the National Sustainable Agriculture Coalition, urban agriculture can deliver a range of social, economic and environmental benefits, including job creation, community building and improved food security. The COVID-19 pandemic has increased interest in urban farming as people grow their own food and seek self-sufficiency.

Urban Farming Scenario in India

The Ministry of Agriculture and Agricultural Welfare reports that India's urban and suburban agricultural areas are estimated at around 38,000 hectares, producing more than 1.9 million tonnes of food annually. In recent years, urban agriculture has gained popularity in cities such as Mumbai, Delhi, Bangalore and Kolkata, with initiatives ranging from community gardens to rooftop farms. In Bangalore, the government has launched an urban farming promotion program with the goal of creating his 1,000 urban farming businesses across the city. In Mumbai, the government has launched a program called 'The Future of Agriculture in Mumbai' to encourage urban agriculture with a focus on rooftop farms and community gardens. Hydroponics and the use of aquaponics are becoming increasingly popular in India, especially in urban areas where space is limited. The National Institute of Urban Affairs reports that there are over 300 hydroponic and hydroponic farms in India. Urban agriculture in India also provides employment opportunities and income for urban residents.

Advantages of Urban Gardening

1. Access to Fresh, Healthy Produce: Urban gardening provides access to fresh, healthy produce. These products are often more nutritious than store-bought produce. Growing your own food can also save you money on your grocery bill, which can make it more affordable.

2. Environmental Benefits: Urban gardening can help alleviate some of the environmental problems facing cities, such as air pollution and the heat island effect. Plants absorb pollutants and help release oxygen into the atmosphere, which can improve air quality. In addition, green spaces help reduce the amount of heat absorbed by urban surfaces. , helps mitigate the urban heat island effect.

3. Community Building: Urban gardening can be a way to bring people together and build stronger communities. You can provide a space for your neighbors to work together, share knowledge, and socialize.

4. Educational Opportunities: Urban gardening offers people the opportunity to learn about plant biology, sustainable practices and conservation.

5. Mental Health Benefits: Gardening has been shown to have mental health benefits, such as reducing stress and anxiety and increasing feelings of well-being.

6. Food Security: It can help ensure food security by enabling access to fresh vegetables in locations where it is not commonly found.

7. Sustainable Practices: It may encourage resource conservation and waste reduction strategies like composting and rainwater gathering.

There are Many Crops that are Well-Suited for Urban Gardening, Including

Leafy Greens: Leafy greens like lettuce, kale, and spinach are ideal for urban gardening because they are fast-growing and can be grown in small spaces. They are also rich in nutrients and can be harvested continuously.

Tomatoes: Tomatoes are a popular crop for urban gardening because they can be grown in containers and have a high yield. They are also rich in vitamins and antioxidants.

Herbs: Herbs like basil, cilantro, and parsley are easy to grow and can be used in cooking. They can also be grown in small spaces like windowsills or on a balcony.

Peppers: Peppers are another crop that can be grown in containers and have a high yield. They are also rich in vitamins and antioxidants.

Radishes: Radishes are a fast-growing root vegetable that can be grown in small spaces like containers or raised beds. They are also a good source of vitamin C.

Strawberries: Strawberries are a fruit that can be grown in containers and have a high yield. They are also a good source of vitamin C and antioxidants.

Microgreens: Microgreens are small, edible plants that can be grown indoors and are often used in salads and sandwiches. They are easy to grow and can be harvested in as little as two weeks.

Economic and Environmental Benefits of Urban Gardening

Economic Benefits:

a. Reduced Food Costs: By allowing access to fresh, healthy produce that would otherwise need to be acquired from grocery shops or farmers' markets, urban gardening can help individuals and families lower their food costs.

b. Income Generation: It can also provide an opportunity for income generation, as excess produce can be sold to neighbours, at farmers' markets, or to local restaurants and cafes.

c. Employment Opportunities: It can create employment opportunities, particularly in urban areas where unemployment rates are high.

d. Increased Property Values: Green spaces, including urban gardens, can increase property values in urban areas, which can benefit property owners and the surrounding community.

Environmental Benefits:

a. Reduces Water Consumption: It can be designed to use water efficiently, reducing the amount of water needed for irrigation.

b. Improves Air Quality: It can improve air quality by capturing pollutants and carbon dioxide, and releasing oxygen into the atmosphere

c. Mitigated Heat Island Effect: By lowering the amount of heat absorbed by urban surfaces, it can aid in lessening the urban heat island effect.

d. Biodiversity: It can promote biodiversity by providing habitat for pollinators and other urban wildlife.

Conclusion

Urban gardening is more than a trend; it is a catalyst for positive change in urban landscapes. The remarkable growth in the global urban farming market underscores a growing awareness of the benefits it provides. In India, where urban agriculture is gaining momentum, initiatives like rooftop farms and community gardens are shaping sustainable urban development. The advantages of urban gardening extend beyond fresh produce, encompassing economic growth, environmental conservation, and enhanced community well-being. As we cultivate green cities, urban gardening stands as a powerful tool to address pressing urban challenges and build resilient, vibrant communities.

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ASSESSMENT OF ENVIRONMENTAL AND HEALTH IMPACTS OF HEAVY METAL POLLUTION ON AQUACULTURE

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Abstract

Heavy metals, distinguished by their substantial density and toxicity at minimal concentrations, ubiquitously permeate environments, including aquatic ecosystems, through anthropogenic activities such as industrial effluents, urban runoff, atmospheric deposition, and electronic waste disposal. These contaminants pose a significant risk to aquaculture. The bioaccumulation and bio magnification of heavy metals within aquatic food webs lead to detrimental effects on aquatic fauna, manifesting as population declines, morphological anomalies, and compromised health. This contamination extends to human populations through the consumption of contaminated aquatic organisms, integrating heavy metals into human food chains with potential health risks. Moreover, the persistence of heavy metals and their bioaccumulative nature in aquatic environments result in prolonged ecological impacts, undermining water quality and biodiversity. Addressing heavy metal pollution in aquatic ecosystems is imperative for preserving aquaculture viability and protecting public health, necessitating stringent environmental management and pollution control strategies to mitigate these pervasive contaminants.

Keywords : Heavy metal, Ecosystem, Aquaculture, toxicity, aquatic environment.

Introduction

Heavy metals, characterised by their high density and toxicity even at low concentrations, pose significant environmental and health risks in aquatic ecosystems. These metals, including mercury, lead, arsenic, chromium, cadmium, and thallium, are ubiquitous in the environment and enter aquatic ecosystems through various natural and anthropogenic sources. Natural sources include weathering of rocks and volcanic eruptions, while anthropogenic sources encompass industrial activities, domestic sewage, landfill leaching, storm runoff, and atmospheric deposition. Once introduced, heavy metals exhibit a bio accumulative nature, accumulating in organisms over time and posing risks to aquatic fauna and ecosystems.

The presence of heavy metals in aquatic environments is particularly concerning due to their adverse effects on aquatic organisms. Fish, in particular, are highly vulnerable to heavy metal toxicity, as they are unable to flee from contaminated waters. Heavy metals can disrupt various physiological processes in fish, affecting growth, health, survival, and development. Additionally, heavy metals act as potent neurotoxins in fish, potentially impairing their sensory functions and communication abilities. This can have cascading effects on the entire aquatic food web, impacting predator-prey interactions and ecosystem dynamics (Samuel et al., 2023).

Factors such as pH, dissolved oxygen levels, temperature, and turbidity influence the toxicity of heavy metals in aquatic organisms. For example, the pH of aquatic environments can affect heavy metal speciation, altering their chemical forms and bioavailability to organisms. Furthermore, the bioaccumulation of heavy metals in aquatic organisms can lead to bio magnification within the food chain, with predators accumulating higher concentrations of metals than their prey. This bio-magnification can harm higher trophic levels, including humans who consume contaminated aquatic organisms.

The presence of heavy metals in aquaculture poses additional challenges. Aquaculture, the controlled cultivation of aquatic organisms, is susceptible to heavy metal contamination from various sources. Heavy metal pollution in aquaculture systems can lead to physical deformities in organisms, compromised health, and reduced productivity. Moreover, heavy metal contamination in aquaculture products can pose risks to human health, as these products are often consumed directly by humans.

Sources of heavy metal pollution

Heavy metals, renowned for their density and toxicity even at low concentrations, pose a significant threat to aquatic ecosystems, including those utilized for aquaculture. The sources of heavy metal pollution in aquaculture systems are diverse and encompass both natural processes and anthropogenic activities. Heavy metals exist in various forms, including hydroxides, oxides, sulfides, sulfates, phosphates, silicates, and organic compounds, all of which have implications for aquatic ecosystems and human health.

Natural sources of heavy metals in aquatic environments include geological phenomena such as volcanic eruptions and the weathering of metal-containing rocks. These processes release heavy metals into the surrounding water bodies, contributing to contamination. Additionally, sea-salt sprays and forest fires can introduce heavy metals into aquatic ecosystems, further complicating the issue of pollution.

Anthropogenic activities play a significant role in the introduction of heavy metals into aquaculture environments. Mining operations, industrial activities, and agricultural practices are significant contributors to heavy metal pollution. Mining activities release metals into water bodies through runoff and leaching, while industrial operations discharge heavy metal-laden wastewater directly into rivers, streams, and coastal areas. Similarly, agricultural practices involving the use of metal-containing fertilizers and pesticides can result in the runoff of heavy metals into nearby water bodies.

Wastewater discharge is a prominent source of heavy metal pollution in aquaculture. Sewage effluents from urban areas and industrial facilities often contain elevated levels of heavy metals, which can be detrimental to aquatic organisms. In some regions, sewage-fed aquaculture systems utilize treated wastewater for fish farming, introducing heavy metals into the aquaculture environment.

The use of antifouling paints on aquaculture infrastructure presents another pathway for heavy metal contamination. Copper-based paints applied to nets, cages, and boat hulls can leach heavy metals into the surrounding water over time, leading to accumulation in sediments and water columns (Senior et al., 2020). While these paints serve to deter fouling organisms, they pose a risk of secondary contamination to aquatic organisms.

Contaminated feeds used in aquaculture represent a significant source of heavy metal exposure for cultured organisms. Formulated feeds may contain ingredients with high concentrations of heavy metals, either due to contamination during production or through the inclusion of contaminated raw materials (Glencross et al., 2020). Fish and other aquatic organisms fed on these contaminated feeds can accumulate heavy metals, posing risks to both animal health and human consumers.

Furthermore, water sources used for aquaculture, such as dams, rivers, and streams, may be contaminated with heavy metals above permissible limits. This can occur due to industrial discharges, urban runoff, or natural weathering processes, leading to the introduction of heavy metals into aquaculture systems.Indirect contamination pathways also contribute to heavy metal pollution in aquaculture. Sediments and soils may act as reservoirs for heavy metals, which can be mobilized and transferred to aquatic environments through erosion, runoff, or sediment resuspension. Aquatic plants and organisms may then accumulate these metals, serving as vectors for contamination within aquaculture systems.

Effect of heavy metals on health of aquatic ecosystem

Heavy metals, characterized by their inability to undergo metabolism into less toxic forms, pose significant environmental risks in aquatic ecosystems. Once introduced, metals are distributed throughout water columns, accumulate in sediments, or are ingested by organisms, leading to bioaccumulation in aquatic flora and fauna. Sediments serve as semi-permanent reservoirs of metal contamination, releasing metals into the surrounding water over time and contributing to their bioaccumulation in aquatic organisms.

Metal accumulation in sediments occurs through various processes, including precipitation, binding to solid particles, association with organic molecules, and co-precipitation with metal or manganese oxides or carbonates. Metal bioavailability, influenced by organism biology, metal chemistry, and environmental conditions such as temperature, pH, and salinity, determines the fraction of total metal concentration capable of accumulating within organisms.Organic binders and other factors such as pH, temperature, and salinity can enhance the bioavailability of metals by facilitating their diffusion through lipid membranes (de Almeida Rodrigues et al., 2022). The association between solid particles and metals also affects metal uptake by organisms, with suspended solids serving as carriers of insoluble metal compounds.

The contamination of aquaculture by heavy metals is a global issue, with detrimental effects on fish health and potential risks to consumers. Mitigating the impact of heavy metal pollution in aquatic ecosystems requires a comprehensive understanding and management strategies to minimize environmental risks and protect human health.

Effect of Heavy metal pollution in aquaculture

Heavy metals are significant water pollutants, affecting aquatic organisms directly or indirectly. Fish uptake heavy metals through gills, body surface, or digestive tract, causing biochemical, physiological, and histological alterations. They serve as valuable indicators of metal pollution's biological impacts on water bodies. Uptake mechanisms vary among species, influenced by developmental stages, environmental factors, and lifespan. Fish accumulate heavy metals in tissues, with distribution influenced by metal concentration, exposure duration, uptake route, and environmental conditions like temperature and pH. Metals exhibit varying affinities for fish tissues, with the liver, kidney, and gills being common accumulation sites. Accumulation can lead to skeletal lesions and functional disturbances, underscoring the adverse effects of metal pollution on aquatic fauna.

Heavy metals pose significant threats to aquaculture, affecting various aspects of fish physiology and ecosystem health. Lead, arsenic, cadmium, and chromium are among the heavy metals known to have detrimental effects on aquatic organisms. Lead exposure, particularly at high concentrations, inhibits fish maturation, while cadmium disrupts enzyme activity involved in oxidative metabolism. These metals can enter fish bodies through multiple pathways, including gills, body surfaces, and the digestive tract.

Heavy metals also impact the reproductive system of fish. Zinc, lead, cadmium, copper, and mercury accumulate in fish gonads, contaminating eggs and sperm and impairing fertility and embryonic development. Mercury exposure can cause cardiovascular and skeletal abnormalities in fish embryos, leading to reduced hatching rates and increased mortality in larvae. Additionally, mercury, especially in its methylated form, exhibits neurotoxic effects, resulting in brain damage and developmental abnormalities in fish.

The respiratory system of fish is also affected by heavy metal exposure. Zinc and chromium accumulation on fish gills can lead to respiratory distress and anatomical changes, affecting tissue respiration and causing hypoxia. Other heavy metals, such as nickel and cadmium, induce cardiovascular issues, including increased blood pressure and myocardial disease in fish.

Heavy metals have genotoxic effects as well, with arsenic inhibiting DNA repair and causing chromosomal abnormalities in cells. Carcinogenic metals like cadmium, arsenic, nickel, and chromium have been associated with DNA damage, mutations, and oxidative stress in fish.

Physiological damage caused by heavy metals includes histological alterations in fish organs, such as gill necrosis and fatty degeneration of the liver. These alterations can lead to reduced growth rates, underdevelopment of organs, and increased stress in fish. Heavy metal exposure can also impair immune system function in fish, making them more susceptible to infectious diseases and increasing mortality rates.

Effect of heavy metals in the food chain

Heavy metals, such as zinc, copper, and selenium, are essential micronutrients critical for various metabolic processes in humans. However, their accumulation beyond physiological requirements can lead to toxicity. Exposure to heavy metals predominantly occurs through contaminated mediums like water, air, and food, with bioaccumulation being a notable concern, particularly in aquatic organisms and subsequently in humans.

Assessing the global distribution of heavy metal pollution is vital for understanding its ecological and public health implications, considering diverse sources and environmental factors. Heavy metal contamination adversely affects aquatic ecosystems, with fish acting as bio magnifiers, concentrating these toxic substances as they move up the food chain. Consequently, human consumption of contaminated fish can lead to severe health issues, including renal damage, hypertension, and neurological disorders.

Heavy metals exert various toxicological effects on human health, encompassing toxicity, carcinogenicity, and oxidative stress. Chronic exposure to heavy metals has been linked to neurological disorders, cardiovascular diseases, and reproductive impairments. Therefore, stringent regulations on industrial emissions, wastewater discharge, and agricultural practices are imperative to minimize heavy metal contamination. Additionally, ongoing monitoring programs are essential for evaluating environmental metal levels and associated health risks.

Effectof heavy metals on human health

Heavy metals, including lead, arsenic, mercury, cadmium, nickel and chromium, are ubiquitous environmental pollutants known for their adverse effects on human health. These metals enter the environment through various anthropogenic activities such as industrial processes, mining, agriculture, and combustion of fossil fuels, as well as natural sources like weathering of rocks and volcanic emissions.

Lead is a highly toxic heavy metal that can cause neurological damage, especially in children, leading to developmental delays, learning disabilities, and behavioural problems. Sources of lead exposure include lead-based paints, contaminated water from lead pipes, and industrial emissions. Chronic exposure to lead can result in cognitive impairment, cardiovascular diseases, and renal dysfunction.

Arsenic contamination is widespread globally, primarily due to mining activities, industrial processes, and the use of arsenic-based pesticides. Arsenic exposure has been linked to various health issues, including skin lesions, cardiovascular diseases, diabetes, and cancer. Chronic ingestion of arsenic-contaminated water is a significant concern in many regions, particularly in developing countries where access to safe drinking water is limited.

Mercury is a neurotoxic heavy metal that can cause severe neurological disorders, especially in fetuses and young children. Sources of mercury exposure include coal-fired power plants, artisanal gold mining, and certain industrial processes. Consumption of contaminated fish and seafood is a significant route of mercury exposure for humans, leading to adverse effects on the nervous system, cardiovascular system, and reproductive health.

Cadmium is a highly toxic metal commonly found in industrial effluents, phosphate fertilizers, and tobacco smoke. Chronic exposure to cadmium can lead to kidney damage, bone disorders (Itai-Itai disease), and an increased risk of cancer, particularly lung cancer. The widespread use of cadmium in various industrial applications poses a significant environmental and health risk.

Nickel exposure is associated with allergic dermatitis, lung diseases, and carcinogenic effects. Inhalation or skin contact with nickel-containing compounds can cause allergic reactions, while chronic exposure to nickel dust or fumes can lead to respiratory problems and an increased risk of lung and nasal sinus cancer.

Chromium is commonly used in industrial processes such as electroplating, stainless steel production, and leather tanning. Exposure to hexavalent chromium, a highly toxic form of chromium, can occur through inhalation of contaminated air or ingestion of contaminated water or food. Hexavalent chromium exposure is linked to lung cancer, respiratory problems, and gastrointestinal disorders.

Zinc, although an essential nutrient, can be harmful in excessive amounts. Chronic zinc exposure can lead to gastrointestinal disturbances, immune system dysfunction, and neurological disorders. Sources of zinc exposure include industrial emissions, mining activities, and dietary supplements.

Heavy metal pollution poses significant risks to human health, with exposure occurring through various environmental pathways. Strict regulations and mitigation strategies are essential to reduce heavy metal contamination and protect human health from the adverse effects of these toxic pollutants.

Conclusion

The presence of heavy metals in water bodies, particularly in aquaculture settings, poses significant environmental and health risks. Effective removal of these contaminants from wastewater is essential to prevent adverse impacts on aquatic ecosystems and human health. Detection methods, including chemical techniques and analytical instruments, should be employed to monitor heavy metal concentrations in industrial wastewater before discharge into water bodies. Compliance with established guidelines and standards, such as those set by the World Health Organization (WHO), is crucial. Proper disposal of medical waste is necessary to prevent heavy metal contamination of water sources. Water treatment plants play a vital role in treating effluents to remove pollutants before discharge. Awareness programs aimed at various stakeholders, including industrial workers, medical professionals, farmers, and local communities, can help reduce waste generation and minimize heavy metal pollution. Regular testing of water sources is essential to ensure the safety of drinking water and aquatic ecosystems. Education about heavy metals and their environmental impacts should be integrated into academic curricula to raise awareness among future generations and promote environmental stewardship.

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ENZYMATIC EXTRACTION AND CLARIFICATION OF APPLE JUICE: A COMPREHENSIVE OVERVIEW

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Abstract

Many commercially available juices are made using a traditional method of extracting the juice from the fruit, which can washout important nutrients and flavor. However, there is a new, more effective modern technique that is gaining popularity in the industry: enzymatic extraction, particularly in the case of apple juice. By utilizing natural enzymes to break down pectin molecules, this method results in a clear juice that preserves the true essence of the apples. The process involves careful selection, cleaning, crushing of ripe apples to obtain a fine pulp consistency, adding enzymes such as pectinase, allowing an incubation period for the enzymes to work their magic, pressing the pulp to extract the juice, then filtration and pasteurization. Factors affecting juice clarity include the quality of the apples used for extraction and the use of enzymes like pectinase, amylase and cellulose to improve recovery and clarity in apple juice processing.

1. Introduction

Apple (Malus domestica; Rosaceae) is a highly significant fruit from both an economic and cultural standpoint, as it is rich in nutrients and cultivated in all temperate zones. The entirety of the fruit, excluding the seeds, boasts edibility and is harnessed to fabricate a variety of products including ciders, juices, jams, tea, wine, and dehydrated apples. It boosts immunity and contains beneficial substances. Modern medicine has also confirmed the health benefits of apples.

Apple's enzymatic production of juices uses enzymes to extract essential nutrients from the apple pulp and clarify it. Polyphenol oxidase, an apple enzyme, is responsible for initiating enzymatic browning, and affects the color, flavor, and texture of apples. Having a comprehensive understanding of this enzyme can preclude undesirable reactions and wastage. Apple pulp teems with pectin, polyphenols, fatty acids, fiber, and other compounds. To facilitate healing and clarification, enzymes such as pectinase, amylase, and cellulase are incorporated into apple juice.

Table 1. Nutrient composition of whole apples

Constituents (fresh weight)	Whole apple
Macronutrients, %	
Fat	0.16–0.18
Protein	0.24–0.28
Total carbohydrate	13.81
Simple carbohydrates (%)	
Fructose	5.8–6.0
Glucose	2.4–2.5
Complex carbohydrates (%)	
Total fiber	2.1–2.6
Pectin	0.71–0.93

Constituents (fresh weight)	Whole apple
Major minerals, mg/100 g	
Potassium	104.8–109.2
Calcium	5.7–6.3
Phosphorus	10.7–11.3
Magnesium	4.9–5.1
Trace elements, (mg/100 g)	
Iron	0.11–0.13
Zinc	00.026–0.028

Source- USDA, Food Composition Databases (Apple), 2016

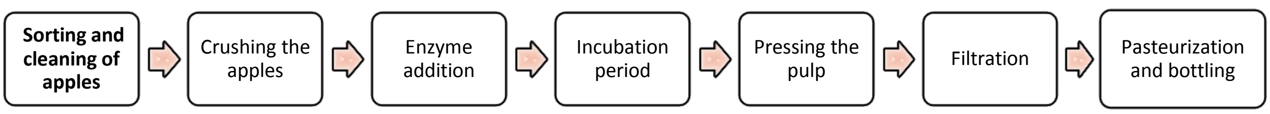
2. Enzymatic extraction and clarification

Enzymatic production is a revolutionary method that is changing the fruit juice industry. Traditionally, in the process of producing fruit juices, the fruit would undergo crushing and pressing to extract the juice. However, this particular method, although yielding satisfactory outcomes, frequently led to a cloudy appearance as a result of the presence of suspended solids and pectin. On the other hand, enzymatic extraction and clarification uses enzymes like pectinase and cellulase to break down the pectin molecules and unwanted impurities found in fruit juices like apples. Enzymatic clarification is an important step after extraction in apple juice production, which plays a crucial role in achieving crystal-clear apple juice. The enzymatic clarification process is often accompanied by filtration, which helps to separate the clarified juice from any remaining solids or impurities and uses the natural power of enzymes to break down the. Pectin, a complex polysaccharide, is responsible for the cloudy appearance and gel formation in fruit juices. By utilizing specific enzymes, we can effectively degrade the pectin, resulting in a clear juice that showcases the true essence of the apples.

The expression of enzymes enhances the appearance, taste and mouthfeel of apple juice. It also helps to preserve the natural flavor and aroma of the apples, as the juice is authentically delicious. By harnessing the power of enzymes, apple juice producers can directly extract the juice and clarify it for maximum clarity and transparency. Enzymatic extraction and clarification not only improve the quality of the entire juice but also help improve its taste, as disruption of the cell walls removes the natural sugars and flavors in the apples.

One of the major benefits of enzymatic production of juice is its ability to operate under milder conditions compared to traditional methods. It can be performed at lower temperatures, minimizing the risk of nutrient degradation and preserving the delicate flavors that nature intended. In addition, it offers the potential to increase yield because enzymes can access pockets of hard-to-reach juices in the fruit. Traditionally, in the process of producing fruit juices, the fruit would undergo crushing and pressing to extract the juice. However, this particular method, although yielding satisfactory outcomes, frequently led to a cloudy appearance as a result of the presence of suspended solids and pectin.

Fig.1. Process of Enzymatic extraction and clarification-



2.1. Understanding the role of enzymesin juice extraction and clarification

Enzymes are biological protein molecules that act as catalysts and speed up the rate of chemical reactions without being consumed in the process. Enzymatic extraction uses specific enzymes that bind and break down a specific substrate, such as pectin or cellulose, found in fruits. By specifically targeting these components, enzymes effectively break down the structural barriers of the fruit, making juice extraction more efficient.

Enzymatic extraction and clarification are the main processes of apple juice production, which play an important role in the quality and taste of the final product. The enzymes used in this process usually come from natural sources such as fruits or microorganisms. A commonly used enzyme is pectinase, which specifically breaks down pectin, a complex carbohydrate found in apples that cloud the juice. Pectinase breaks down pectin molecules into smaller simple molecules that are more soluble, thereby facilitating the clarification of juice and enhancing its overall quality. It is also important to consider the specific characteristics of different apple varieties as they contain different amounts of pectin and cellulose, and the right choice of enzymes that can affect and break down these components is the key to crystal apple juice.

2.1.1 Enzymes used in apple juice production and their functions-

- **Pectinase**: Pectinase is an important enzyme used to break down pectin, a complex carbohydrate in fruit cell walls. While making apple juice, pectinase helps to extract the juice by breaking down the pectin matrix that surrounds the juice sacs.
- **Cellulase**: Cellulase is another important enzyme used to make apple juice. Cellulases target the cellulose to help release the juice from the apple pulp and increase the extraction process. Cellulase also helps filter and clarify water by removing residual particles.
- **Amylase:** Amylase is responsible for breaking down starch present in apple pulp into simple sugars such as glucose and fructose. In the production of apple juice, amylase helps to convert the starch into soluble sugars, which is essential for making cider. By using this enzyme, we can ensure that the juice contains more sugar, resulting in a sweeter, more flavorful product.

Each fruit has its unique enzymatic requirements, and an optimized enzyme combination can unlock the full potential of its juice. By carefully selecting and utilizing the right enzymes, producers can achieve the desired characteristics in terms of flavor, aroma, clarity, and nutritional value.

3. Factors that affect the clarity of apple juice during enzymatic extraction

Several factors play a crucial role in determining the clarity of apple juice during enzymatic extraction.

1. **Quality of apples used for extraction**: Using fresh, ripe apples is an important step to ensure clear juice. If an apple has blemishes or bruised areas, enzymes and pectin can be released, making the juice cloudy and unappealing.
2. **Concentration and activity of these enzymes**: - To obtain clear juice, it is important to find the optimal enzyme dosage and ensure the correct enzyme activity.
3. **Temperature and duration of the enzymatic extraction process**: – Enzymatic reactions are temperature dependent. It is important to find the right combination of temperature and duration to maximize pectin degradation while minimizing negative effects on juice clarity.

4. **Juice packaging and storage conditions**: - Its clarity may be affected over time. Exposure to oxygen or improper storage can cause oxidation reactions and make the juice cloudy. Using oxygen-barrier packaging materials and storing juice in a cool, dark place will help maintain its clarity and freshness.

By carefully considering these factors and implementing appropriate measures, producers can achieve crystal-clear apple juice.

Conclusion

In conclusion, enzyme extraction is a game changer for the fruit juice industry. It maintains the natural flavor and improves the quality control of the final products, making it an excellent choice for producing excellent and tasty fruit juices. Apple is a nutritive and multi-purpose fruit that has many nutrients and can be used to make a variety of products. Enzymatic extraction is a method of extracting valuable compounds, juice from apple pulp using enzymes such as pectinase, amylase and cellulase. This method preserves the flavor and aroma of the fruit, obtaining a clear juice that reveals the true essence of the apple.

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CITY COMPOST A SUSTAINABLE WAY TO MANAGE WASTE IN URBAN AREAS

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City compost
We know that city compost is not only topic of my city it is big topic of whole world so first we can define my commercial and we useful topic of City compost.

City compost
It is a biodegradable organic fertilizer that is made from plant nutrient full material here we can say the fertilizer provides major nutrient like nitrogen phosphorus potassium manganese calcium magnesium and others it also in the soil with micronutrients like boron, zinc, Molybdenum, iron etc.In addition to the nutrient'scity compost is nitrogen fixing bacteria which promotes the activity of good bacteria in soil

Why City compost adopt?
The major goal of composting is to reduce the amount of solid waste you generate and keep it out of the municipal landfills which could ultimately save you tax money finished composed also can be used as natural fertilizer and its way more environment friendly than synthetic fertilizers.

- Bacteria and fungi breakdown the organic matter in the compost of city
- Single cell organism like protozoa nematode and mites feed on bacteria and fungi all these organised work to balance the population of organic with in the composed which increase the efficiency of entire process

Biology of City compost composting creates in the ideal condition for the nature decaying and rotting process that occur in nature composting required that following: -

- Organic based like newspaper, leaves, grasses, kitchen waste, woody materials and some other waste products.
- water
- oxygen

Soall materials is decaying by microorganisms and it also need of water live and multiply through the respiration process microorganism give off CO_2 and heat but condition have to balancefor efficient decomposition.You have make sure your compost pile gets:

- Plenty of air: Turn it every 4 to 7 days specially at first
- Adequate water: it should be moist but not soaking wet give it a spray in weekly.
- Proper mix carbon to nitrogen: the CN ratio is 30 ratio 1
- Small piece: break big chunks up as smaller particleswill breakdown it faster.

Let's go making the city compost:
Selection of site

- Downwind from your site even well managed compostpile of city many occasionallyemit unpleasant odors. although wind provide air too much wind can dry and scatter the material

- Good sunlight help warm the city compost pile.
- Drainage is various elements then more important so too much water doesn't collect by the pile.
- Surface bare earth is better than concrete makes sure to give you self a sufficient work area around the pile.

Choose a structure

In small town or city, we can use plastic, hard bags but big city it is unit of city compost.

Make the city compost

In Delhi city compost unit

- firstly, all the city materials in throw the chamber like drum where all vegetable like products and plastic items, glasses, steel, iron product are separate by the chamber.
- Then hard grinder spoiled and break down all hard material.
- One by one all the product making layers than aerobic condition fungus and nematodes and microorganisms decaying items with same specific temperature and condition.
- after go days our city compost is ready
- use the machine or labour we can packing the city compost

Layer of city compost

It is the best to arrange carbon rich and nitrogen rich materials in alternating layers green then brown and new layers of composting material to the top along with fresh soil water compost bin regularly to keep the compost moist turn the compost every few days to ensure an adequate supply of oxygen.

Chamber of finished composed

- Size of the volume reduce by 50 to 75% and you may see some gas bubbles in the pile.
- Its colour be dark brown or black.
- Texture should be smooth and crumbly.
- Smell like sweet, earthy smell like peat moss.
- Temperature should be worm.

Composition

S.N.	Particulars	Value
1	Particle size	4 mm
2	Colour	Brown to Black
3	Smell	Smell less
4	pH	6-7
5	Moisture	20-25%
6	Bulk density	0.9 gram/cc
7	Nitrogen	0.6-0.9%
8	Phosphorus	0.5-0.75%
9	Potassium	0.5-0.75%
10	Organic Carbon	Minimum 12%

Benefits of city compost

We know that it is such a very good organic or natural fertilizer for crop and soil let's define its value

- Improve the soil structure in garden and yard.

- Increase the activity of soil microbes
- Enhance the nutrients of soil
- Improve the chemistry of your soil pH particularly the degree of acidity.
- Insulate the changes in soil temperature around plants and tree.
- Improve insect and disease resistant in your garden plants and trees.

Composting in the 21st century

Composting hascome long way in the past few decades. most people can and may do, compost no matter where they live or what they grow, suburban flower beds, rooftop herb, gardens and country vegetables garden all benefits from compost made at home or city compost unit.It also keeps a lot of garbage outland fields speaking of garbage collection many municipalities offer composting at thecrub.In cities is like residents are given garbage can a recycling bin and a compost bin for all yard waste and food scraps.It's collected along with the other trash and process at massive composting sites.

Why bother with composting?

This can seem like a lot of work for a little dirt, but it's worth it for a lot of reasons.Let's start with one people don't often talk about money. Take a city like Portland, Oregon which has city wide composting.The green composting bin is picked up every week all year, just like the recycling bins. Ther are garbage bin is only picked up every two-week depending on the size of your family that garbage can is going to fill up fast. It you throw every bit of your trash in the garbage, you are going to need large bin to hold to weeks' worth of trash, which is expensive. If you can shift the bulk of the material to the compost and recycle bins you can save a lot of money by the choosing a smaller garbage bin.There also the benefit of keeping trash out of landfills and the benefit of helping plants thrive, which helps increase oxygen in on our atmosphere. The satisfaction of using fertilize you made yourself with a help from tiny bug friends and worms.

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EMPOWERING INDIAN AGRICULTURE: HARNESSING THE POTENTIAL OF SMARTPHONES FOR PRECISION FARMING

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Abstract

This study explores the pivotal role of smartphones in revolutionizing Indian agriculture through precision farming techniques. In the face of evolving environmental conditions, traditional farming methods no longer suffice, necessitating the adoption of modern technologies. Smartphones, equipped with diverse applications, offer solutions for resource management, disease identification, weather forecasting, and access to vital agricultural information. The study categorizes smartphone applications into farming, farm management, information systems, and extension services, highlighting their profound impact on enhancing productivity, profitability, and sustainable practices in Indian agriculture.

Introduction

At the present time to ensuring the food security Indian farmers need of adopt to new and modern methods to enhance the agriculture production. Now a days the traditional methods is no longer suitable, because farming outputs depend largely on surrounding environmental conditions and management practices. Among them technologies invented in the past few decades, new methods for farming have been invented like, precision agriculture. In this smart phone is currently most important electronic device in agriculture where farmers itself getting the solution their farming problems and boost the knowledge regarding farming practices with the help of mobile apps. Smart phone with its current trends and most applicable in field of agriculture to assess the weather and climate (cloud computing,) information for selection of cropping system and carryout the timely agricultural practices, soil description, agriculture market information related to price of crops, current demand of commodities and various useful government schemes, crop disease news sensor control, GPS, GIS, data mining, language processing and other technique have used to provide knowledge about smart farming. Meanwhile, farmers who already adopt assistance from other information technologies, they can utilize smartphone-based assistance apps to achieve better profit and farming productivity.

Major Role of Smart Phone in Agriculture

In this we describe the smartphone applications from ore survey. The applications were categorized into four major categories: farming, farm management, information systems and extension services.

1. Resource information- To identified and provide the information about fertilizers, pesticide insecticidal, herbicide, seed quality.
2. Agriculture input calculation- Smart phone use to getting the precise and calculate the amount of agriculture input in a very short time. Applying fertilizer is an important farming activity with the right amount for better response. Farmers may calculate proper amounts

of fertilizers for crop fields upon analysingcolour of crop leaves with some help from smartphone applications.

3. Diseases identification and control- Smartphone applications like; Plantix is dedicated to disease detection in farms when utilizing sensors on smart-phones.
4. These applications worked by capturing images of plant leaves being investigated for diseases and also suggest the control, ting the processed images to remote laboratories. The image
5. Current agriculture news- Provide the valuable news regarding agriculture in local and global market, such as agriculture produce market prices, subside in agriculture farm inputs, and warning related to use of high toxic residue chemicals.
6. Crop water needs estimation- For the obtaining higher production farmers also need to make the decisions on the time and amounts of water their crops need. Crop. The water requirement depends on the various conditions like: type crop, season, climate and critical stages of crops. Crops loss the water through the evapotranspiration. Crop water needs are analyzed to supplement water loss. A smartphone application called PocketLAI helped farmers in determining Leaf Area Index (LAI), which is a key factor to calculate crop water requirement.
7. Information System Applications- Now a days many applications provide information, which is a key factor for making effective decisions in all industrial sectors including agricultural sector. It is widely recognized that information can help farmers increase agricultural productivity. Up-to-date informationabout prices as well as market demands helps farmers in choosing the type and amount of crops to grow and where to sell their products, to maximize profits.
8. Maintain crop and livestock calendar
9. Weather information
10. Insect and Pest warning
11. Providing tips for organic cultivation of crops
12. Calculation of total field area and provide field map
13. Pollution and activity report submission
14. Government schemes.

Conclusion

The integration of smartphones into Indian agriculture has emerged as a transformative force, addressing the imperative need for innovative approaches to ensure food security. The study elucidates the multifaceted role of smartphones in resource management, disease control, weather forecasting, and dissemination of critical agricultural information. Through diverse applications, farmers can make informed decisions, optimize input utilization, and boost overall productivity. The ongoing evolution of smartphone technologies is poised to further empower farmers, fostering a resilient and sustainable agricultural sector in India.

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HYDROPONICS -A SUSTAINABLE APPROACH FOR CROP GROWTH

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The main challenge facing by present day farmers is to feed the expandingglobal population from the limited arable land by increasing productivity through optimal use of available water and land resources. As water scarcity spreads around the globe, finding ways of getting more crop per drop to meet our food needs is among million hectares at present. There is a need for technology in agriculture that can contribute towards water saving and have a positive impact on food production, security and availability*. One such solution is hydroponics a* soil-less culture technique in which plant can grow in a mineral nutrient solution.

Hydroponics can be defined as the science of growing plants without the use of soil, but by use of an inert medium, such as gravel, sand, peat, vermiculite, pumiceor sawdust, to which nutrient solution is added containing all the essential elements needed by the plant for its normal growth and development. The word “Hydroponics” is derived from combining two Greek words “Hydro” means water and “Ponos” means labour. Thus, hydroponics is the cultivation of plants in nutrient-enriched water, with or without the mechanical support of an inert medium such as sand or gravel. Hydroponics is gaining popularity due to efficient management of resources and food production. Various commercial crops can be grown such as leafy vegetables, tomatoes, cucumbers, peppers, strawberries etc.

There are 2 systems in hydroponics, they are Passive and Active systems.

- Passive systemsrelies on a wick or the anchor of the growing media.
- Active systemsmeans that nutrient solutions will be moved, usually by a pump.

Passive systems

Capillary or Wick System : The capillary or wick system does not use pumps or timers. Water and nutrients are drawn up to the roots by capillary action. These systems may be important when designing a system to operate in a space station where gravity is non-existent. The Wick system is by far the simplest type of hydroponic system. The nutrient solution is drawn into the growing medium from the reservoir with a wick.

Advantages

- Affordable
- Low maintenance
- No nutrient pump

Disadvantages

- Limited oxygen access
- Slower growth rate

- No nutrient recirculation
- Prone to algae growth

Active systems

Deep water culture : The water culture system is the simplest of all active hydroponic systems. The platform that holds the plants is usually made of Styrofoam and floats directly on the nutrient solution. An air pump supplies air to the air stone that bubbles the nutrient solution and supplies oxygen to the roots of the plants.

Advantages

- Cheapest of the active systems
- Simple set up
- No nutrient pump
- Reliable

Disadvantages

- Risk of root rot if not cleaned regularly
- Slower growth rate
- Must top water until roots are long enough to fall into the nutrient solution
- Must frequently refill reservoir
- Doesn't work well with large plants or with long-term plants

Drip system : Drip systems are probably the most widely used type of hydroponic system in the world. Operation is simple, a timer controls a submersed pump. The timer turns the pump on and nutrient solution is dripped onto the base of each plant by a small drip line. In a Recovery Drip System the excess nutrient solution that runs off is collected back in the reservoir for re-use. The Non-Recovery System does not collect the run off.

Advantages

- Excess nutrient solution recirculates
- Sufficient oxygen flow

Disadvantages

- Prone to clogging
- Prone to algae growth
- Requires regular cleaning

Nutrient-film technique : The nutrient solution is pumped into the growing tray (usually a tube) and flows over the roots of the plants, and then drains back into the reservoir. There is usually no growing medium used other than air, which saves the expense of replacing the growing medium after every crop. Normally the plant is supported in a small plastic basket with the roots dangling into the nutrient solution. N.F.T. systems are very susceptible to power outages and pump failures. The roots dry out very rapidly when the flow of nutrient solution is interrupted.

Advantages

- Excess nutrient solution recirculates
- Plentiful oxygen flow
- Space efficient

Disadvantages

- Prone to clogging

- Technical malfunction could result in crop loss

Advantages of hydroponics over traditional soil based growing systems

- Plants grown in hydroponics systems tend to grow faster and yield more due to the quality nutrition, higher oxygen levels and the carefully controlled ambient variables
- It uses 20% less space for growing with respect to conventional system
- Because hydroponics systems deliver a nutrient-rich solution directly to the root zone, plants can be grown closer together without competing for root space
- Farmers can grow 3 to 10 times the number of crops in the same amount of space as traditional farms
- Compared to traditional farming methods, this farming model can produce 7 to 14 times more growth cycles
- Saves up to 90% of water usage
- Soil borne pests and diseases are eliminated
- Weeds are controlled
- Automation is possible
- Ease of harvesting

Conclusion

Hydroponics is a promising strategy for growing different crops round the year in a very limited space with low labour. Thus, hydroponics can play a great contribution in areas with limitation of soil and water and for the poorer and landless people.

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KITCHEN GARDEN: PERCEIVED ROLE AND UTILIZATION AMONG RURAL HOUSEHOLDS

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Abstract

Kitchen gardening in general and organic vegetable production in particular are gaining popularity and have become indispensable components of organic farming systems. The concept of kitchen gardening was developed by various institutes for growing winter and summer vegetable crops. If these vegetables are grown in a planned manner, one can get fresh vegetables to supply good human nutrients to the body. Every person should consume a balanced diet to stay healthy, and this concept is a blessing for providing us with a balanced diet. The growing of vegetables by this technology provides us with fresh, pesticide-free vegetables. It can also save a huge amount of money, which is spent on the purchase of vegetables at the market. In urban and peri-urban areas, people cannot produce vegetables for themselves, even if they wish to grow them, due to a shortage or higher land prices. In this regard, a rooftop or terrace vegetable nutrition garden is the best alternative to growing vegetables. It ensures a regular supply of fresh vegetables. Pollutants can be taken up by vegetables cultivated in these soils and concentrated in their edible parts. In this review, the behavior of vegetables cultivated in contaminated kitchen gardens is assessed through ten examples of the most widely cultivated vegetables (tomato, brinjal, chilli, radish, okra, onion, cluster bean, tomato, dolichos bean, snake gourd, and bottle gourd). Keeping into consideration the importance of vegetables in daily diets and their low per capita availability, the Jaya agricultural college has conducted various trainings and demonstrations for the students in order to ensure better per capita availability at household level and an increased level of knowledge regarding the establishment of kitchen gardens.

Key word : Kitchen gardening, fresh vegetable, balanced diet, healthy food.

Introduction

Kitchen gardening is the traditional practice of growing vegetables and fruit on a small piece of land near the residence in a planned manner to get fresh produce throughout the year to meet the family's requirements. These gardens are also known as home gardens, nutrition gardens," or vegetable gardens. The main purpose of the kitchen garden is to get a regular supply of nutrient- and energy-rich fresh vegetables, which helps in diet diversification. It is becoming an indispensable part of the organic farming system to produce seasonal fruit and vegetables needed for household consumption, which are daily sources of nutrients like protein, vitamins, minerals, fats, and carbohydrates, the lack of which results in malnutrition and poverty (Shaheb *et al.,* 2016). According to the Indian Council of Medical Research (ICMR), the Recommended Dietary Allowance (RDA) for vegetable consumption is 300 g/day, including roots and tubers, green leafy vegetables, and green leafy vegetables. The practice of kitchen gardening is gradually becoming more popular even in urban and peri-urban areas of the country due to people's consciousness about the health hazards of pesticides, the higher price of vegetables, especially in the off-season, and personal physical exercise as well. Rural and urban people should promote its startup because these nutritional kitchen gardens generate household-level food security. As far as household food security is concerned, food is produced in variety according to harvesting seasons at the household level to create healthy eating practices for good family health and financial support. The application of this concept to the family level, with family members within households, is the main aim of household-level food security as a kitchen garden concern (Mohsin *et al.,* 2017). But kitchen gardens are primarily focused on the production of family food products through mix cropping, rotational cropping, relay cropping, and multistoried cropping, which helps minimize the larger dose of pesticides used. In addition to this, the gradual increase in people's awareness of the health hazards of pesticides has motivated them to grow at least certain fruits and vegetables in a pesticide-free environment in their kitchen gardens (Sethy *et al.,* 2010). Households have been trying to grow diverse species of vegetables and fruit in their kitchen gardens, focusing on organic by default. It seems rational to assess some location-specific findings on the productive efficiency of vegetable production in this system for promoting productivity, profitability, and efficiency of inputs used.

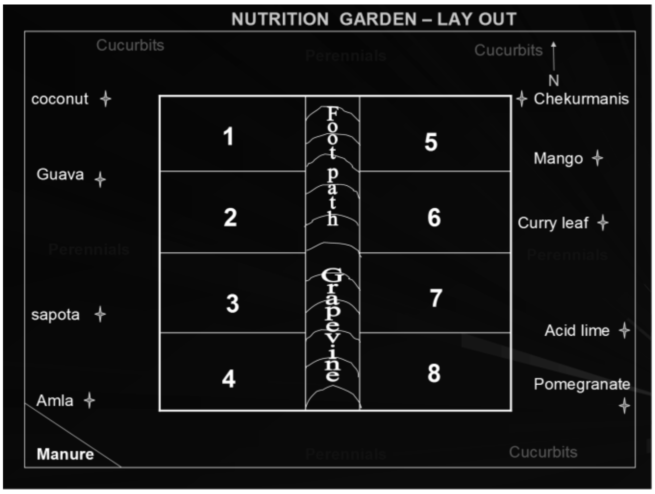
Advantages of Kitchen garden:

- ✓ Supply fresh fruits and vegetables high in nutritive value.
- ✓ Supply fruits and vegetables free from toxic chemicals.
- ✓ Help to save expenditure on purchase of vegetables.
- ✓ Vegetables harvested from home garden taste better than those purchased from market.
- ✓ Effective utilization of kitchen waste water and kitchen waste materials.
- ✓ Exercise to the body and mind.

Site selection

1. The first selection of sites for kitchen gardens, and the final choice, is usually the backyard of the home.
2. This is convenient as the members of the family can give constant care to the vegetables during leisure, and the wastewater from the bathrooms and kitchen can easily be diverted to the vegetable plot.
3. The size of the kitchen garden depends on the availability of space and the number of people in the family.
4. There is no restriction on the shape of the kitchen garden, but wherever possible, a rectangular garden is preferred to a square one.
5. With succession cropping and intercropping, five cents of land would be adequate to supply vegetables for an average family of four to five people.
6. On average, 2.5 kg of vegetables can be obtained per day.

Layout of kitchen garden



Features of a Kitchen Garden

Perennial plot

This area should be located at the rear end of the garden so that the perennial plants can be grown effectively, as its shade does not affect the growth of other crops. Crops like moringa, curry leaf, tapioca, yams, agathi, and fruits like lime, banana, and West Indian cherry can be grown in this area.

Fence

It is very important to fence the garden to protect it from animals and trespassers. If no compound wall is provided, a live fence can be grown. Bamboo tatties, barbed wire, or plain wire can be erected for fencing. On this fence line, coccidia, bitter gourd, lablab, and basely can be grown.

Manure pits

Manure pits are dug at two corners of the garden at the rear end, near the perennial plot. In this pit, garden, and kitchen waste, including ash and household sweepings, is dumped and composted. This can be used for manuring the kitchen garden.

Gourds like snake gourd, and ribbed gourd can be grown near the manure pit and trained on a pandal erected above the manure pit.

Land preparation

1. Firstly, spade digging is done to a depth of 20-25cm.
2. Stones, bushes, and perennial weeds are removed.
3. 200 kg of well-decomposed farmyard manure is applied and mixed with the soil.
4. Ridges and furrows are formed at a spacing of 45 × 60 cm, as per the requirement.
5. Flat beds can also be formed instead of ridges and furrows.

Paths and irrigation channels

A main path dividing the entire garden into two halves with side paths and walks is to be made. The area for main and side paths should be the minimum. The width of the path should be 60 to 60 cm. The number of irrigation channels should also be kept to a minimum. Along the main path, pandals may be provided. Along the side paths, greens like drumstick, palak, coriandor, mint, and small onions can be grown.

Prepare beds

After allocating areas for the above features, the rest of the area can be divided into beds of equal size and rectangular shape. According to the area available, 6-8 beds may be formed. Ridges that are separating the beds may be grown with radish or small onion for effective utilization of the land area under cultivation.

Selection of vegetables

The vegetables to be grown in a home garden depend on the choices of the family members and the size of the garden. Preference may be given to leafy and seasoning vegetables (Palak, amaranth, lettuce, methi, onion, garlic, turmeric, ginger, and coriander) and peas and beans, as well as those vegetables that have multiple harvests (tomato, chilies, brinjal, okra, peas, beans, etc.), unlike cabbage or cauliflower. Vegetables with good nutritive value and early maturity may also be selected for kitchen gardens. Some people may like to grow specialty vegetables like broccoli, celery, parsley, endive, chive, patchouli, basil, asparagus, artichoke, red cabbage, colored (red and yellow) sweet peppers, and small pickling cucumbers. Those vegetables that require large amounts of space for growth (melons, watermelon, pumpkin, etc.) are not suitable for growing in a home garden.

Sl. No.	Types of vegetables	Name of vegetables	Duration
1.	Fruit vegetables	Tomato, Brinjal, Chillies, Okra	4 - 5 months
2.	Root vegetables	Radish, Carrot, Beet root, turnip	3 months
3.	Bulb crops	Small onions, bellary onion, garlic	3 - 4 months
4.	Legumes	Lab lab, Cowpea, French beans, peas, cluster beans	3 - 4 months
5.	Cucurbits	Pumpkin, Bitter gourd, ribbed gourd, snake gourd, coccinia	4 - 5 months
6.	Tuber crops	Sweet potato, Tapioca, yams	8 - 9 months
7.	Cole crops	Cabbage, Cauliflower, Knol-khol	3 - 4 months
8.	Leafy vegetables	Amaranthus, coriander, fenugreek, palak, Alternanthera, mint etc.	2 months

Choosing **your** vegetables

The first step of this process will be to choose what you want to grow. Before one can decide what one wants to grow, it is important to consider the season and what kind of crop goes best in this season.

Summer vegetables

Tomato, Hot Pepper, Sweet Pepper, Brinjal, Cucumber, Okra, Bottle Gourd, Sponge Gourd, Bitter Gourd, Tinda Gourd, Pumpkin, Arum, Potato, Mint, Turmeric, Ginger, Musk Melon, Watermelon, Sweet Potato, and Groundnut.

Winter vegetables

Cabbage, cauliflower, broccoli, carrot, potato, onion, lettuce leaf, radish, turnip, peas, spinach, fenugreek, beets, mustard, coriander, mint, and garlic

- Once you have decided on your vegetables according to the relevant season, it is important to know that wherever you plan to garden, there should be at least seven to eight hours of direct sunlight available.
- It is also important to know that different kinds of vegetables should not be grown together.
- Moreover, vegetables that require vines should be separated from those that do not.
- The vines require some support, which can be provided with sticks or walls.

Direct sowing and transplanting

The main objective of a kitchen garden is maximum output and a continuous supply of vegetables throughout the year. Direct-sown crops like bhendi, cluster beans, and cowpea can be sown on one side of the ridges. Amaranthus (meant for the whole plant's pulling out and clipping) can be sown by broadcasting in the plots. Small onions, mint, and coriander can be planted or sown along the bunds of plots. Seeds of transplanted crops like tomatoes, brinjal, and chilli can be sown in nursery beds or pots one month in advance. After sowing, cover with topsoil, and then dust with 250 grams of neem cake so as to save the seeds from ants.

- The perennial plants should be located on one side of the garden, usually on the rear end of the garden, so that they may not shade other crops or compete for nutrition with the other vegetable crops.
- If seeds and seedlings are planted too far apart, much of the space in between goes to waste, where weeds will grow. Weeds use precious water and compost and cause extra work to keep clear.

Cultural practices

Vegetables can be grown from seeds (okra, root crops, peas, french bean, amaranth, palak, methi, coriander, etc.) or by transplanting seedlings (tomato, eggplant, chilies, capsicum, onion, cabbage, cauliflower, broccoli, knolkhol, etc.). Parval (pointed ground) is raised by planting rooted cuttings, potatoes by tubers, multiplier onions by small bulbs; and garlic by cloves. In a limited garden space, it may be useful to follow multiple cropping systems like intercropping, mixed cropping, relay cropping, and succession cropping.

In a home garden, the use of chemical fertilizers and pesticides should be avoided or used judiciously. The use of manures like farmyard manure, compost, cow dung manure, oil cake, vermicompost, and green manure is safe for human health and environmentally friendly. Vermiculture may be adopted for producing vermicompost using kitchen waste. Nowadays, organic farming practices and integrated pest management are being advocated for home gardening.

Generally, furrow irrigation is practiced to supply water to plants. Water from a tube well or bore well is used for irrigation. Drinking water from house taps should not be used for irrigation. Nowadays, the harvesting of rainwater is encouraged in urban areas. Rainwater collected in large plastic tanks can be used for irrigation.

Harvesting

Harvest times will be different depending on the vegetables, the timing of planting, and the location. If you include a variety of plants, you can enjoy fresh vegetables and flowers from your garden throughout the growing season.

If you are thinking of growing your own herbs, start by planting things that you like to eat. Plants don't cost much, and once they get settled in, all they need is a little water. If you choose the right herbs, they can also act as mosquito repellents.

Economic benefits of gardening

Gardeners feed their families first and then sell, barter, or give away surplus garden foods. In certain contexts, however, income generation may become the primary objective of the home garden. In any case, it is counterproductive to impose the nutrition objective to the exclusion of the income generation objective since, in most contexts, they are linked and compatible. The potential economic benefits of home gardening include the following:

- Gardening has the dual benefits of food and income generation;
- Gardens provide fodder for household animals and supplies for other household needs (handicrafts, fuel wood, furniture, baskets, etc.);
- The marketing of garden produce and animals is often the only source of independent income for women.

Conclusion

From the present investigation, it may be concluded that the establishment of kitchen gardens played an immense role in tackling the problem of malnutrition and micronutrient deficiencies in rural areas. Women are the main caretakers of the garden, and the kitchen garden empowers them, ensures better utilization of the income for food, and increases family welfare. Kitchen gardening decreases expenditure for vegetables, increases the supply variety of vegetables, increases crop diversity, increases kitchen motivation, increases community connection after starting kitchen gardening activities, and improves the social environment.

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HARMONY IN BLOOM: EXPLORING THE AESTHETIC AND ENVIRONMENTAL DIMENSIONS OF BIO-AESTHETIC PLANNING

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Abstract

Bio-aesthetic planning, coined by Prof. Lancelot Hogben, is a deliberate effort to enhance the visual allure of a country through conscious cultivation of flora and fauna. This paper delves into the historical roots of bio-aesthetic planning, with a focus on its implementation in India, spearheaded by visionaries like Dr. M.S. Randhawa and Le Corbusier. The objective is to underscore the ecological adaptation within this planning paradigm, emphasizing the collaboration between town planning and bio-aesthetic planning. The paper also identifies key areas for bio-aesthetic interventions, emphasizing public spaces for widespread appreciation. Furthermore, it explores the myriad benefits, encompassing environmental factors such as temperature regulation, air quality improvement, noise reduction, and aesthetic enhancements. The principles and components of bio-aesthetic planning are outlined, underscoring its potential to unite communities, support nature conservation, and provide direct financial benefits to local populations.

Introduction

Bio aesthetic planning can be defined as a 'conscious plan of the Flora (Plants) and Fauna (Animals) with the objective of beautifying the country.' In both towns and villages, it entails planting decorative flowering trees beside city roadways, in parks, open spaces, on private property and in dwellings. It also includes the development of 'nature parks' for the preservation of beautiful non-carnivorous animals and the creation of bird sanctuaries. Landscape gardening is included in bio-aesthetic planning as well. A bioaesthetic planning for India has as its goal encouraging the planting of particular attractive flowering plants in our towns and villages. The bio-aesthetic planners are expert painters, using gorgeous flowering plants as their paints and the entire nation as their canvas. They use vivid colours like blue, orange, red, yellow, crimson and pink to paint the landscape. They adorn the walkways of the streets, train platforms, canal banks, residential communities and public buildings with vibrant flowering trees.

Historical Background

Prof. Lancelot Hogben coined the phrase "bio-aesthetic planning," which describes the intentional planning of the flora and fauna with the goal of beautifying our surrounds or country. Dr. M.S. Randhawa promoted the idea of bio-aesthetic planning in India and together with Le Corbusier and his collaborators Pierre Jeanneret, E. Maxwell Fry and Jane B. Drew, they helped plan Chandigarh. The term "bio-aesthetic planning" refers to the planned ecology of living organisms from an artistic and aesthetic perspective. It encompasses both the science of animals and plants. The purpose of this idea is to produce decorative flowering trees along roadways, in parks, residential communities and public spaces. Bio-aesthetic planning can play important role in environmental amelioration of urban and industrial areas along with their beautification. It is only with a touch of bio-aesthetic planning that the countryside and other places will look not only natural but pleasing too to the eye. The ecological adaptation of the plots should be given appropriate consideration in bio-aesthetic planning. Town planning and bio-aesthetic planning should work together. Making the country as a whole beautiful requires the engagement of the public through organisations like Park Management Committees, Kitchen Garden Societies, Eco-clubs, etc. at every stage, from planning to management (https://biotecharticles.com/).

Objective

The ecological adaptation of the plots should be given appropriate consideration in bio-aesthetic planning. Town planning and bio-aesthetic planning should work together. To realize its full potential, bio-aesthetic designs should be created as part of the master plans. Making the country as a whole beautiful requires the engagement of the public through organisations like Park Management Committees, Kitchen Garden Societies, Eco-clubs, etc. at every stage, from planning to management (Rajput and Saxena, 2021).

Areas for Bio-Aesthetic Planning

In bio-aesthetic planning, public spaces that belong to the community as a whole rather than to specific people should take precedence. As a result, a sizable portion of the population, particularly those who cannot afford their own private home gardens, will be able to appreciate the natural beauty of plants andflowers. The following list includes many areas for bioaesthetic planning in cities and rural areas (Anand *et al*., 2016):

1. Airports, railway tracks, bus stands, bus terminals, railway stations, railway junctions, highways and canal banks.
2. Burning ghats, cemeteries, etc.
3. Individual home gardens.
4. National, state, district, block and village roads.
5. Private hotels, shopping complexes, private residential colonies, etc.
6. Public parks and gardens.
7. Public places such as hospitals, banks, courts, post offices, university campuses, schools, colleges, dak bungalows, etc.
8. Religious places such as temples, mosques, churches, gurdwaras, etc.
9. Village panchayat ghars, community lands, chaupals, etc.

Benefits of Bio-Aesthetic Planning

1. Environmental benefits:

a. Temperature and energy use: Since the late 19th century, global surface temperatures have increased by 0.3-0.6 0C. Because of their concrete construction, less wind, increased high-density surface area and heat produced by human related activities, urban areas in particular function as heat islands.

b. Air quality: The main air pollutants that cause respiratory and other health issues include carbon monoxide, lead, ammonia, suspended particulate matter, sulphur dioxide, and oxides of nitrogen. Through their function as biological and physical nets, plants aid in the regulation of air pollution.

c. Precipitation and humidity: Plants catch rainwater and slow its descent to the soil's surface, resulting in increased infiltration and decreased runoff and soil erosion.

d. Noise abatement: Vegetation barriers reduce some of the noise from factories, building sites, and vehicles. These screens should be positioned close to the noise source and should be thick, tall, and wide.

e. Carbon sequestration: Bio aesthetic planning also helps to reduces the CO2 level from environment.

f. Reduces water erosion: Plants reduce soil erosion, water runoff, loss of nutrients and sediments and increase ground water recharge by preventing hazardous pollutants from soil from entering rivers.

g. Wind protection and air movement: As much as 2-5 times the height of the tallest tree on the windward side and 30-40 times on the leeward side, trees that are perpendicular to the wind's direction might slow it down.

2. Aesthetic benefits of bio-aesthetic planning: It integrating aesthetics and nature conservation, landscaping of roads and highways and other surrounding areas (Kumari, 2019).

Principle:

a. It unites the communities and sustainable nature
b. It increase the beneficial impact of flora and fauna
c. Built environment and cultural awareness Provide positive experience for both visitors and hosts
d. Provide direct financial benefit and empowerment for local people
e. Support international human rights and labour agreement.

Components: It comprises the walkway and paths are common element within the landscape along with bricks, woodchips, stone, water features, statuary and other ornamental accessories can also be added.

Conclusion

In conclusion, bio-aesthetic planning emerges not merely as a horticultural endeavor but as a holistic approach to transform our surroundings into vibrant canvases of natural beauty. By integrating ecological adaptation into town planning and involving communities, we can achieve sustainable and visually appealing landscapes. The environmental benefits, from temperature regulation to air quality improvement, underscore the profound impact bio-aesthetic planning can have on urban and industrial areas. Embracing principles of unity, sustainability, and cultural awareness, bio-aesthetic planning not only enhances the aesthetics but also fosters a positive relationship between individuals and their environment. As we continue to navigate the challenges of urbanization and environmental degradation, the principles and practices of bio-aesthetic planning stand as a beacon for creating a harmonious coexistence between humanity and nature.

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LIVESTOCK AND AGRI-FOOD SYSTEM TRANSFORMATION

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Abstract

Livestock play a vital role in the food system, but there's an urgent requirement to undergo a significant transformation within this sector. The goal is to ensure that it actively contributes to the shift towards sustainable food systems. A global consensus is emerging on the necessity to revolutionize food systems to address crucial global objectives concerning both human well-being and the health of the planet. The Sustainable Development Goals (SDGs) underscore the importance of transforming our approach to eradicate hunger, achieve food security, and enhance nutrition through sustainable agriculture, good health and minimizing adverse environmental impacts. Therefore, the future of food systems must focus on providing a diverse range of affordable foods, facilitating universal access to diets of high nutritional quality for everyone.

Keywords: Livestock, Nutrition, Food security and agri-food systems.

Introduction

The global situation has reached a critical juncture, with 783 million people experiencing hunger in 2022 and over 3.1 billion unable to afford a nutritious diet. The existing agri-food systems not only fall short in providing adequate and healthy food access but also contribute significantly to environmental degradation and substantial health expenses. In an era marked by environmental concerns, food security challenges, and evolving consumer preferences, the imperative to transform livestock and agri-food systems has never been more pressing. The intersection of agriculture and livestock production stands at a critical juncture, demanding a paradigm shift towards sustainability, efficiency, and resilience. It explores the multifaceted landscape of Livestock and Agri-food System Transformation, delving into strategies that reconcile the growing demand for food with the need to mitigate environmental impact (Pathak, 2023). From innovative technologies to ethical practices, this examination navigates the path towards a more responsible and adaptive approach to meet the demands of a changing world. The transformation of livestock and agri-food systems seeks to achieve nutrition and affordable diets for good health by promoting sustainable farming practices and alternative protein sources.

Livestock: Contribution and Growth

Livestock is integral to India's economy, supporting 20.5 million livelihoods and contributing 16% to small farm households' income. With two-thirds of the rural community relying on livestock, it offers employment to 8.8% of India's population. The nation's abundant livestock resources contribute 4.11% to the GDP and account for 25.6% of the total Agriculture GDP (Anonymous, 2022). The Gross Value Added (GVA)of livestock sector is about Rs. 11,14,249 crore at current prices during FY 2020-21 which is about 30.87% of Agricultural and Allied Sector GVA and 6.17% of

Total GVA. At constant prices (2011-12), the GVA of livestock sector is about Rs. 6,17,117 crore during FY2020-21with a positive growth of 6.13% over previous financial year (Anonymous, 2022).

The agricultural and allied sector has exhibited robust performance in recent years, primarily attributed to government initiatives aimed at enhancing crop and livestock productivity (Madhu *et al.,* 2023). These measures include ensuring farmers' income certainty through price support, encouraging crop diversification, and upgrading market infrastructure. Food grains production in India saw sustained increase and stood at 315.7 million tonnes in 2021-22. Free food grains to about 81.4 crore beneficiaries under the National Food Security Act for one year from January 1, 2023 (Anonymous, 2022a).

Role of livestock in Agri-food system

Livestock plays a multifaceted role in agri-food systems, encompassing various aspects such as food production, economic contributions, and environmental impact. Here are key roles of livestock in agri-food systems:

- **Food Production:** are a significant source of protein, supplying meat, milk, and eggs for human consumption.
- **Economic Contributions:** a vital economic activity, providing livelihoods for millions of people globally. The sector contributes to income generation through the sale of livestock products and by-products.
- **Diversification of Agriculture:** Integrating livestock into agricultural systems enhances farm diversification, contributing to more resilient and sustainable farming practices.
- **Manure and Soil Fertility:** Livestock manure serves as a valuable organic fertilizer, enhancing soil fertility and promoting healthier crop yields.
- **Draught Power:** Livestock, especially cattle, serve as draught animals, supporting agricultural activities such as ploughing and transportation.
- **Cultural and Social Significance:** Livestock are often integral to cultural practices and play a crucial role in the social fabric of many communities.
- **Income Diversification:** Livestock farming provides an additional income stream for farmers, contributing to income diversification and risk mitigation.
- **Sustainable Land Management:** Integrating livestock in agri-food systems can support sustainable land management practices, preventing soil degradation and enhancing ecosystem services.

Agri-food systems from knowledge to action

The priority areas around the three betters of the new strategic narrative. The objectives include ensuring the transformation of what we do i.e., better livestock production, better nutrition and better environmental sustainability.

Better livestock production

We need more livestock production to meet India's growing food and nutritional needs by 2050, the India's population will reach 1.7 billion people, creating the most populated country in the world. Food demand will increase by 70%, and is already lagging domestic food production. Meet the growing demand with fewer ruminants, new technological and policy innovations to bring about highly efficient and ecologically sound livestock production. Rapidly increase the productivity of livestock in country. Introducing climate smart breeds and feeds. Reduce the endemic disease burden of livestock and prevent zoonotic diseases. The current livestock and poultry production scenario indicated below.

From the table 1, bovine category, which includes cattle, buffalo, yaks, and mithun, experienced an overall growth rate of 1.26%. Cattle and buffalo, the most significant contributors, witnessed modest increases of 1.34% and 1.06%, respectively. Yaks exhibited a notable decline of -24.90%, while mithun showed a growth of 29.52%. Among small ruminants, sheep and goat populations demonstrated robust growth rates of 14.13% and 10.14%, respectively. However, the pig population decreased by -12.03%. Other animals, a miscellaneous category, experienced a significant decline of -48.70%. The total livestock population increased from 512.06 million in 2012 to 536.76 million in 2019, marking a growth rate of 4.82%. Poultry showed a remarkable growth of 16.81%, rising from 729.21 million to 851.81 million during the same period. The overall positive trends in the total livestock population and significant expansion in the poultry sector.

Table 1: Livestock and Poultry Population

Sl. No.	Species	19th Livestock Census 2012 (no. in millions)	20th Livestock Census 2019 (no. in millions)	Growth Rate (%) 2012-19
1	Cattle	190.90	193.46	1.34
2	Buffalo	108.70	109.85	1.06
3	Yaks	0.08	0.06	-24.90
4	Mithun	0.30	0.39	29.52
Total Bovines		**299.98**	**303.76**	**1.26**
5	Sheep	65.07	74.26	14.13
6	Goat	135.17	148.88	10.14
7	Pigs	10.29	9.06	-12.03
8	Other animals	1.54	0.79	-48.70
Total Livestock		**512.06**	**536.76**	**4.82**
9	Poultry	729.21	851.81	16.81

Source: Annual Report (2022), Department of Animal Husbandry, Dairying and Fisheries, MoAFW, GoI.

Better Nutrition and Health benefits from Livestock:

We recognize a profound connection between Sustainable Development Goal (SDG) 2 – aiming to eradicate hunger, achieve food security, and enhance nutrition through sustainable agriculture and SDG 3 – striving for universal access to good health and well-being across all age groups. The sustained availability of ample of nutritious food is integral for individuals to establish and uphold good health. Conversely, maintaining good health is crucial for individuals to derive optimal benefits from the food they can obtain.

Animal-derived foods like milk, meat, and eggs play a pivotal role in nutrition and health. They offer a diverse range of nutrients, energy, and protein. Currently, livestock contributes about 26% of the proteins and 13% of the calories in human diets. These animal-sourced foods are abundant in essential micronutrients (such as vitamin A, vitamin B12, riboflavin, calcium, iron, and zinc), which play a critical role in sustaining the health of women of child bearing age and in the physical and cognitive development of children (Varijaksha *et al.* 2019). Hence, livestock can serve as a channel to address nutritional challenges, aligning closely with the objectives of SDGs 2 and SDGs 3.

Better sustainable Environment

Livestock production, like many economic activities, generates various externalities—unintended consequences affecting third parties who are not directly involved in the production process.

Positive Externality

Livestock often face criticism for their perceived environmental impact. However, in India's mixed farming systems, livestock play a crucial role in conserving natural resources through their symbiotic relationship with crop cultivation. Conservation of land through the recycling of agricultural by-products as animal feed and the use of dung-cake as domestic fuel. Reduction in the need for chemical fertilizers by utilizing dung as a natural and organic fertilizer. Mitigation of carbon dioxide emissions by employing animal energy in agricultural activities. The estimated land conservation from the livestock production system, achieved through recycling crop by-products as animal feed and using dung as domestic fuel, is approximately 42 million hectares. The use of dung as a natural fertilizer contributes to the conservation of 1.2 million metric tons of soil nutrients. Substituting animal energy for mechanical energy has the potential to save approximately 13 million metric tons of diesel consumption and reduce greenhouse gas emissions associated with diesel combustion. This highlights the positive role of livestock in India's mixed farming systems in achieving sustainable and resource-efficient agricultural practices (Dikshith *et al.* 2013).

Negative Externality

Negative externalities from livestock production are profound, particularly in greenhouse gas emissions and soil erosion. Livestock and their by-products contribute to 51% of global greenhouse gas emissions, emitting approximately 32,000 million tons of carbon dioxide annually. Methane, released significantly by livestock, is 25-100 times more destructive than CO_2 within a 20-year timeframe. Additionally, livestock is accountable for 65% of human-related nitrous oxide emissions, a greenhouse gas with 296 times the global warming potential of CO_2. Soil erosion, exacerbated by commercialised livestock production, overgrazing and monoculture farming practices, driven by the demand for livestock feed, further intensify environmental degradation (Han *et al.* 2022). The anticipated 80% increase in agricultural emissions by 2050 poses a serious threat. These concerns underline the urgent need for sustainable agricultural practices to mitigate environmental damage.

Conclusion

The comprehensive transformation of livestock and agri-food systems hinges on three crucial components: optimizing livestock production, enhancing the nutritional quality of animal sources, and fostering a sustainable environment. By focusing on these pillars, we can aspire to create a balanced and resilient system that not only meets the demands for food but also promotes the well-being of both humans and the planet. We can mitigate the negative impacts of current systems while maximizing positive outcomes. Embracing these principles will contribute to a future where agriculture thrives in harmony with the environment, ensuring both food security and ecological sustainability.

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ENHANCING AGRICULTURAL PRODUCTIVITY THROUGH THE USE OF NANOPESTICIDES: A COMPREHENSIVE OVERVIEW

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Abstract

Nanopesticides represent a cutting-edge innovation in agricultural technology, offering a promising solution to optimize pest control strategies and improve overall crop productivity. By leveraging nanoscale materials and formulations, these novel pesticides exhibit enhanced efficacy, reduced environmental impact, and targeted delivery mechanisms. This study explores the current state of nanopesticide research, highlighting key advancements, potential benefits, and challenges associated with their application in agriculture. As we delve into the intricate world of nanotechnology, the potential for transforming pest management practices and sustainable crop production becomes increasingly apparent. This study sets the stage for a comprehensive examination of nanopesticides, emphasizing their role in shaping the future of modern agriculture.
Keywords: Nanopesticides, Pest control, Agriculture, Nanotechnology.

Introduction

There has been a surge in research on nanotechnology in agriculture, with plant protection products gaining more interest than nanosensors and fertilizers. Agrochemical innovation commonly protects crop areas from pests like infectious agents, hazardous pests, and infected plants that threaten crop yield and efficiency. This involves detecting soil and plant viability, as well as monitoring livestock and aquaculture products. However, the unregulated use of pesticides sprayed against harmful pests and insects has significantly impacted production, encouraging resistance to pathogens and insects, and increasing the need for new agrochemicals. It has also accelerated the disruption of environmental balance. Nanopesticides are an emerging technical advancement in agriculture that employs nanomaterials to enhance the delivery of pesticides, resulting in improved efficacy and decreased environmental consequences.

This innovative approach focuses on creating active chemicals at the nanoscale level and their formulation and delivery. The research in this field includes investigating the interaction between insects and nanoparticle substances, incorporating active ingredients into nano-emulsions and dispersions containing pesticides, and developing novel nanopesticides that use nanomaterials as active agents or transporters for delivery. A thorough research is being conducted on nanopesticides with the aim of overcoming the limitations of current pest control methods. This study intends to develop innovative nano-based products that can efficiently target pests, persist in the natural environment, and have no adverse effects on non-target organisms. Additionally, the products should be economically feasible.

Polymer-based nanoformulations

Polymer-based nanoformulations are a potential strategy for creating nanopesticides. These nanopesticides are designed to enhance the effectiveness of pesticides while minimizing their effect on the environment. The polymer components employed in these formulations can be either synthetic or natural and may be shaped into a variety of three-dimensional structures, such as small capsules, nanospheres, micelles, nanofibers, electrospun nanofiber and nanogels. These nanoparticles have the potential to improve the longevity of pesticides, reduce their toxicity, and control their dispersion rates. However, developing these nanopesticides is a challenging task, as it requires innovative analytical methods to confirm their effectiveness in practical situations. Moreover, additional research is necessary to develop standardized protocols for expanding the synthesis of polymeric nanocarriers for commercial purposes.

Nanoemulsions

Nanoemulsions are a unique type of nanopesticide composition that shows great promise in the agricultural sector by providing safe, environmentally friendly substitutes to traditional agrochemicals with diverse impacts on the ecosystem and organisms. They consists of emulsions with droplets that are in the nanometer range. Nanoemulsions consist of tiny droplets (between 20–500 nm) containing an oil phase within an aqueous phase, offering advantages such as increased surface area, better solubility, and enhanced stability. They enable the targeted delivery of hydrophobic pesticides, improving their efficacy while minimizing negative environmental impacts. Research indicates that nanoemulsions can lead to better kinetic stability, higher solubility, and faster dissolution of pesticides, ultimately contributing to more sustainable agriculture practices. They are classified into different types such as oil-in-water, water-in-oil, and bi-continuous nanoemulsions. These nanoemulsions are created to carry active ingredients, improve pesticide stabilization, bioavailability, and targeted delivery. The potential applications of nanoemulsions in pest management have been explored, including their utilization in tea pest control. Research on nanoemulsions loaded with pesticides has been an essential area of study, highlighting both their advantages and the drawbacks linked to their implementation.

Nanogel

Nanogels are small molecules produced by mixing a hydrogel with a cross-linked hydrophilic polymer. Various pharmaceutical sectors have utilized these systems for drug delivery due to their immense potential. However, there is limited research on the utilization of nanogels as nanopesticides.

The study was published in Scientific Reports, highlighting the effectiveness of pheromone used in nanogels in controlling fruit pests. The study demonstrated that the process of trapping and fixing methyl eugenol (ME) within the intricate three dimensional nano sized fibrillar structure with fiber diameter between 100- 200 nm effectiveness reduced the evaporation of ME from the nanogels in comparison to using ME alone. The nanogel shown to thermal, chemical and mechanical stability, and the long lasting effectiveness of the pheromone within the nanogel enhance its utility.

Electro spun nanofibers

Electrospun nanofibers have shown tremendous promise in the manufacturing of nanopesticides. They have the capacity to include functional nanoparticles, which allows for regulated release mechanisms and increased bioactivity. Electrospinning is a cost-effective and scalable process that enables bulk manufacturing of nanofibers with diameters ranging from tens of nanometers to several micrometers.

Functional nanoparticles are easily incorporated into the surface of electrospun nanofibers, which allows for the development of nanopesticides with specific releasing properties. In addition to other methods, electrospinning allows for better control over the distribution of nanoparticles along the length of the nanofibers, potentially resulting in more homogeneous nanopesticide products. Nanoparticles on electrospun nanofibers improve the surface area for interaction with target species, thereby improving the efficacy of nanopesticides. Sustainability is also a key factor, as nanoparticles form spontaneously on electrospun nanofibers, eliminating the requirement for post-processing. This simplifies production and minimizes waste.

Table 1. Different types of nanopesticides and their examples

Type of nanopesticides	Examples
Nanoemulsions	Glyphosate Neem oil Permethrin
Polymer based on	Polyethylene glycol Beta-cyfluthrin Carbofuran Acephate
Nanogel	Pheromones Essential oil Copper
Electrospun nanofibers	Thiamethoxam Coated liposomes
Other polymers	Emamectin Lansiumamide B

Nanopesticides employ various strategies to achieve controlled release, including:

Stimuli-responsiveness: Nanoparticles respond to external cues such as temperature, light, pH, or humidity, releasing the active ingredient (AI) upon encountering specific condition.

Encapsulation: Active ingredients are enclosed within polymeric matrices, liposomes, or other carriers, allowing gradual release over time.

Self-organizing systems: Systems like liposomes, dendrimers, and metallic nanoparticles provide sustained release capabilities.

These approaches lead to longer-lasting protection, fewer applications, and reduced environmental pollution.

Challenges and Considerations

Despite the numerous benefits offered by nanopesticides, several challenges must be addressed to ensure their safety and environmental sustainability:

- Potential toxicity differences between nanopesticides and their bulk counterparts.
- Unpredictable transformations in the environment, affecting the toxicological profiles of nanopesticides.
- Limited understanding of the long-term ecological consequences of nanopesticides.
- Cost implications associated with developing and implementing nanopesticide technology.
- To address these issues, researchers emphasize the importance of conducting thorough risk. assessments before introducing nanopesticides to the market.

Conclusion

Nanopesticides represent a significant advancement in modern agriculture, offering safer, more sustainable, and highly effective solutions for managing pests and diseases. By leveraging the unique properties of nanomaterials, scientists aim to create a new generation of "smart" pesticides that will revolutionize global farming practices.

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INNOVATIVE DAIRY SOLUTIONS: UNVEILING THE POTENTIAL OF DESIGNER MILK FOR PERSONALIZED NUTRITION AND HEALTH ENHANCEMENT

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Abstract

Milk, a natural complete food, is evolving to meet modern health-conscious demands. This article explores the concept of designer milk, where genetic modifications, advanced farming practices, and biotechnology converge to enhance nutritional properties. With applications spanning dietary and health benefits, including improved fatty acid profiles and reduced lactose content, designer milk emerges as a promising solution. The article also delves into nutritional alterations, emphasizing the positive impact on human health. Ultimately, designer milk offers a proactive approach to nutrition, contributing to overall well-being.

Introduction

Among all the foods available, milk is a natural complete and balanced food, which is a rich source of fat, protein, essential vitamins and minerals. In particular, milk is a good source of calcium that is very much essential for the prevention of bone disorders such as osteoporosis and it is also necessary for the growth and development of new born young one, growing children's.

In modern era consumers are very much aware about their health. So, the demand of functional foods is increasing day by day at a global level. The optimistic views of increasing demand of Functional foods are also supported by number of institutions and health related organizations such as the American Dietetic Association.

To compete with the today's demand of human beings, milk has to be designed in such a way, which increases its properties according to the need of the changing scenario. Designer or enriched milk are those in which the content has been modified from the standard constituent of milk.

Designer milk will give improved and value-added products naturally with improved neutraceuticals to meet the requirement of new generations. Now a day's biotechnologists have identified genetic markers in cows for disease or desirable traits such as milk fat synthesis.

So future perspective cow will produce low milk fat naturally, which can be achieved through combination of traditional genetics, marker assisted selection and genetic modification of dairy cattle and by farm and feed management. From Human Health point of view some of the desirable improvements are:

a. Increased proportion of unsaturated fatty acids and low-fat milk and its products
b. Low lactose content
c. Complete absence of b-lacto globulin from milk. Such type of milk may be classified as humanized milk, milk with high therapeutic purpose.

Applications of Designer Milk

The applicability of designer milk can be classified into two categories i.e. in diet and human health measures as well as in processing/technological developments. Among applications of designer milk in diet and human health is that it generates a greater proportion of Unsaturated Fatty Acids (USFA) in milk fat, reduced lactose content that benefits lactose intolerant individuals and removal of β-lacto-globulin from milk. However, it applicability in processing and technological developments includes alteration of primarystructure of casein to improve technological properties of milk, production of high-protein milk, accelerated curd clotting time for cheese manufacturing, increased yield and/or more protein recovery, milk containing nutraceuticals and replacement for infant formula etc.

Relation between Nutrition and Health

In order to strengthen the immune system for the prevention of various diseases and thereby to improve health, dietary strategies may be effective alternatives. In western and developing countries, consumption of milk and dairy products is increasing, but milk fat contains lauric, myristic and palmitic acids that increase the level of cholesterol, so it has a poor health impact, but some milk components such as conjugated linoleic acids, butyric acids and n-3 polyunsaturated fatty acids have health benefits and participates in chronic disease prevention. Whey proteins of milk also contain good amount antimicrobials, such as lactoferrin, lactoperoxidase, lysozyme, and immunoglobulins. Casein protein, vitamins A, E, K and D, probiotics, different minerals (calcium, phosphate, potassium, magnesium, chloride) and energy are also present in milk.

Nutritional Alterations to Produce the Designer Milk

Less than 10% polyunsaturated fatty acids, less than 8% saturated fatty acids and more than 82% monounsaturated fatty acids are the ideal milk fat for human wellbeing. At different stages, the milk components may be altered.

Rumen microbiota is the source of bioactive fatty acids in ruminants, which are incorporated into animal milk and meat. Dietary ingredients have an effect on milk composition of animals. Altering the composition of milk by dietary interventions is feasible.

The proportion of potentially safe milk fatty acids, oleic acid, vaccenic acid, rumenic acid, alpha-linolenic acid, and total polyunsaturated fatty acids increased in the diet of lactating cows by supplementing canola, soybean oil and linseed rich in alphalinolenic acid.

In general, ruminant foods contain Polyunsaturated Fatty Acids (PUFAs), but ruminant products such as meat or milk contain saturated fatty acids and certain quantities of Conjugated Linoleic Acid (CLAs).

This is due to the lipolysis of microbial enzymes and the bio-hydrogenation of rumen Polyunsaturated Fatty Acids (PUFA). The main rumen-grown bio- hydrogenation bacteria are Butyrivibriofibrisolvens. Manoeuvring the rumen environment creates opportunities to alter the lipid composition of meat and milk by modifying the disposition of intramuscular and mammary tissue Fatty Acids (FA) for absorption.

Various probiotics or microbial feed supplements favourably alter lipid metabolism and modify milk composition. Phytometabolites such as tannins, polyphenol oxidase, essential oils, fatty acid oxygenation and saponins have various effects on the composition of the milk and increase the consistency of the milk.

Pastured cow milk has a higher ratio of Essential Fatty Acids (EFAs) and grass-fed cow milk has higher conjugated linoleic acid than grain-fed animal milk. A varying number of microbiota or microbial metabolites of the rumen may also alter the composition of the milk.

As the fatty acid composition of rumen microbiota is changed by the grazing regime, it can be used to change rumen microbial populations, thus changing the milk fatty acid profile. With the dietary addition of fish oils or fish meal, changes in milk fat concentration of Conjugated Linoleic Acid (CLA) are also observed.

Benefits of Designer Milk

Eating designer milk has several health benefits that are:

1. Reduce the problem of lactose intolerance by decreasing the lactose level in designer milk
2. By increasing omega- fatty acids in the designer milk lower the risk of cardiovascular disease, autoimmune disorders, allergies, obesity, and diabetes
3. By minimizing saturated fats in the milk, lowering the incidences of obesity, cholesterol l levels, and cardiovascular diseases
4. By altering protein contents, increasing casein to obtain an increase in cheese yield
5. Phytosterol-enriched vitamin A milk decreases serum levels of triglycerides, low-density lipoprotein cholesterol, and apolipoprotein-B that have a detrimental effect on health.

Conclusion

In the pursuit of optimal nutrition, designer milk emerges as a groundbreaking solution. By leveraging genetic advancements and nutritional alterations, it addresses contemporary health concerns. The applications of designer milk extend beyond dietary benefits, influencing processing and technological developments in the dairy industry. The nuanced modifications result in reduced lactose, improved fatty acid profiles, and enhanced health outcomes. Embracing designer milk signifies a pivotal shift towards personalized nutrition, offering a multifaceted approach to promote well-being and cater to the evolving needs of consumers.

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KNOW HOW THE EFFECT OF THE SMALL QUANTITY OF NANO UREA IS COMPARABLE WITH THE HIGH QUANTITY OF CONVENTIONAL UREA

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Abstract
Sustainableagriculturedemands minimal useofagrochemicals. Nano-fertilizers offer sustainable and profitable remedies to modern agriculture practices while restricting the use of chemical fertilizersby offering several advantages, such as improved efficiency, reduced waste, and increased nutrient uptake by plants. These smart fertilizers have significantly contributed towards efficient and eco-friendly approaches in crop productivity, nutrient penetration and soil fertility.The results ofthe on-station and on-farm IFFCO Nano urea trials clearly indicated the possibility of reduction in the doses of nitrogen to the extent of 25 to 50% in different crops under varying agro-ecological conditions.

Introduction
Natural source of nutrients like organic manures and external source of nutrients, viz. fertilizers, are considered as the two eyes in plant nutrient management in which fertilizers hold the centre of attraction in recent years for enhancing the agricultural production. However, their nutrient use efficiency is still very low due to numerous pathways of losses such as leaching, denitrification, microbial immobilisation, fixation and runoff. Nanotechnology is a novel, innovative and interdisciplinary scientific approach that involves the design, development and application of materials and devices at molecular level in nanometre scale (one billionth of a meter)ie. at least onedimension ranges in size from 1 to 100 nanometres (nm). They are capable of providing targeted delivery of nutrients to specific plant tissues, resulting in improved plant growth and higher yields.

The studies indicate that foliar applied nanomaterials can pass through physical barriers in plants and potentially achieve higher agent delivery efficiency compared to conventional agrochemical application techniques.Nanoparticle size also plays a role in their distribution in different plant organs after foliar application.The smaller size of star polymers may favour their phloem unloading into nonvascular tissues of leaves, thereby favouring their distribution to younger and older leaves, while the large size polymers may inhibit phloem unloading and phloem to xylem exchange, leading to greater accumulation of the larger star polymer in roots. The synthetic polymer nanocarriers demonstrated high foliar uptake and good translocation and cell uptake. This paper highlights how the efficacy of the small quantity of nitrogen applied through IFFCO Nano Urea, which is the first of its kind in the world, is comparable with so high quantity of applied nitrogen through urea.

Traditional Fertilizers vs. Nanofertilizers
In conventional method offertiliser application, a meagrefractiononlyreachestothetargetsite and the remaining portions, ie. 40–70% of nitrogen, 80–90%of phosphorus, 50–90% ofpotassium and

more than 95% of micronutrient content of appliedfertilizers, are lost in theenvironment and causes substantial economic losses. The encapsulation technique innanofertilizers helps in reducing the nutrient loss rate significantly incurring through volatilization, leaching, denitrification, run off, fixation and eutrophication, so the wastage of nutrients and thus prevent undesirable nutrient load 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.

Nano fertilizers (NFs), on the other hand, consist of particles that are much smaller in size and are designed to penetrate plant tissues and deliver nutrients directly to cells. Nanoparticles have small size, large surface to volume ratio, higher chemical reactivity, enhanced solubility and unique magnetic and optical properties. The encapsulation technique innanofertilizers helps in reducing the nutrient loss rate significantly.

This targeted delivery system ensures that nanotechnology-based fertilizers due to their controlled and targeted delivery mechanism can improve the crop productivity by enhancing the seed germination, improved nutrient use efficiency and in turn improved plant growth and higher yields.In addition to their ability to deliver nutrients, NFs can also help plants resist environmental stressors causing abiotic and biotic stresses by activating plant defence mechanisms.Because of these specialities NFs have the potential to reduce environmental pollution and thus reduce the costs for environmental protection. Apparently, NFs minimize over accumulation of salt in soil as they are required in small amount. Nano fertilizers can be applied to plants through various methods, including foliar spraying, seed coating, and root dipping**.** NFs (Nano Urea) offer several advantages over traditional fertilizers as presented below.

Benefits of Nano Frtilizers

Solubility and Dispersion of Mineral Nutrient : The bioavailability of thenutrient applied through conventional fertilizers can be enhanced byreducing theirsize, shape and soluble nature as Nanofertilizers. NFs have comparatively higher solubility and diffusion that impart superiority over fertilizers. The miniature size, high specific surface area and high reactivity of NFs increase the bioavailability of nutrients. NFs can deliver nutrients more effectively and efficiently than traditional fertilizers, resulting in reduced waste and improved plant growth.

Controlled and Prolonged Release of Nutrient: Nano encapsulated slow andcontrolled release fertilizers supplythe nutrients in precisely controlledmanner over a period of time andimprove the nutrient use efficiency Surface coatings ofnanomaterials on fertiliser particleshold the material more strongly dueto higher surface tension than theconventional surfaces and thus helpin controlled release ofnutrients for prolonged period ofplant growth, which not onlyfavour for better yield but alsoreduce the loss of nutrients and inturn reduce the environmentalpollution. 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. The slow or controlled releasenanostructured formulations arebest for controlled release ofnutrients for prolonged period ofplant growth, which not onlyfavour for better yield but alsoreduce the loss of nutrients and inturn reduce environmentalpollution. 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. Smart release of N from nano-ureaimproved photosynthesis by acquiring sufficient light-harvesting chlorophyll-protein complexes and also did not cause any stress in the crops resulting in the enhanced growth and ultimately yield (Babuetal. 2022). Nano-urea discharges nutrients in 40–50 days and it is applied on the leaves instead of soil; whereas conventional urea is applied in soil and discharges nutrients in 2–7 days (Seleiman et al. 2021, (Kumar et al. 2021a),). Nano-ureareleasesnitro-gen 12 times slower than urea and thus is available for functional metabolic interaction for alonger time and this can be one of the reasons for increased grain yields (Saurabh et al. 2019).

Targeted delivery*:* The small size of nanoparticles allows them to target specific plant tissues and deliver nutrients where they are needed most. 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 chemical fertilizers. Benefits of IFFCO Nano Urea over Conventional urea and Nutrient absorption and uptake benefits of IFFCO Nano Urea over Conventional urea are being displayed in **Fig. 1** and **Fig, 2**, respectively.

According to nano experts, the size of one molecule of nano urea is equal to 0.7 nano meters or 7 angstroms. Nano urea is customized as per requirement by encapsulation through nano technological intervention due to which the average size of the prepared nano urea aggregate is very small or say 25 nano meters. But urea molecules usually exist in aggregate form. Due to continuous aggregation of granular urea molecules, the average size of a urea aggregate is 10,000 nano meters.Thus, it is clear that the size of an aggregate of nano urea is 400 times (10000 divided by 25) smaller than that of an aggregate of granular urea. Thus, when foliar spraying is done at a given time, 400 molecules of nano urea aggregates are available for reaction on the leaf surface, whereas when granular urea is used in the soil, only one urea aggregate is available for reaction in the root zone of the crop. Further, nano nitrogen increases and induces some mechanisms which increases amino acids/protein content (~ 18-20% N), chlorophyll content (~7-8% N), Nucleic acid (~5-8% N) in the plants. Thus, it increases N uptake. Apart from other benefits, Nano nitrogen due to its unique nanoscale characteristics help activating several paths so enhancing nitrogen balance to ensure requisite N content (2.5-3.7%) in the plant tissues as well as in the edible part. Nano urea also acts as a bio-stimulant and helps increasing the yield, protein and chlorophyll contents in plants compared to those fertilized with conventional urea.

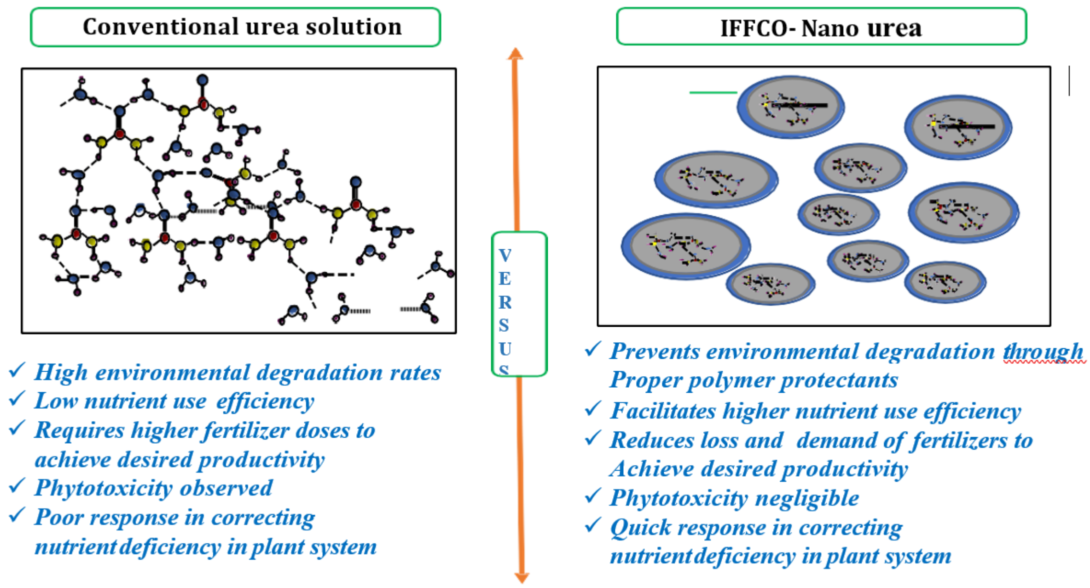

Fig.1. Benefits of IFFCO Nano Urea over Conventional urea

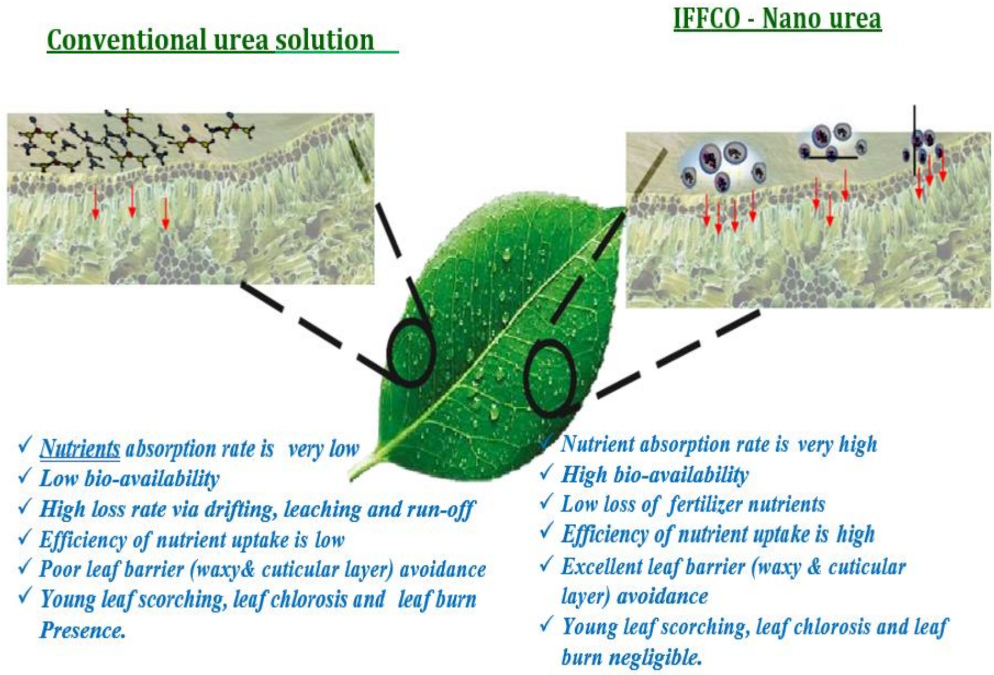

Fig. 2. Nutrient absorption and uptake benefits of IFFCO Nano Urea over Conventional urea

Improved efficiency : The conventional fertiliser sources of macro and micronutrients are lost via leaching, fixation, volatilisation and microbial mineralisation, so the nutrient use efficiency and uptake ratio will be poor. Apparently, in conventional fertilizers, we could not avert the loss of nutrients due to the sudden burst of nutrient release at once either may through soil or foliar. Not only can create the problem for plant growth and yields due to poor nutrient use efficiency and toxicity effects but also give the high impacts on economic and resource losses, environmental pollution and ecological balance of soil. Nano encapsulated slow and controlled release fertilizers supply the nutrients in precisely controlled manner over a period of time and improve the nutrient use efficiency. Nanofertilizers are coated or loaded with the nanosized polymers, clay minerals and metal oxides. Surface coatings of nanomaterials on fertiliser particles hold the material more strongly due to higher surface tension than the conventional surfaces and thus help in controlled release.

Mobilize Other Native Nutrients: NFs, asaresultoftheir unique properties, influence metabolic activities of the plant to different degrees compared to conventional materials and have the potential to mobilize nativenutrientsintherhizosphere and thus help towards balanced nutrition.

Nutrient uptake efficiency **:** The conventional fertiliser sources of macro- and nutrients arelost via leaching, fixation, volatilisation and microbial mineralisation, so the nutrient use efficiency and uptake ratio will bepoor. The nanotechnology-based fertilisercan help to increase the nutrient use efficiency and uptake ratio because of the smaller size of the particle that can easily penetrate into the root andleaf cuticular cells through soil and foliar applications, respectively.

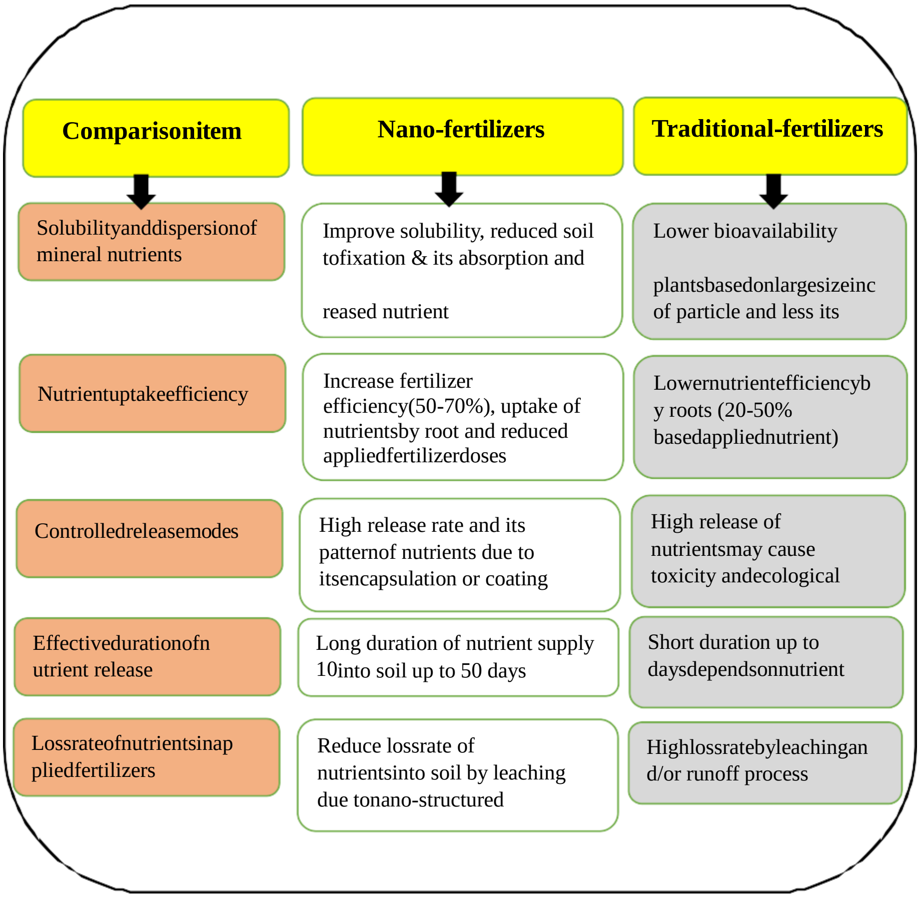

Fig.1. A comparison between traditional fertilizers and nano fertilizers.
Source: Adapted from Fassbender et al. (2022)

Moisture Retention : 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.

Biotic and Abiotic Stresses *:* Warmer temperatures over time are responsible for climate change which in turn changing weather patterns and disrupting the usual balance of nature. The direct and indirect effects of climate change are causing intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms and declining biodiversity. drought, water logging, extreme temperatures (cold, frost and heat), salinity and mineral toxicity, biotic and abioticstresses, which negatively impact growth, development, yield and produce quality of crops and the environment. NFs facilitate the crop plants to fight various biotic and abiotic stresses. Nanofertilizers have a great ability to mitigate the abiotic/biotic stresses on cultivated plants through many mechanisms because of their vast surface areas and their nanoscale size. Nanofertilizers can improve the morphological, biochemical, and physiological indices of cultivated plants, such as the photosynthetic rate and its efficiency, the nutrient uptake efficiency, the regulation of phytohormones, and the enhancement of the plant defense system (Verma et al., 2023) (**Fig.3**).

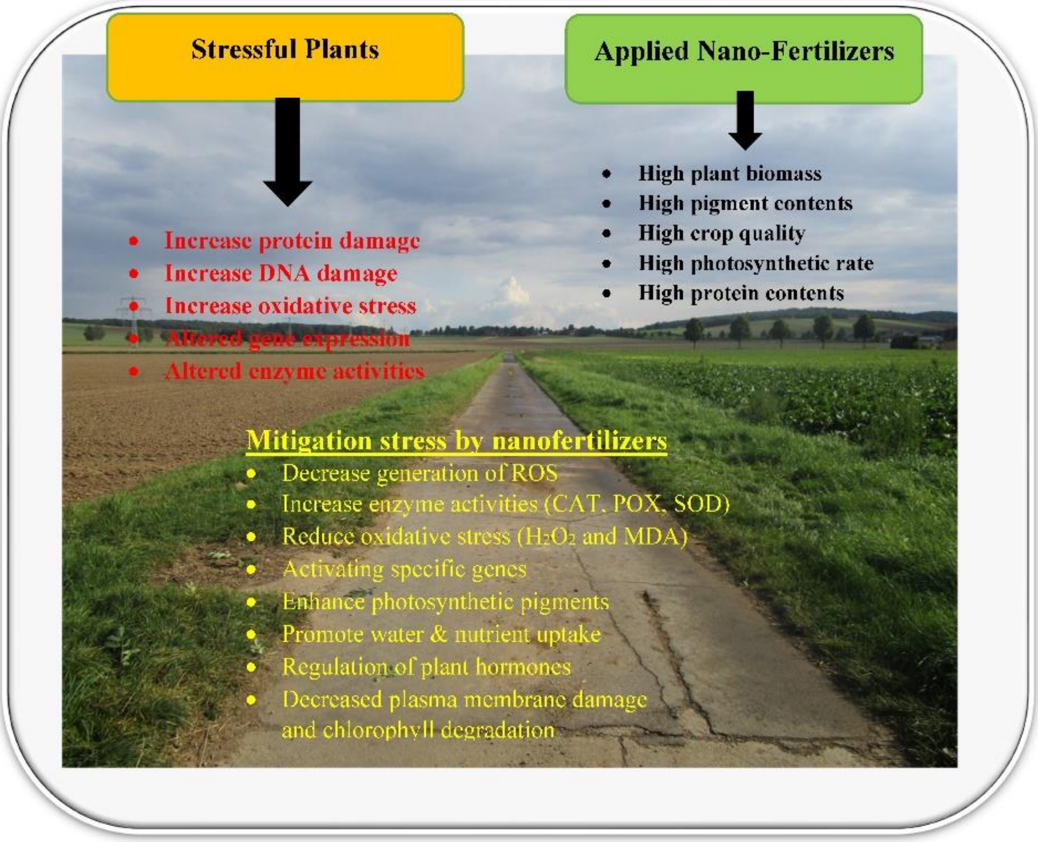

Fig.3. The main problems that result from stresses on plants, the expected roles of applied nanofertilizers, and the different mechanisms of the mitigation of stress on cultivated plants by nanofertilizers. ROS: reactive oxygen species; CAT: catalase; POX: peroxidase; SOD: superoxide dismutase; MDA: malondialdehyde.
(Source: Verma et al. (2023).

Weed Control : In a foliar application mode, the smaller weeds get less nutrients so the growth of weeds is automatically suppressed. The foliar application of NFs is much better and preferred than the soil application of NFs due to its significant enhancements in the growth, physiological and biochemical traits, yield, and quality of crops-particularly in smart agriculture.

Transportation **:** NFs required in small amount which reduce the cost of transportation.

Production costs: The production cost of IFFCO Nano Urea being less, so it is cheaperthan conventional urea.

Government Subsidy : The price of IFFCO Nano Urea is Rs. 225 per bottle of 500 ml without any subsidy while the price of urea is higher and variable which huge amount of subsidy being provided by the Government to make the price of urea affordable to the farmers.

The IFFCO Nano Urea

IFFCO Nano Biotechnology Research Center (NBRC) at Kalol, Gandhinagar, Gujarat is doing R&D addressing the current and futuristic challenges in plant nutrition for advancing sustainable and precision agriculture through innovative Nano fertilizers. The NBRC in the recent past, had developed three patented products, Nano Nitrogen, Nano Zinc and Nano Copper based on

nanotechnology for their on-station and on-farm testing with various crops across the country representing different agro-ecological conditions in collaboration with ICAR institutes and the State Agricultural Universities and also KVKs through IFFCO's field executives. Through the IFFCO's research initiative, it was observed that use of these nanotechnology-based products (Nano Nitrogen, Nano Zinc and Nano Copper), farmers can reasonably reduce the quantities of their counterpart conventional chemical fertilizers. In the recent past, IFFCO Nano urea (liquid) and Nano DAP (liquid) have been included in Fertilizer Control Order and are available in the market.
IFFCO introducednano urea (liquid) to address low or declining use efficiency of nitrogen.Nano urea contains nanoscale nitrogen particles (18-30 nm) which have moresurface area (10,000 times over 1 mm urea prill) andnumber of particles (55,000 nano urea – liquid (Nanonitrogen) particles over 1 mm urea prill by mass volume). Nanourea–liquid (nanonitrogen) particles with pore size (20 nm) can easily penetrate through cell wall and reach up to plasma membrane. Large size particles (20-50 nm) can penetrate through stomatal pores. These are also transport edviaphloem cells through plasmodesmata (40 nm diameter) toother plant parts. These can bind to carrier proteins through aquaporin, ion channels, and through endocytosis and metabolized inside the plant cell. Primary aim of nano-zinc and nano-copper nanofertilizers is to substitute their conventional fertilizer ana logues which have use efficiency between 2-5%, increase crop productivity, and enhance its quality through agronomic fortification.

The Nano urea –liquid (Nano Nitrogen) utilizes the dynamics of shape, size, surface area and better assimilation. Its application enhances plant metabolic processes, promotes meristematic activities; ensures higher apical growth and leaf photosynthetic area, triggers enzymes, and induces mechanisms/pathways inside the plant for achieving the desired N levels in amino acids/protein content, chlorophyll content, nucleic acid, photosynthates, etc. Precise and targeted application of nitrogen through foliar application of nano urea–liquid (nanonitrogen) reduces urea losses; increases nutrient uptake efficiency; and addresses environmental issues of soil, air and water pollution.

The IFFCO Nano Urea meets the mandatory specifications as per FCO gazette notification, Government of India (Adidam N, Kumar A (2021). As per Clause 20 D (7) of FCO, GoI, the IFFCO provides to the Central Government (India) a test report of each batch from its National Biotechnology Accredited Laboratory before distribution or dispatch of Nano Urea. It is tested for structural, morphological, chemical properties, release kinetics, dissolution dynamics etc. which are in confirmation to Department of Biotechnology (DBT) Govt. of India *"Guidelines for Evaluation of Nano-Based Agri-Input and Food Products In India-2020"* which follows OECD protocols and harmonised with International guidelines (DBT-2020).

Nano-urea boosts speedy nutrients availability to growing plant parts, ensuing increaseddry matter accumulation, chlorophyll production, plant growth, development (data notreported) and yield. Nitrogen is an important structure of chlorophyll and higher N contentcan positively influence chlorophyll biosynthesis (Sun et al. 2020) which in turn can reflect as increased photosynthesis and subsequent increase in dry matter accumulation, this can explain theincreased yield seen in the foliar applied Nano N treatment. The enhancement in the crop yield is possibly due to the synchronous release of N from the nano-urea following the demand of the crops (maize, wheat, pearl millet and mustard). Smart release of N from nano-urea improved photosynthesis by acquiring sufficient light-harvesting chlorophyll-protein coplexes and also did not cause any stress in the crops resulting in the enhanced growth and ultimately yield (Babuetal.

2022). Nano-urea discharges nutrients in 40–50 days (Kumar et al. 2021a), and it is applied on the leaves instead of soil; whereas conventional urea is applied in soil and discharges nutrients in 2–7 days (Seleiman et al. 2021). Leaching and volatilization accounts more than 70% of applied conventional urea and leaving only <20% (Kahri et al. 2010) readily available for plants growth. Nano-urea releases nitrogen 12 times slower than urea and thus is available for functional metabolic interaction for alonger time and this can be one of the reasons for increased grain yields (Saurabh et al. 2019).

IFFCO Nano urea applied through foliar sprays (first at 30th day and second at panicle initiation stage) with half quantity of nitrogen applied by the farmer helped meeting N requirement of the crop plants at 30-50% lower dose of urea after correcting other existing nutrient deficiencies and considering all cumulative benefits of Nanoparticles as mentioned in foregoing paragraphs. The results of these investigations helped establishing beneficial effect of application of IFFCO Nano urea on plant growth and yield of over 20 different crops (cereals, pulses, oilseeds, spices, vegetables and fruit crops) tested in different agro-ecological zones across the country. Similar strategies were adopted to confirm the efficacy of IFFCO Nano DAP (liquid) and it was found that seed/seedling treatment with IFFCO Nano DAP @5ml/litre water at sowing/transplanting and one foliar spray of this @ 4 ml/liter at 30th day of sowing/transplanting could help reducing 25 to 50% of conventional DAP.

It is important to mention here that many times, when farmers compare the colour of the crops fertilized with conventional urea and that with Nano Urea (liquid), there may be slightly darker colour with conventional urea as compared to the optimistically desired colour with IFFCO Nano Urea (Liquid) merely due to very quick conversion of all the amide nitrogen into nitrate form which is much beyond the need of the crop at that stage and thus it is only partly utilized by the crop and remaining amount may be lost due to volatilization after broadcasting and through leaching and denitrification under unfavourable weather and soil-water conditions. NFs can deliver nutrients more effectively and efficiently than traditional fertilizers, resulting in reduced waste and improved plant growth through increased nutrient use efficiency.

Field Evaluation

Multi-location multi-cropon-stationandon-farm trials of IFFCO nanofertilizers were conducted for studying the impact of these fertilizers on sustainability of crop production, nutrient use efficiency, and farmers' profitability (**Picture 1**). On-station and on-farm trials have been undertaken by IFFCO for last more than 4 seasons on 13 crops at 43 locations (on-station) and 11,000 trials on 94 crops across 21 states (on-farm) since 2019 and continued during2021-22 in all the agro-ecological regions of India. Treatments were varied as per the research program of IFFCO and the participating institute(s), depending upon the crop N requirement and testing facilities available at the research institutes.

As example, a fixed plot field experiment was conducted at ICAR-IARI Research Farm to assess the economic and environmental competency of conventional fertilizers with and without nano-urea (novel fertilizer) in two predominant crop-ping systems *viz*., maize-wheat and pearl millet-mustard under semi-arid regions of India. Result indicates that the supply of 75% recommended N with conventional fertilizer along with nano-urea spray (N_{75}PK + nano-urea) reduced the energy requirement by ~8–11% and increased energy use efficiency by ~6–9% over 100% nitrogen through prilled urea fertilizer(business as usual). Furthermore, the application of N_{75}PK + nano-urea exhibited ~14% higher economic yields in all the crops (maize, wheat, pearl millet mustard) compared with $N_{50}PK$ + nano-urea. Application of $N_{75}PK$ + nano-urea registered comparables oil N and dehydrogenase activities (35.8 µg $TPFg^{-1}$ $24hrs^{-1}$ across all crops over the conventional fertilization ($N_{100}PK$). This indicates that application of foliar spray of nano-urea with 75% N is a soil supportive production approach. More interestingly, two foliar sprays of nano-urea curtailed nitrogen load by 25% without any yield penalty, besides reducing the green house gases (GHG) emission from 164.2 to 416.5 kg CO_2-eq ha^{-1} under different crops. Therefore, the application of nano-urea along with 75% N through prilled urea is an energy efficient, environmentally robust and economically feasible nutrient management approach for sustainable crop production. The results of various other Institutes clearly indicated the possibility of reduction in the doses of nitrogen to the extent of 25 to 50% with application of IFFCO Nano urea in different crops under varying agro-ecological conditions.

The IRRI-ISARC, Varanasi in their trials conducted since 2020-21 for assessing the Performance of Nano-fertilizers on productivity, profitability, nutrient use efficiencies, and yield-scaled Greenhouse Gas Emissions in Rice-Wheat Systems have concluded that 34 % N reduction is possible. Anand Agriculture University, Gujarat have reported the result of two years experimentation conducted on nano urea application of RDF (50 % N, 100 % P & 50 % Zn) + joint application of two sprays of Nano N, Zn and Cu showed higher yield attributing characters and significantly higher grain (57.13 q/ha) and stover yield (87.91 q/ ha) of Maize over standard NPK treatment.

Similar results were also reported in wheat without adverse effect on soil. Kashyap et al. (2023) in their studies on fodder maize which was conducted during 2021 and 2022 at NDRI, Karnal recorded that the yield obtained by applying 50% of RDN through urea, along with dual foliar sprays of nano-urea was comparable with 100% RDN through urea only. ICAR- CSSRI, Karnal, based on 3-year field and controlled experiments conducted since 2020 in rice-wheat cropping system have concluded that up to 50 % replacement of conventionally used prilled urea by Nano Urea did not affect grain yield of both rice and wheat. Replacing prilled urea with Nano Urea up to 33% in rice and 50% in wheat significantly improved achievable NUE with the conclusion that it is sustainable to use Nano Urea with Urea in most popular intensive rice-wheat cropping system of India. A general view of a few field experiments conducted under IFFCO sponsored collaborative research initiative are shown in Picture 1.

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Picture1. A view of On-station and on-farm trials of IFFCO nano urea and other nano fertilizers conducted in India

In the light of the efficiency and benefits of Nano urea over conventional urea discussed in this paper, one can easily analyse the truthfulness of various issues raised by Frank and Soren (2023). As I see, the authors of the "opinion paper" have not performed any experiment on their own to verify the efficacy of IFFCO's well authenticated commercial product, but have merely indulged in pre-meditated bald and damaging remarks based on their erroneous selective mosaicking of information in papers and articles in the public domain and as such derived at biased conclusions. It is to be appreciated that IFFCO's product has proved its irrefutable performance in India and abroad under diverse field and climatic conditions. Moreover, the field experiments conducted to test efficacy of Nano urea vis a vis conventional urea showed 25 to 50% saving of the dose of urea. However, the news published in the recent past in a News Paper based on theexperiment conducted at Punjab Agricultural University, Ludhiana with lesser doses of Nano urea and also due to rains occurred soon after the foliar spray of Nano urea, in contrast, highlighted the loss in the yield with Nano urea as compared to urea which is not in consonance with the findings of any published papers so far. As such, this is an exception to the findings reported in large number of review papers. Such a statement may be misleading and gratuitous, therefore, could have been avoided to bring it into the public domain which, unnecessarily, is creating confusion.

Epilogue

Applicationof Nano urea has greater role in improving nutrients useefficiency (NUE), enhancing the crop yield, reducing the environmentalpollution hazard and the fertilization cost for crop production. It is more soluble, reactive, and could increase the penetration through the cuticle for targeted delivery. Meanwhile, plant root entry also increases the passage of nutrient uptake as it's highly porous to nano-fertilizer compared to inorganic fertilizer. Furthermore, the optimum concentrations of nano-fertilizers could improve crop growth but excessive dose may lead to reduced crop growth. Thus, the optimization of nano-fertilizer dose is of prime importance to improve nutrients use efficiency. IFFCO has initiated Collaborative Research Projects with State Agricultural Universities (SAUs), State Agricultural Universities and KVKs to get more insights on nano urea and its interaction with plant system. IFFCO Nano Urea is a polymeric nanomaterial which have nitrogen based functional molecules. Foliar application of NU at critical crop growth stages results in overall yield increase in crops based on enhancement in crop growth and yield contributing factors.

Indian farmers have adopted nanotechnology based IFFCO Nano urea for field application and found its performance quite reasonable under local conditions. It has distinct benefits in terms of reduction in consumption of urea, better environment, ease in transportation, storage and warehousing. Further, as per experience of the farmers, there are benefits in terms of enhanced germination, reduced crop lodging, occurrence of pests (insect and diseases) and prolonged duration of fruiting in vegetables.

It is important to mention at this juncture that IFFCO exports Nano urea based on its demand from overseas countries. Procurement is done as per "techno-commercial" evaluation and requirement only. IFFCO Nano Urea cost is 15.7 % less than the prevailing price of one subsidised Urea bag. Internationally, Nano Urea holds price advantage in view of fluctuating urea prices across the globe. Above all, a huge money being spent by the Government towards subsidy to ensure availability of fertilizers at affordable price to the farmers, may be saved.

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PARTICIPATORY IRRIGATION MANAGEMENT: EMPOWERING COMMUNITIES FOR SUSTAINABLE AGRICULTURE

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ABSTRACT

In agricultural landscapes, where rainfall is inconsistent, irrigation emerges as a vital tool for sustaining crops. However, conventional centralized management often results in inefficiencies and environmental degradation. Recognizing these shortcomings, Participatory Irrigation Management (PIM) has emerged as a transformative alternative, empowering local communities to govern their water resources effectively. Rooted in principles of subsidiarity and decentralization, PIM involves farmers in decision-making processes, fostering flexibility and alignment with local needs. Water User Associations (WUAs) serve as pivotal platforms for community engagement, overseeing irrigation operations and conflict resolution. PIM promises multifaceted benefits, including enhanced water productivity, social cohesion, and empowerment of marginalized groups. Yet, challenges persist, requiring robust solutions spanning institutional capacity-building, policy advocacy, and resource mobilization. Despite obstacles, evidence showcases PIM's positive impact on agricultural development globally. The comprehensive framework of PIM, coupled with targeted solutions, holds promise for building resilient and inclusive water management systems, essential for sustainable agriculture in the face of evolving challenges.

INTRODUCTION

In the realm of agriculture, irrigation stands as a vital lifeline, particularly in regions where rainfall proves unreliable (Pandyaet al., 2019). However, the conventional approach to irrigation management, often characterized by centralized decision-making, has resulted in inefficiencies, disparities, and environmental degradation. Recognizing these limitations, Participatory Irrigation Management (PIM) has emerged as a transformative alternative, empowering farmers and local communities to take charge of their water resources (Patel, 2019).PIM embodies the principles of subsidiarity and decentralization, advocating for the active involvement of water users, primarily farmers, in the planning, operation, and maintenance of irrigation systems (Patel and Rank, 2016; 2020). By decentralizing decision-making authority, PIM fosters flexibility and adaptability to local conditions, ensuring that water resources are managed in a manner that aligns with the needs of farmers and the environment (Patel et al., 2014).

A cornerstone of PIM is the establishment of Water User Associations (WUAs), which serve as vehicles for community participation in irrigation management. Comprising representatives from

the farming community, WUAs oversee various aspects of irrigation, including water allocation, infrastructure maintenance, and conflict resolution.The benefits of PIM are multifaceted. By involving farmers in irrigation management, PIM enhances water efficiency, reduces wastage, and fosters sustainable agricultural practices. Furthermore, it contributes to social cohesion, stability, and the empowerment of marginalized groups, including women and smallholder farmers.
However, the implementation of PIM is not without its challenges. It requires a supportive policy framework, institutional capacity-building, and adequate technical and financial resources. Overcoming these obstacles is essential to unlock the full potential of PIM in enhancing water productivity, equity, and sustainability (Rank and Vishnu, 2023).Despite the challenges, evidence from around the globe underscores the positive impact of PIM on agricultural development and rural livelihoods. From the terraced fields of Nepal to the rice paddies of Southeast Asia, participatory irrigation management has emerged as a cornerstone of efforts to build resilient and inclusive water management systems. Rainfall and runoff relations are also effective parameter of PIM (Parmar et al., 2016). As we confront the challenges of the present and future, the principles of PIM offer a promising pathway towards sustainable agriculture and water stewardship.

Steps of Participatory Irrigation Management (PIM):
The holistic framework for implementing Participatory Irrigation Management, empowering local communities to sustainably manage water resources and enhance agricultural productivity. The following steps are pillars of PIM.

1. **Formation of Water User Associations (WUAs)**
    - The initial step in PIM involves the establishment of WUAs, comprising representatives from the local farming community.
    - WUAs are typically democratically elected or appointed and serve as the primary platform for community participation in irrigation management.
2. **Community Mobilization and Awareness:**
    - Engaging and mobilizing community members to understand the importance of PIM and their roles within the WUAs.
    - Conducting awareness campaigns, training sessions, and workshops to educate stakeholders about water management principles and sustainable practices.
3. **Development of Water Management Plans:**
    - Collaboratively developing water management plans with input from WUAs and relevant stakeholders.
    - These plans outline water allocation strategies, infrastructure maintenance schedules, and protocols for conflict resolution.
4. **Implementation of Water Management Practices:**
    - Implementing agreed-upon water management practices as outlined in the water management plans.
    - This may involve efficient water distribution methods, maintenance of irrigation infrastructure, and adoption of water-saving technologies.
5. **Monitoring and Evaluation:**
    - Regular monitoring of water usage, infrastructure condition, and adherence to water management plans (Rank and Vishnu, 2019; 2021a, 2021b).
    - Evaluation of the effectiveness of implemented practices and identification of areas for improvement or adjustment.

6. **Capacity Building and Training:**
    - Providing ongoing capacity-building initiatives and training programs to enhance the skills and knowledge of WUA members and community stakeholders.
    - This includes technical training on irrigation techniques, conflict resolution, and organizational management.
7. **Conflict Resolution Mechanisms:**
    - Establishing transparent and effective mechanisms for resolving conflicts related to water allocation, usage, and management.
    - Encouraging open dialogue and mediation to address disputes and ensure equitable distribution of water resources.
8. **Sustainability and Continual Improvement:**
    - Promoting sustainable practices and conservation efforts to safeguard water resources for future generations.
    - Continual review and adaptation of PIM processes based on feedback, changing environmental conditions, and emerging challenges.
9. **Policy Advocacy and Networking:**
    - Advocating for supportive policies and regulations that recognize and facilitate participatory approaches to irrigation management.
    - Building networks and partnerships with government agencies, NGOs, and other stakeholders to share best practices and leverage resources.
10. **Celebration of Success and Recognition:**
    - Recognizing and celebrating achievements and successes in PIM, fostering a sense of ownership and pride within the community.
    - Publicizing successful PIM initiatives to inspire and motivate other communities to adopt similar approaches.

Benefits of Participatory Irrigation Management (PIM):

Participatory Irrigation Management offers a range of benefits that extend beyond agricultural productivity to encompass social, environmental, and economic dimensions of sustainable development. By empowering local communities to manage their water resources effectively, PIM represents a promising pathway towards resilient and inclusive water management systems.

1. **Improved Water Management:**
    - PIM promotes efficient and equitable allocation of water resources, reducing wastage and optimizing water use for agricultural production (Rank and Satasiya, 2022; Rank et al., 2023b).
    - By involving local stakeholders in decision-making, PIM ensures that water management practices are tailored to the specific needs and conditions of the community.
2. **Enhanced Agricultural Productivity:**
    - Engaging farmers in irrigation management encourages the adoption of modern techniques and technologies, leading to increased crop yields and improved agricultural outcomes (Sadatiya et al., 2019).

- PIM fosters a culture of innovation and experimentation, allowing farmers to explore sustainable practices that maximize productivity while minimizing environmental impact.

3. **Empowerment of Local Communities:**
   - PIM empowers marginalized groups, including women and smallholder farmers, by giving them a voice in decision-making processes.
   - Through participation in Water User Associations (WUAs), community members gain leadership skills, organizational capacity, and a sense of ownership over their water resources.
4. **Social Cohesion and Equity:**
   - Participatory approaches to irrigation management foster cooperation, trust, and solidarity among community members.
   - By promoting transparency and inclusivity, PIM helps mitigate conflicts over water allocation and ensures fair distribution of resources, thereby strengthening social cohesion within communities.
5. **Environmental Sustainability:**
   - PIM encourages the adoption of sustainable agricultural practices that minimize environmental degradation and preserve natural ecosystems.
   - By promoting water-saving technologies, soil conservation measures, and biodiversity preservation, PIM contributes to the long-term health and resilience of agricultural landscapes (Patel et al., 2023). The technologies also helped in saving fertilizers (Modhavadia et al., 2023; Rathod et al, 2023).
6. **Resilience to Climate Change:**
   - Participatory approaches to irrigation management enable communities to adapt to changing climatic conditions and mitigate the impacts of climate change on agriculture.
   - By promoting water conservation and resource-efficient practices, PIM helps farmers cope with droughts, floods, and other extreme weather events associated with climate variability (Rank et al., 2020; 2022; 2023a).
7. **Economic Development:**
   - Effective water management under PIM can lead to increased agricultural incomes, improved livelihoods, and overall economic development within rural communities.
   - By optimizing water use and enhancing agricultural productivity, PIM contributes to poverty reduction, food security, and sustainable rural livelihoods.
8. **Institutional Strengthening:**
   - PIM strengthens local institutions and governance structures by building the capacity of Water User Associations (WUAs) and other community-based organizations.
   - By promoting democratic decision-making processes and accountability mechanisms, PIM enhances the resilience and sustainability of irrigation systems over the long term.

Challenges of Participatory Irrigation Management (PIM):

The challenges requires a holistic and collaborative solutions that engages diverse stakeholders, fosters innovation, and promotes adaptive management strategies. Despite the obstacles, participatory irrigation management holds great promise for enhancing agricultural productivity, promoting social equity, and safeguarding water resources for future generations (Vadar et al., 2016; 2019).

1. **Limited Institutional Capacity:**
    - Many communities lack the institutional capacity and technical expertise needed to effectively implement PIM initiatives.
    - Building the capacity of Water User Associations (WUAs) and other local organizations is essential but often requires significant investment in training and support.
2. **Unequal Power Dynamics:**
    - Power imbalances within communities can hinder meaningful participation in PIM processes, particularly among marginalized groups such as women and smallholder farmers.
    - Addressing unequal power dynamics and ensuring inclusive decision-making requires proactive efforts to promote equity and diversity within WUAs and other participatory structures.
3. **Lack of Supportive Policies and Regulations:**
    - The absence of supportive policies and regulatory frameworks at the national and local levels can undermine the effectiveness of PIM initiatives.
    - Advocacy efforts are needed to promote policy reforms that recognize and facilitate participatory approaches to irrigation management.
4. **Resource Constraints:**
    - Limited financial resources and access to appropriate technologies can pose significant barriers to the successful implementation of PIM projects.
    - Securing funding and technical assistance from government agencies, donors, and development organizations is often essential but can be challenging.
5. **Social and Cultural Barriers:**
    - Social and cultural factors, including traditional gender roles and norms, may impede the full participation of women and other marginalized groups in PIM activities.
    - Sensitivity to local customs and practices is essential, and efforts to promote gender equality and social inclusion must be integrated into PIM strategies.
6. **Water Conflict and Competition:**
    - Competition over water resources can lead to conflicts among different user groups, including farmers, industries, and urban communities.
    - Developing effective mechanisms for resolving water-related disputes and promoting cooperation among stakeholders is critical for the success of PIM initiatives.
7. **Environmental Degradation:**
    - Unsustainable agricultural practices, such as over-extraction of groundwater and indiscriminate use of agrochemicals, can lead to environmental degradation and depletion of natural resources (Kumar and Rank; 2023).
    - Integrating environmental considerations into PIM planning and implementation processes is essential for promoting long-term sustainability and resilience.

8. **Climate Change Impacts:**
    - Climate change poses additional challenges to PIM by altering precipitation patterns, increasing the frequency of extreme weather events, and exacerbating water scarcity.
    - Building adaptive capacity and resilience to climate change is essential for ensuring the effectiveness and sustainability of PIM initiatives in the face of evolving environmental conditions.

Solutions to the Challenges of Participatory Irrigation Management (PIM):

By addressing challenges through targeted interventions and collaborative efforts, Participatory Irrigation Management can realize its potential as a transformative approach to sustainable water resource management and agricultural development. Investing in community empowerment, institutional strengthening, and environmental stewardship is essential for building resilient and inclusive irrigation systems that benefit both present and future generations.

1. **Capacity Building and Training:**
    - Invest in comprehensive capacity-building programs to enhance the technical and managerial skills of Water User Associations (WUAs) and community members.
    - Provide training on irrigation techniques, conflict resolution, organizational management, and gender-sensitive approaches to ensure effective participation.
2. **Promote Inclusive Decision-Making:**
    - Foster inclusive decision-making processes by actively engaging marginalized groups, such as women and smallholder farmers, in all aspects of PIM initiatives.
    - Implement quotas or affirmative action policies to ensure equitable representation within WUAs and other participatory structures.
3. **Advocate for Supportive Policies:**
    - Advocate for the development and implementation of supportive policies and regulatory frameworks that recognize and facilitate participatory approaches to irrigation management.
    - Engage with government agencies, policymakers, and other stakeholders to promote legal reforms and institutional changes that prioritize community participation and empowerment.
4. **Secure Funding and Resources:**
    - Mobilize financial resources from government budgets, international donors, development agencies, and private sector partners to support PIM initiatives.
    - Explore innovative financing mechanisms, such as community-based revolving funds or public-private partnerships, to sustainably finance irrigation infrastructure and capacity-building efforts.
5. **Address Social and Cultural Barriers:**
    - Raise awareness and promote dialogue on gender equality, social inclusion, and cultural diversity within communities.
    - Implement targeted interventions, such as sensitization workshops and awareness campaigns, to challenge stereotypes and traditional norms that may hinder women's participation in PIM activities.

6. **Strengthen Conflict Resolution Mechanisms:**
   - Establish transparent and participatory mechanisms for resolving conflicts over water allocation and usage.
   - Train community members and local leaders in mediation, negotiation, and consensus-building techniques to facilitate constructive dialogue and resolution of disputes.
7. **Promote Sustainable Agricultural Practices:**
   - Encourage the adoption of sustainable agricultural practices, such as drip irrigation, conservation tillage, and agroecological farming methods, to minimize environmental degradation and enhance water efficiency.
   - Provide technical assistance, incentives, and extension services to farmers to promote the adoption of environmentally friendly practices.
8. **Build Climate Resilience:**
   - Integrate climate change adaptation strategies into PIM planning and implementation processes, including the development of resilient water infrastructure and drought-tolerant crop varieties (Rank et al., 2016).
   - Foster collaboration and knowledge-sharing among stakeholders to identify and implement adaptive measures that enhance the resilience of irrigation systems to climate variability and change.

SUMMARY

Participatory Irrigation Management (PIM) is a promising approach for sustainable agriculture and water stewardship. By involving local communities, PIM ensures the viability of irrigation systems and supports farmers' livelihoods. In addressing climate change and water scarcity, PIM offers a practical framework for collaboration and responsible resource management. Through community engagement and decentralized decision-making, PIM enhances water productivity, promotes social equity, and empowers marginalized groups. Despite challenges like institutional capacity constraints and unequal power dynamics, investing in capacity-building, policy reforms, and stakeholder engagement can unlock PIM's transformative potential. Looking ahead, PIM principles guide the construction of resilient water management systems, addressing climate challenges and population pressures. Embracing participation, equity, and sustainability, PIM enables a more just, prosperous, and resilient world for future generations.

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THE INDIAN SPICE BOX: A PANACEA

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Introduction

The world is waking to what has been the age-old wisdom we have inherited from our grandmothers. The panacea for many ailments lies right on our kitchen shelves. Popularly known as "turmeric latte" today, is nothing but a fancy word for what we have known as "haldi doodh". The health benefits of popular Indian spices have been known for decades. Globally India contributes 70% to the global spice production, ranking first in the world in terms of spice production (Das et al., 2023). The International Organization for Standardization (ISO) has listed 109 spices in the world, out of which 63 spices are grown in India. In addition to imparting aroma and flavour to food items, spices are known to serve as antimicrobials and therefore are highly valued for their healing abilities. These are abundant in certain pytochemicals which possess many health promoting properties (Shahidi and Hossain, 2018; Nath and Debnath, 2023). Due to this reason, spices find immense utility in the science of Ayurveda. It is believed that consumption of a balanced amount of spices on a daily basis provides balance to the three doshas of the human body namely Vata, Pitta and Kapha (Rao 2003). In the event of an imbalance of these doshas, the body becomes unhealthy. The common Indian spices and their principal phyto-constituents are presented in Figure 1. The figure also enumerates the potential health promoting properties of each of these spices based on the available literature. Only a few, commonly known benefits associated with consumption of these spices are listed for the purpose of brevity.

Phytochemicals are defined as bioactive chemicals of plant origin. The popular Indian spices are rich in phytochemicals like alkaloids, flavonoids, glycosides, reducing sugars, saponins, steroids, phenols, terpernoids, anthraquinones, tannin, etc (Tacouri et al., 2013; Ali et al., 2018). In a study conducted by Tacouri et al., 2013 where the *in vitro* anti-oxidant and anti-microbial activities of extracts derived from six different spices (ajwain, coriander, cinnamon, fennel, garlic and turmeric) was estimated, it was observed that cinnamon possessed the highest antioxidant activity while turmeric had the least antioxidant potential. Both turmeric and cinnamon exhibited strong antimicrobial activities against the bacteria *Staphylococcus aureus* and *Escherichia coli*. Owing to the various beneficial attributes of spices, these have been used for preventing or ameliorating chronic diseases such as cardiovascular disease, arthritis, cancer, and neurological disorders (Upadhyay and Pandey, 2022). The major class of polyphenols found in spices are the phenolic acids and flavonoids (mainly flavones and flavonols) and the various volatile oils and oleoresins, that are recognized to have antibacterial, antiviral, and antifungal properties. This allows their use as stabilizer or preservative agents in food. Owing to the abundance of these beneficial phytochemicals in spices, many species have also been used as natural sources of these compounds in the pharmaceutical industry. For instance, diosgenin, a steroidal saponin isolated from fenugreek, is manufactured in the form of steroidal drugs (Jesus et al., 2016).

Spices have been used for their medicinal properties since time immemorial. However, unlike cereals and pulses, which draw considerable attention of agricultural scientists, research on spices remains notably scant. This is because cereal and pulses serve as staple food items globally and are source of nutrients and dietary energy (Shahzad et al., 2021). The disparity is more evident with the genomes sequenced for most cereal and pulse crop species. On the other hand, for many spices like fenugreek, cumin, Indian bay leaf, no whole genome sequence information is available. However, with the advances in Next-generation sequencing technologies (NGS), we believe that more species will be picked up for sequencing in the near future. Unravelling the genome of these spices would help in identifying genes and metabolic pathways involved in biosynthesis of the important phytochemicals.

Conclusion

Many spices of Indian origin and the ones which are widely used in Indian cooking, are known for their therapeutic properties. Despite their health benefits, research on the genomics aspect of these remains poor. Efforts need to be undertaken to generate more genomic information for these spices, so as to be able to understand the molecular basis of biosynthesis of the beneficial phyto-chemicals.

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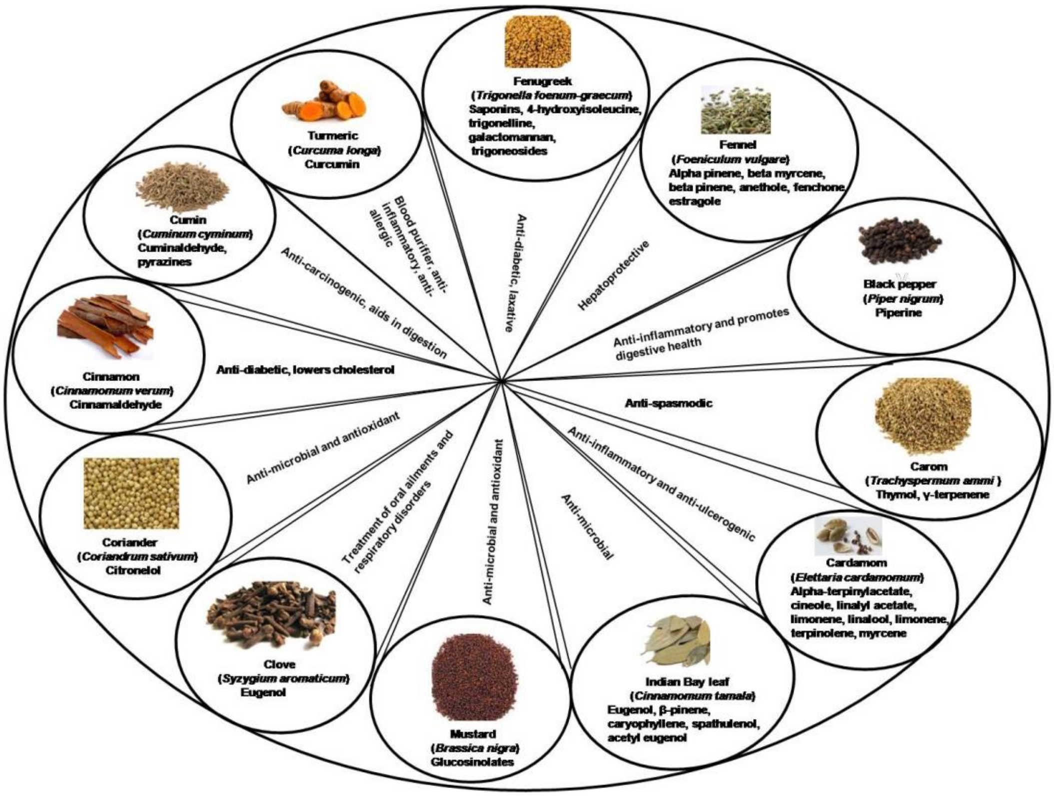

Fig. 1: Popular Indian spices along with their active ingredients and potential health benefits.

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APPLICATION OF METAGENOMICS IN THE DETECTION OF MICRO-ORGANISMS ASSOCIATED WITH PLANT SAMPLES

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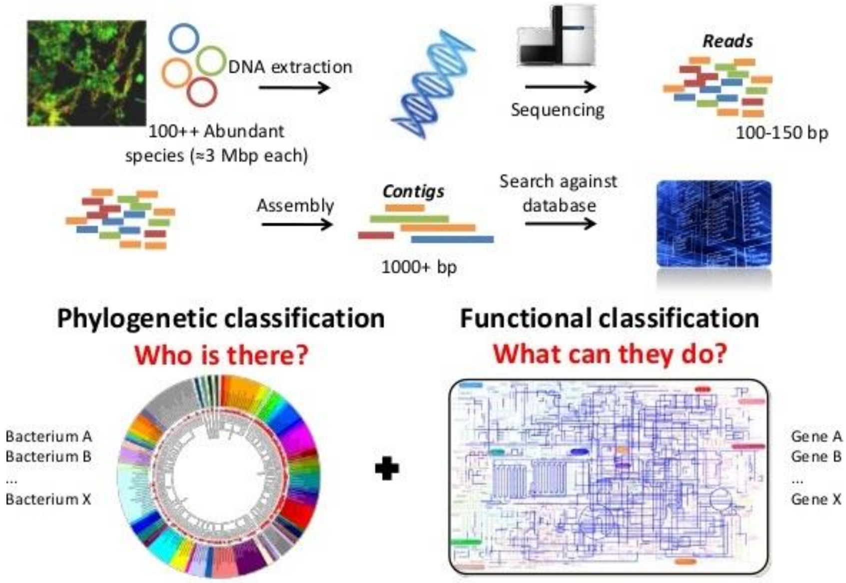
Introduction

About thirty years ago, in 1986, Pace and collaborators proposed the revolutionary idea of cloning DNA directly from environmental samples to analyze the complexity of natural microbial populations. At that time, authors stressed that although the DNA was originated from a mixed population of microorganisms, the methodology allowed the recovery and subsequent sequencing of individual rRNA genes. By evaluating complete or partial rRNA sequences, the composition of the original microbial populations could be retrieved. The adopted strategy was based on shotgun cloning of 16S rRNA genes using purified DNA from natural samples. Around ten years later, in 1998, the term “metagenome” appeared, when Handelsman and collaborators described the importance of soil microorganisms as sources for new natural compounds. According to them, a new frontier in science was emerging-the mining for novel chemical compounds from uncultured microorganisms, which comprises more than 99% of the microbial diversity. This new concept in microbial science opened the mind of the scientific community with respect to the astonishingly large catalogue of biochemical functions available in nature remaining to be discovered (Chen and Pachter, 2005).

Metagenomics is the study of metagenome and genetic material recovered directly from environmental sample such as soil, water or faeces. It is mainly based on the genomic analysis of microbial DNA directly from the communities present in samples. Metagenomics technology is genomics on a large scale will probably lead to great advances in medicine, agriculture, energy production and bioremediation. It can unlock the massive uncultured microbial diversity present in the environment for new molecule for therapeutic and biotechnological application (Paulraj*et al.,* 2021). These studies have identified many novel microbial genes coding for metabolic pathways such as energy acquisition, carbon and nitrogen metabolism in natural environments that were previously considered to lack such metabolism. It will bring about a transformation in biology, medicine, ecology and biotechnology that may be as profound as that initiated by the invention of the microscope. All plants and animals have closely associated microbial communities that make necessary nutrients (carbon, nitrogen, and oxygen), metals (sulfur) and vitamins available to their hosts. We depend on microbes to remediate toxins in the environment- both the ones that are produced naturally and the ones that are the by-products of human activities, such as oil and chemical spills.

Steps in metagenomic analysis

Sample collection, DNA extraction, Library preparation, Next generation sequencing, Assembly, Binning



How Next generation sequencing in metagenomics was performed?

Metagenomic sequencing is unique in the sense that - to sequence a large diverse pool of microbes, each with a different genome size, often mixed with host DNA. Current sequencing technologies offer a wide variety of read lengths and outputs. Illumina sequencing technology offers short reads, 2x250 or 2x300 bp but generates high sequencing depth. Longer reads are preferred as they overcome short contigs and other difficulties during assembly. However, instruments that offer longer reads, e.g. PacBio and Oxford Nanopore are accompanied with higher error rates, lower sequencing depth and higher costs. PacBio error rates can be reduced using circular concensus sequencing (CCS) which involves repeat sequencing of a circular template and generation of a DNA insert consensus. High quality 500-4000 bp can be generated with >99% Q20 accuracy.Illumina platforms provide higher accuracies and are more cost-effective. However, they only provide limited read length (∼2× 300 bp). At present, both Pacific Biosciences single-molecule real-time (SMRT) and Oxford Nanopore Technologies sequencing platforms are preferred due to their longer read sizes of 15–100 and ∼1000 kilobases, respectively(Adams *et al.,* 2009).

After sequencing, the products are filtered using quality check tools like fastp, cutadapt and trimmomatic. Then onwards assembly and binning should be carried before subjecting for metagenomic analysis through softwares (MG RAST, MEGAN, EBI metagenomics and IMG). There are two approaches in metagenomics which include 16S rRNA and shotgun metagenomics.

16SrRNA metagenomics

Metagenomics is not 16S sequencing. Metagenomics is the study of the functional genomes of microbial communities while 16S sequencing offers a phylogenetic survey on the diversity of a single ribosomal gene, 16S rRNA. The 16S rRNA gene is a taxonomic genomic marker that is common to almost all bacteria and archaea. The marker allows one to examine genetic diversity in microbial communities, specifically what microbes are present in a sample. While some estimates of relative abundance within similar samples can be made, drawing conclusions across different sample types is not recommended due to amplification artifacts introduced during PCR.

16S rRNA sequencing is accomplished by designing primers to the entire 16S locus or targeting multiple hypervariable domains within the gene. The nine variable regions of the 16s rRNA gene are flanked by conserved stretches in the majority of bacteria. Conserved regions can be used as targets for PCR primers, designed upstream and downstream of the variable domains. These hypervariable regions provide the species-species signature necessary for identification. After these domains have been amplified, sequencing related primers are either ligated or added by a second PCR step.

Short gun method

Shotgun metagenomic sequencing is an alternative approach to the study of uncultured microbiota that avoids these limitations. Here, DNA is again extracted from all cells in a community. But, instead of targeting a specific genomic locus for amplification, all DNA is subsequently sheared into tiny fragments that are independently sequenced. This results in DNA sequences (i.e., reads) that align to various genomic locations for the myriad genomes present in the sample, including non-microbes. Some of these reads will be sampled from taxonomically informative genomic loci (e.g., 16S), and others will be sampled from coding sequences that provide insight into the biological functions encoded in the genome. As a result, metagenomic data provides the opportunity to simultaneously explore two aspects of a microbial community: who is there and what are they capable of doing?

High-throughput sequencing approaches enable genomic analyses ideally of all microbes in a sample, not just those that are amenable to cultivation. One such method, shotgun metagenomics, is the untargeted (‘shotgun’) sequencing of all (‘meta-’) microbial genomes ‘genomics’ present in a sample. Shotgun sequencing can be used to profile taxonomic composition and functional potential of microbial communities and to recover whole genome sequences. Approaches such as high-throughput 16S rRNA gene sequencing1, which profile selected organisms or single marker genes, are sometimes referred to as metagenomics, but this is a misnomer, as they do not target the entire genomic content of a sample. In the 15 years since it was first used, metagenomics has enabled large scale investigations of complex microbiomes. Discoveries enabled by this technology include the identification of environmental bacterial phyla with endosymbiotic behavior and species that can carry out complete nitrification of ammonia. Other notable findings include the widespread presence of antibiotic genes in commensal gut bacteria, tracking of human outbreak, the strong association of the viral and bacterial fractions of the microbiome with inflammatory bowel diseases, and the ability to monitor strain-level changes in the gut microbiota after perturbations such as those induced by fecal microbiome transplantation (Lee, 2005). Here we discuss best practices for shotgun metagenomics studies, including identification and tackling of limitations, and provide an outlook for metagenomics in the future. A typical shotgun metagenomics study comprises five steps, after the initial study design: (i) the collection, processing and sequencing of the samples; (ii) preprocessing of the sequencing reads; (iii) sequence analysis to profile taxonomic, functional and genomic features of the microbiome; (iv) statistical and biological post-processing analysis, and (v) validation. Numerous experimental and computational approaches are available to carry out each step, which means that researchers are faced with daunting choices. And despite its apparent simplicity, shotgun metagenomics has limitations, owing to potential experimental biases and the complexity of computational analyses and their interpretations. We assess the choices and common problems that accompany each step.

Application of metagenomics in plant pathology

Through the analysis of nucleic acid sequencing, metagenomics provides information of phylogeny of fungi. Uncultured bacteria was revealed through the study of metabolism, which includes the expression of chitinase and oxidoreductases genes form marine microorganisms and lipases, amylases and nucleases of soil microorganisms (Cottrell *et al.,* 2005). Metagenomic study processes of plant pathogenic viruses can be developed by isolation of RNA, cDNA synthesis and finally the sequencing the possible plant pathogens (Gibbs and Mackenzie, 1997).

Conclusion

Metagenomics has benefited in the past few years from many visionary investments in both financial and intellectual terms. The science of metagenomics is currently in its pioneering stages of development as a field and many tools and technologies are undergoing rapid evolution. The best use of the metagenomics as a tool to address fundamental question of microbial ecology, evolution, diversity, to derive and test new hypothesis. As datasets become increasingly more complex and comprehensive, novel tools for analysis, storage and visualization will be required. Metagenomics allows us to discover new genes and proteins or even the complete genomes of non-cultivable organisms in less time and with better accuracy than classical microbiology or molecular methods. In addition to the phenotypic dimension of human biology such as gene expression profiling, proteomics and metabolomics, perhaps we need to extend our concept of the human to include the more comprehensive and plastic human metagenome in laboratory medicine. Therefore, metagenomics can retrieve unknown gene sequences leading to the “discovery” of novel microorganisms and functional genes. No a prior knowledge of the microbial community composition or function is needed for the analysis.Metagenomics has opened avenues in bioprospecting the genetic potential of microorganisms by offering access into a world of unexplored microbial diversity from unusual environments. The advent of next-generation sequencing technologies and advances in computational tools has transgressed the traditional barriers to drug discovery. Developments in structural and functional metagenomics have paved the way to discover novel genes and metabolic pathways for obtaining bioactive compounds with better properties and given a ray of hope for addressing the problem of drug resistance.Within the next few years, we will see the application of metagenomics or sequence-based technologies for genome-inspired personalized medicine.

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REVOLUTIONIZING AGRICULTURE: NANOTECHNOLOGY IN FERTILIZER APPLICATIONS

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Abstract

This study explores the transformative role of nanotechnology in addressing challenges faced by global agriculture. With a significant dependency on fertilizers for crop productivity, the paper introduces nanotechnology as a smart solution. Nanoparticles, particularly in nano-fertilizers, demonstrate enhanced nutrient use efficiency, controlled release, and minimal environmental impact. The advantages, such as increased crop yield and reduced greenhouse gas emissions, position nano-fertilizers as a promising strategy for sustainable and efficient agriculture.

Introduction

Most developing nations have long relied heavily on agriculture as their economic engine. In agriculture the main reason to use fertilizer is to give full-fledged macro and micro nutrients which usually soil lacks, 35-40% of the crop productivity depends upon fertilizers. To overcome these entire draw backs a smart way i.e., Nanotechnology can be one of the sources. Nanotechnology is the study of manipulating matter on a nanoscale. The creation, manufacturing, and use of structures, devices, and systems by manipulating their size and shape at the nanoscale. Nanotechnology deals with structure in the size range between 1- 100 nm and developing materials or devices within that size. World agriculture cropping systems intensively using large number of fertilizers, pesticides, herbicides to achieve more production per unit area but more doses than optimum level leads to severe problems like environmental pollution, low input use efficiency, decrease the quality of food materials. For solving these problems in crop production nano-fertilizers and pesticides and herbicides may effectively tools in agriculture for better pest and nutrient management because it having more penetration capacity, surface area and use effectiveness that prevent environmental contaminants. So, the value chain of the entire agriculture production system can utilize these agriculturally useful nano-particles created with the aid of nanotechnology.

Nanotechnology

Nanotechnology is the manipulation, integration or self-assembling of atoms, molecules or molecular clusters into complex form to create a material at nano scale. The Greek word for "dwarf" is where the name "Nano" derives from. One nano meter is a billionth of meter or 10-9 of a meter.

Nanotechnology Application in Agriculture

Worlds agriculture is now facing a lot of challenges viz., Static crop yield, low nutrient use efficiency, declining soil organic matter, multi-nutrient deficiency, shrinking arable land, water availability and shortage of labours etc.,

For this Nanotechnology, planning ultra-small particles having exponential properties. Now, it becomes an emerging and promising strategy to increase crop productivity. Now a days nanotechnology providing different Nano devices and Nano materials which having a unique role in agriculture such as Nano.

Nano-Fertilizer

Nano-fertilizers are synthesized or modified form of traditional fertilizers, which are produced with the help of nanotechnology to improve soil fertility, productivity and increase Nutrient Use Efficiency. It helps in controlling nutrient loss, increase plant cell uptake because of large surface area, absorption capacity and controlled release to target site. So, it is called “Smart Fertilizer”. Due to their massive surface area and tiny size, they react strongly with other chemicals. In a variety of solvents, including water, they are extremely soluble. Particle size of Nano-fertilizers is less than 100nm which facilitates more penetration of Nano particles in to the plant from applied surface such as soil or leaves. Fertilizers encapsulated in Nano-particles will increase availability and uptake of nutrient to the crop plant.

Why Nano-Fertilizers?

Farmers typically apply fertilizers through soil by:

1. Surface broadcasting
2. Subsurface placement
3. Mixing with irrigation water or foliar spray.

However, a large portion of applied fertilizers are lost to the atmosphere or surface water bodies and pollutes the environment.

a. Nano-fertilizers are more beneficial as compared to chemical fertilizers.
b. Three times increase nutrient use efficiency
c. 80- 100 times less requirement of chemical fertilizers.
d. 10 times more stress tolerant
e. 30% more nutrient mobilization by the plant.
f. Improvement in the crop yield
g. Reduce Green house gas emission.

Advantages of Nano-Fertilizers

1. Nano-fertilizers are advantageous over conventional fertilizers as they increase soil fertility and crop productivity through slow and controlled release.
2. Due to their small size and target specificity, they increased the Nutrient Use Efficiency (NUE) which are applied in nanoparticle form.
3. Reduce bulk requirement of traditional fertilizers and increase yield and quality of crops.
4. They are non-toxic and less harmful to environment and human as compared to conventional ordinary fertilizers.
5. Nano-fertilizers minimize the cost and maximize profit because they are used in very small quantities.

Disadvantages of Nano-Fertilizers

1. Nano-fertilizers has inhibitory effect when it exceeds the optimum concentration it causes ill-effect upon plant system viz., by it may plug the stomata pore, forming toxic layer upon the stigmatic surface, which further prevent pollen tube penetration, it may enter into vascular tissue and impair translocation of water, minerals and photosynthates.
2. The higher cost of Nano-fertilizer constitutes another hurdle in the way of promulgating them for crop production under varying Pedo-climatic conditions across the globe.

3. Nanoparticles produce waste toxic materials which if contact with soil and aquatic environment can cause contamination or pollution (eutrophication or hypoxia).

Conclusion

Nanotechnology emerges as a game-changer in agriculture, specifically in the realm of fertilizer applications. Nano-fertilizers showcase remarkable benefits, including improved nutrient use efficiency, reduced environmental impact, and enhanced crop yield. Despite some challenges such as potential inhibitory effects and higher production costs, the overall advantages suggest that nano-fertilizers can play a crucial role in transforming traditional farming practices. As technology continues to advance, integrating nanotechnology into agriculture offers a promising pathway for sustainable and efficient food production.

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GLOBAL WARMING AND ITS IMAPACT ON AQUACULTURE

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Abstract

Climate change poses a multidimensional challenge to the aquaculture sector, changing water temperatures, pH levels, oxygen concentrations, and salinity content while also influencing both primary and secondary production, ecosystem structure, and input supply availability. The present article investigates both the immediate and long-term impacts of global warming on aquaculture, concentrating on major components such as temperature rise, altered rainfall patterns, elevated sea levels, and unpredictability of external inputs. Geographic variations in climate change impacts show the need for specific adaptation methods. Adaptation alternatives include improving organizational procedures and infrastructure, increasing genetic variety, implementing early warning systems, investing in research and development, and collaborating with stakeholders. Understanding the complex interplay between climate change and aquaculture is critical for building resilience and encouraging sustainable development in the face of continuous environmental issues.

Keywords : climate change, aquaculture, global warming, sustainable development.

Introduction

The Earth's temperature is rising every day, and the root cause of it is global warming. Global warming refers to the long-term rise in the average temperature of the earth system. Climate change is actually happening and this is just a beginning. Climate change defined as change in weather conditions over a period of time consequent upon the nature variability properties or due to human activity that is interpreted in many quarters with many scientific data analysis (Lombor,2001).The warming of the climate system is indisputable. The earth atmosphere and ocean have warmed the amount of snow decreasing and sea level is increasing day by day. In the last 10,000 years, the temperature on the earth has remained constant, but since the pre-industrial 19th century the temperature on the earth has risen by 1°c, and now we are approaching 1.5°C really fast, if we reach 2Cc, then things would really turn in to disastrous. Climate system is going towards change, because of increase in the atmospheric concentration of carbon dioxide and other greenhouse gases. Carbon dioxide is one of the important heat-trapping greenhouse gases; it is released through human activities, such as fossil fuel emission and deforestation, net land change emission as well as natural processes such as respiration and volcanic eruption. (NASA, Global climate change, 2018).

Aquatic systems that sustain fisheries and aquaculture are undergoing significant changes as a result of global warming. Aquaculture is one of the fastest growing industries in the fisheries sector; serve as source of protein, employments creation, food security, economic growth and poverty reduction strategy. Change in climate system that leads toward global warming has undoubtable affected agriculture production system including fisheries and aquaculture. Climate change has both direct and indirect influence on fisheries and aquaculture. The direct impact of climate change are on physiology and behavior of the fish that affect growth reproduction, mortality and distribution (Allison et al, 2009; IFAD, 2014; yazdi and shakouri, 2010). Due to fluctuation of temperatures in fish habitat that create influence on general metabolism, growth, reproduction, seasonality and ultimately leads to decrease total production.

Greenhouse Effect

Global warming occurs due to greenhouse gases. To understand the global warming, it is necessary to become familiar with the greenhouse effect. The greenhouse effect is a natural occurring process that warms the Earth's surface temperature. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases. Greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofluorocarbons (CFCs).

The absorbed energy warms the atmosphere and the surface of the Earth. This process maintains the Earth's temperature at around 33°C warmer than it would otherwise be, allowing life on Earth to exist.

Cause of Climate Change

The primary cause of climate change is anthropogenic activities that emit large quantities of greenhouse gases into the atmosphere, leading to the retention of heat and subsequent global warming. The combustion of fossil fuels such as coal and oil, the destruction of forests, and the cultivation of animals are the primary anthropogenic factors contributing to climate change. These operations elevate the amount of carbon dioxide (CO_2), methane, and nitrous oxide, the primary greenhouse gases responsible for global warming. Between 1890 and 2010, the variations in solar radiation and volcanic activity only accounted for a minor increase of less than 0.1°C in the overall warming.

Climate Change and its Effect on Aquatic System

Climate change exerts notable effects on aquatic ecosystems, encompassing both marine and freshwater environments. Key consequences include elevated temperatures, alterations in hydrological cycle, water temperature, oxygen content, ice coverage, sea level and ocean acidification, all of which contribute significantly to the impact of climate change on aquatic ecosystems.

Hydrological Cycle and Rainfall Pattern:

- The warning about climate has notable implications for the hydrological cycle.
- Changing temperatures, climate patterns, and precipitation have a bad effect on water resources, leading to an unpreventable effect on aquatic ecosystems.
- Aqua farmers from various regions mainly depend on rainfall patterns that are not stable and will continue to change.
- The unpredictable change in rainfall pattern will affect water availability, ranging from droughts to floods, and also affect water quality and mortality in small-scale aquaculture.

Water Temperature:

- Anthropogenic forcing has made a substantial contribution to the upper ocean warming (above 700 m) that has been observed since the 1960s, with the surface waters warming by an average of 0.7 °C per century globally from 1900 to 2016.
- In freshwater system, water temperature is going to increase as an increase of air temperature.
- There is a high confidence that rising water temperatures will lead to shifts in freshwater species' distributions and exacerbate existing problems in water quality, especially in those systems experiencing high anthropogenic loading of nutrients .

Ice Coverage:

- Changes in climate are causing permafrost warming and the melting of ice in high-altitude regions.
- As global temperatures rise, permafrost zones are also warming quickly. Scientists found that in the past decade, temperatures at dozens of permafrost test sites at least 30 feet deep had raised on average by about half a degree Fahrenheit (3°C).
- During the period from 1979 to 2012, arctic ice decreased at a rate of 3.5% to 11.5% per decade. It is also very likely that the average annual extent of Antarctic sea ice increased by 1.2 percent to 1.8 percent per decade over the same period (Vaughan et al., 2013).

Oxygen Content:

- One of the most important components of aquatic system is dissolved oxygen.
- Changes in the concentrations of dissolved oxygen have major impact on the nitrogen cycle and global carbon.
- Greenhouse gasses cause deoxygenation in many parts of the open ocean.
- Warming of ocean reduce the solubility of oxygen in water.
- Oxygen influence biological and biochemical processes, but its impact are very depends on widely oxygen tolerances of different species and taxonomic groups.
- Due to low level of oxygen in water column reduces vertical migration depths for some species. (E.g. tunas and bill fishes).

Sea Level:

- Sea level has increased by an average of 3.1 mm/year as a result of climatic and non-climatic factors (Dangendorf et al., 2017).
- The rate of increase shows a high variability across regions, with values up to three times the global average in the Western Pacific or null or negative values in the Eastern Pacific. Sea level has already risen by a global mean of 0.19 m over the period 1901 to 2010.
- There is a high certainty that the sea level will rise in 95 percent of the ocean area; however, there will be a significant regional heterogeneity in the SLR and thus in its consequences (IPCC, 2014).

Climate Change and Their Impact on Fisheries

Rising ocean temperature, ocean circulation and ocean acidification is radically altering aquatic ecosystem. Climate changes alter the fish distribution and the productivity of marine and freshwater species. Climate change effects on aquaculture could occur directly or indirectly or positively or negatively, especially on the natural resources that are necessary for aquaculture. These resources include water land, seed, feed and energy inputs. The direct effect of climate change in aquaculture are the release of heat from the ocean to the atmosphere during El Niño events is known to cause changes in global atmospheric circulation, cyclone and hurricane patterns, monsoons, and heat and precipitation patterns, with associated drought and flooding episodes (Reid, 2016). The effects are felt worldwide, with consequences for marine and freshwater systems throughout the food web, including species sustaining fisheries. Since the publication of the IPCC AR5, there have been a number of modeling studies that have shown an increasing frequency of extreme El Niño events as a result of climate change (e.g. Cai et al., 2014, 2015; Wang et al., 2017). It is significant, in this context, that the 1982/83, 1997/98 and most recent 2015/16 El Niño events were not just the most intense in the modern observational record but also the most peculiar, exhibiting unusual characteristics distinct from any other observed events (Santoso, Mcphaden and Cai, 2017).

Climate Change and Their Impact on Inland Fisheries

- Inland fisheries are one of the important part of fisheries. Most food producing inland fisheries are found in developing countries. Most of the food insecure countries in the world are dependent upon inland fisheries for nutritional and food security. Inland fisheries are recognized as a positive means to achieve food security, and to provide employment, income, recreation and cultural enrichment to increasing human global populations. It is essential for stakeholders, including governments, resource managers, fishers and citizens, to understand what climate change means in terms of fisheries.
- Abiotic and biotic conditions are both sensitive to water temperature as a result of the chemical reaction rates double with every 10 °C increase in temperature (Regier, Holmes and Pauly, 1990).
- Water temperature influence all the biological and chemical processes in freshwater including degradation, evaporation, diseases risk, parasite transmission and tropical interaction between consumer and their preys.
- Climate change has various impacts on biological organization of freshwater fishes. For e.g. on phenotypic capacity, epigenetic effect, physiological function, growth rate and body size, migration, immune response, disease and parasitism, mortality and predation risk, etc.
- The reproductive cycle and breeding behavior of many fish are driven by predictable seasonal changes in temperature or water levels.

Climate Change and Their Impact on Marine Ecosystem

- The rising ocean temperature and ocean acidity makes it more difficult for marine organisms such as, oysters, shrimp or corals to form their shells a process known as calcification.
- Coastal areas near large estuaries and cold-water currents display greater acidification (a lower saturation state of aragonite) compared to deeper, offshore waters of warmer origin.
- The pH of bottom waters of estuaries such as the Gulf of St. Lawrence has decreased 0.2 pH to 0.3 pH units over the last 70 years with expected negative impacts on shellfish and potentially on fish early life stages.
- Zooplankton resources, important to the diets of early life stages of fish, may also drastically shift in the future. For example, Calanus finmarchicus is a key species of zooplankton in the diets of early life stages of many commercially important fish on shelf

areas throughout much of the North Atlantic. Projected warming of bottom waters of the Northeast shelf of the United States of America under a "business as usual" scenario of greenhouse gas emissions is expected to decrease the average abundance of C. finmarchicus in this region by as much as 50 percent by the end of this century.

Methods and Tools for Climate Change Adaptation in Fisheries and aquaculture

- Inclusion of climate change in management practices, e.g. EAF, including adaptive fisheries management and co-management
- Inclusion of climate change in integrated coastal zone management (ICZM) and Improved water management to sustain fishery services (particularly inland)
- Improvement or change post-harvest techniques/practices and storage.
- Early warning communication and response systems (e.g. food safety, approaching storms)
- Monitoring climate change trends, threats and opportunities (e.g. monitoring of new and more abundant species).
- Climate resilient infrastructure (e.g. protecting harbours and landing sites).
- Genetic diversification and protection of biodiversity.

Solutions to Reverse Climate Change

- Stop excessive use of fossil fuel such as coal, natural gasses etc.
- The most significant solution to put an end to this disaster is use of alternative energy sources.
- They include wind, solar, bio mass, hydro and geothermal.
- Stop deforestation, the exploitation of forest has a major role in climate change. Trees help regulate the climate by absorbing CO_2 from the atmosphere. when they are cut down, this positive effect is lost and the carbon stored in the trees is released into the atmosphere
- Intensive farming is another cause of global warming, not only with ever increasing livestock, but also with plant protection products and fertilizers. In fact, cattle and sheep produce large amount of methane when digesting their food, while fertilizers produce nitrous oxide emissions.
- Education as a means to create awareness to the citizens at the local, state and national levels.

Conclusion

Global warming poses a significant challenge to our worldwide community. It is a big hazard and this problem is not only cause trouble to fisheries but also to human beings and plants. If temperature of earth is goes on increases constantly, then things would really turn disastrous. If melting of polar ice will increase that means polar bears, whale, seals and seabird will lose their habitat mostly starve to death and go extinct. While on other hand sea level rise would result in flooding of coastal cities, Small Island countries will vanish from face of earth. India and Maldives have already lost few small islands to global warming. Climate change has both direct and indirect influence on fisheries aquaculture. Freshwater and marine systems are strongly connected to climate, as they may influence climate related atmospheric processes and also indicators of climate change. On this paper we are summaries the data that given impact of climate change on fisheries, and their solutions to tackle the situation of climate change for e.g. reforestation, use of alternative energy sources, better management practices and information that improved management of fisheries and of marine ecosystems can undoubtedly play an important role in adapting to the impacts of climate.

These are some recommendations that have been presented for the management of fisheries in the future.

- Reducing fishing efforts and improve stock abundance, both of which result in increases fishing efficiency and reducing greenhouse gas emission.
- Address the hazards and opportunities that climate change presents to food and livelihood security.
- Fuel consumption can considerable reduce through improved design and optimized operation of fishing vessels and gears.
- Use of fisheries management policies is likely to be more effective in reducing the use of fuel and greenhouse gas emission.
- Explore carbon sequestration by aquatic ecosystems.

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ROLE OF CRISPR-Cas9 IN AGRICULTURAL SCIENCE

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Abstract

Clustered regularly interspaced short palindromic repeat (CRISPR), a potent gene-editing tool was found in 2012. CRISPR is a genetic engineering technique that enables genome editing in living creatures and is based on the bacterial CRISPR-Cas9 antiviral defense mechanism. It is simpler, less expensive, and more accurate than previous gene editing techniques. It also has a wide range of valuable uses, including improving crops and treating genetic diseases. Plant science has benefited more from the CRISPR/Cas9 editing technique than medical science. CRISPR/Cas9 has been used in a range of crop-related research and development domains, including disease resistance, plant development, abiotic tolerance, morphological development, secondary metabolism, and fiber creation, as a well-developed cutting-edge biotechnology technique. This paper summarized the role of the CRISPR-CAS9 tool in modern agricultural science.

Key words : CRISPR, Genome Editing, Bacterial, Antiviral defense mechanism,Biotechnology.

Introduction

Producing more crops on the same amount of land is the aim of contemporary agricultural technology. Climate change is the largest problem facing the modern world. Climate change is causing a steady increase in global temperature. Numerous stresses can impact the agriculture industry, such as extreme heat or cold, salinity, and waterlogging. In this context, the growing population necessitates a higher need for food production. The CRISPR-Cas9 method can now be used to change the genomic sequence of many crops. The crops are therefore resistant to salinity, drought, and waterlogging. Those stresses can no longer injure the crop. CRISPR-Cas9 is being used to develop novel types in all crops.

Crop quality improvements

Modern plant breeding aims to enhance quality traits by incorporating desired genes or silencing undesirable ones. Genome editing tools provide a promising avenue for achieving such objectives and have been effectively utilized to improve various traits such as shelf life, fruit size, starch content, fragrance, storage longevity, nutritive value, and parthenocarpy in fruits. For instance, DuPont Pioneer developed a CRISPR/Cas9 knockout waxy corn line with remarkable yields for commercial purposes.

CRISPR-mediated mutations on genes GW2, GW3, and TGW6 have substantially increased seed size by up to 30% in rice, as these genes were found to negatively regulate seed size. Similarly, the inactivation of all homologs of the TaGW2 gene in wheat resulted in down-regulation of seed size but increased seed weight and numbers. Genome editing holds significant potential in ideotype breeding, allowing for the optimization of plant architecture by knocking out negative regulators affecting yield-determining factors such as grain number, size, weight, panicle size, and tiller number.

Improving fragrance, a desirable trait in rice, was achieved by generating a novel allele for the fragrance gene OsBADH2 using CRISPR/Cas technology. Mutant lines produced enhanced aromas with novel volatiles, showcasing the precision and diversity of trait improvement achievable through genome editing. Additionally, seedless tomatoes were produced by targeting and knocking out IAA9 and auxin response factor 7 using CRISPR technology.

CRISPR-Cas Genome Editing in Agriculture for the Management of Insect Pests

Biotechnology plays a crucial role in safeguarding crops from insect pests and enhancing agricultural yields through various methods, including breeding for pest resistance and introducing new genes via genetic modification. While the use of genome-editing techniques to develop insect-resistant plants is still in its early phases, it holds immense potential. By manipulating the genetic makeup of both plants and insects, genome editing offers a means to effectively manage insect populations. This can be achieved by inducing sterility in pests, disrupting their resistance to pesticides, or introducing new resistance mechanisms if necessary genes are absent. CRISPR-Cas9 genome-editing technology is at the forefront of this research, enabling scientists to modify insects to prevent them from damaging plants and enhancing plants' ability to repel insects. This presents an opportunity to create customized plants with superior traits, particularly in situations where targeted genetic alterations can lead to desirable characteristics or trigger gene drives aimed at reducing female insect populations.

The agricultural biotechnology industry faces a significant challenge in combating insect resistance to the Bt trait, prompting a search for innovative, economically feasible, and environmentally sustainable solutions. In this context, CRISPR-Cas9 gene editing has emerged as a leading approach for insect pest control. By leveraging the natural processes within cells, genome-editing technology ensures precise alterations to the DNA sequence of target genomes through the addition, deletion, or substitution of DNA bases. This technology holds promise for addressing insect resistance issues effectively while minimizing reliance on chemical pesticides and promoting environmentally responsible pest management practices.

CRISPR-based targeted genome editing for drought tolerance

Abiotic stresses like drought significantly reduce crop yield by hindering plant growth and productivity. To combat drought, genomic adaptation has been identified as the primary method for achieving drought tolerance. Overexpressing certain genes and transcription factors related to drought signaling can enhance crop drought tolerance by promoting the accumulation of signaling molecules and metabolites. Conversely, the increased expression of sensitive genes makes plants more susceptible to drought due to hormonal imbalances, low antioxidant activity, and the generation of reactive oxygen species (ROS). Negative regulators of drought tolerance, such as OsSRFP1, OsDIS1, and OsDST, have been identified in rice, and silencing these genes has been shown to enhance drought tolerance by increasing antioxidant enzyme levels and reducing H2O2 concentrations. Genome editing, particularly using the CRISPR–Cas9 system, offers a promising approach to achieve natural drought tolerance by targeting drought-sensitive genes or negative regulators of stress response. For instance, in Arabidopsis, mutations introduced into the OST2 gene via CRISPR–Cas9 enhanced drought tolerance by improving stomatal response, crucial for water regulation. Similarly, in tomatoes, mutations in the NPR1 gene using CRISPR–Cas9 led to weaker drought tolerance, highlighting its role in regulating drought response. These findings suggest that genome editing can be used to produce crops with enhanced drought tolerance by targeting specific genes involved in stress response pathways.

Conclusion

While CRISPR/Cas9 technology holds great promise for various applications in crop breeding, there are still limitations to consider. One major challenge is the limited number of genes that significantly impact important agronomic traits. Therefore, there is an urgent need to deepen our understanding of genomic sequence data and explore valuable genetic resources to enhance agriculture. Despite these challenges, the potential of CRISPR-Cas9 in crop development is vast. It is anticipated that its use will become widespread in the agricultural sector in the future, and it is only a matter of time before this technology becomes more prevalent.

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NAVIGATING THE TRANSFORMATIVE LANDSCAPE OF FOOD PROCESSING IN INDIA

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Abstract

This article delves into the dynamic landscape of food processing in India, examining the opportunities and challenges that define its current scenario. The exploration encompasses the impact of government initiatives and policies on industry growth, the evolving preferences of Indian consumers, and the adoption of cutting-edge technologies. Additionally, the article sheds light on the pivotal role of food processing in supporting farmers, the imperative to uphold food safety and quality standards, and the burgeoning export opportunities for Indian processed foods. Amidst these promising prospects, the article also addresses sustainability concerns, challenges in infrastructure, and the resilience strategies necessary for navigating disruptions. Ultimately, this comprehensive analysis underscores the transformative potential of the Indian food processing industry and its pivotal role in the nation's economic development on both domestic and global fronts.

Introduction

India, with its diverse culinary traditions and a burgeoning population, stands at the crossroads of a rapidly evolving food processing landscape. The country's food processing sector has witnessed significant developments driven by technological advancements, changing consumer preferences, and government initiatives. This article explores the current scenario of food processing in India, shedding light on both the opportunities and challenges that industry players face. Following points will shed some light on Food Processing as a sector and its importance.

1. **Government Initiatives and Policies:**
    - Overview of key government schemes and policies promoting the food processing industry.
    - The impact of initiatives such as 'Make in India,' 'Pradhan Mantri Kisan Sampada Yojana,' and others.
    - Incentives and support for food processing units, including subsidies and infrastructure development.
2. **Rising Consumer Demand and Changing Preferences:**
    - Analysis of the evolving taste preferences and dietary habits of Indian consumers.
    - Growing demand for convenience foods, ready-to-eat meals, and healthy snacks.
    - The impact of urbanization and a busy lifestyle on the demand for processed and packaged foods.
3. **Technology Adoption and Modernization:**
    - Integration of advanced technologies in Indian food processing units.
    - Challenges and opportunities in adopting automation, data analytics, and smart manufacturing.

- Case studies of successful technology implementations in the Indian food processing industry.

4. **Agro-Processing and Farmer Welfare:**
    - The role of food processing in enhancing the income of farmers through value addition.
    - Initiatives to reduce post-harvest losses and improve supply chain efficiency.
    - Collaborations between food processing companies and farmers for sustainable sourcing.
5. **Challenges in Food Safety and Quality Assurance:**
    - Addressing concerns related to food safety and quality in the processing industry.
    - Regulatory compliance and the role of the Food Safety and Standards Authority of India (FSSAI).
    - Strategies for ensuring traceability and adherence to global quality standards.
6. **Export Opportunities and Global Market Presence:**
    - Exploration of export potential for Indian processed foods.
    - Overcoming barriers and challenges in accessing international markets.
    - Success stories of Indian food processing companies making a mark on the global stage.
7. **Sustainability and Environmental Impact:**
    - Assessing the sustainability practices within the Indian food processing sector.
    - Efforts to reduce environmental impact, including packaging innovations.
    - The role of corporate responsibility in promoting sustainable practices.
8. **Resilience Amidst Challenges:**
    - Navigating challenges such as infrastructure gaps, logistics issues, and skilled labor shortages.
    - Strategies for building resilience in the face of disruptions, such as the COVID-19 pandemic.
    - Collaborative efforts between industry stakeholders, government, and communities.

Why is it called a Sunrise sector?

The term "sunrise sector" refers to an industry or sector that is in the early stages of rapid growth and development, showing significant potential for expansion and innovation. In the context of India, the food processing industry is often referred to as a "sunrise sector" for several reasons:

1. **High Growth Potential:** The food processing industry in India has experienced remarkable growth in recent years, driven by factors such as increasing population, urbanization, changing lifestyles, and rising disposable incomes. This growth potential positions the sector as a sunrise industry with ample room for expansion.
2. **Government Support and Initiatives:** The Indian government has recognized the importance of the food processing sector for economic development, employment generation, and agricultural growth. Various initiatives and policies, such as the "Pradhan Mantri Kisan Sampada Yojana" and "Make in India," aim to boost the food processing industry, making it a priority for investment and development.
3. **Enhancing Agricultural Income:** The food processing industry plays a crucial role in adding value to agricultural produce. By promoting agro-processing, farmers can benefit from

increased income through value addition, reduced post-harvest losses, and improved supply chain efficiency.

4. **Meeting Consumer Demands:** Changing consumer preferences, increased awareness of health and wellness, and a growing demand for convenience foods contribute to the sunrise status of the food processing sector. Processed and packaged foods, ready-to-eat meals, and innovative food products are gaining popularity among Indian consumers.
5. **Global Export Opportunities:** The globalization of food markets presents significant opportunities for Indian food processing companies to expand their reach beyond domestic borders. With a focus on quality and innovation, Indian processed foods have the potential to capture international markets, contributing to the sunrise status of the sector.
6. **Technological Advancements:** The adoption of advanced technologies, automation, and smart manufacturing practices in the food processing industry further emphasizes its sunrise status. These innovations improve efficiency, reduce production costs, and enhance the overall competitiveness of Indian food processing companies.
7. **Sustainability Focus:** Increasing awareness of environmental sustainability has led to a shift in consumer preferences. The Indian food processing sector is responding by adopting sustainable practices, including eco-friendly packaging and waste reduction, aligning with global trends and contributing to its sunrise status.

Conclusion

India's food processing sector is poised for growth, driven by a confluence of factors. While the industry faces challenges, the opportunities for innovation, sustainable practices, and market expansion are abundant. By addressing the current scenario with strategic initiatives and collaborative efforts, the Indian food processing industry can contribute significantly to the nation's economic development and global standing.

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STRATEGIES FOR EFFECTIVE MANAGEMENT OF REPEAT BREEDING IN CATTLE

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Abstract
Repeat breeding stands out as a significant reproductive disorder in dairy cattle, and its prevalence fluctuates across various management systems and environments. To mitigate the culling rate of repeat breeder dairy cattle, efforts can be directed towards enhancing their conception rates. This involves meticulous handling of genitalia during insemination to prevent acquired abnormalities, administering suitable treatments for uterine infections, employing hormone therapy to enhance fertilization success and reduce embryonic mortality, and ensuring insemination occurs following a thorough clinical examination by a skilled inseminator.

Introduction
Thechallenge of achieving optimal reproductive efficiency in cattle, attributed to repeat breeding syndrome which hinders the profitability of dairy production. A cow is called as repeat breeder when it fails to conceive even after three or more number of services, despite having normal estrus cycle length, no abnormality in the vaginal discharge, no palpable abnormality in the reproductive tract and calved at least once before and less than ten year of age.This syndrome results in extended intercalving intervals, ultimately reducing the calf crop yield.Crossbred cows exhibited a notably higher prevalence of repeat breeding compared to buffaloes and indigenous cows.The factors responsible for repeat breeding syndromeare diverse, encompassing anatomical, hormonal, management and infectious and vary from herd to herd and animal to animals.

Causes of repeat breeding syndrome
Repeat breeding can be caused by a number of factors, including:

1. Sub-fertile bulls, endocrine problems, malnutrition, reproductive tract infections and poor management practices.
2. Increased insemination frequency, extended calving intervals and having higher culling rates can contribute to repeat breeding.
3. Genetic, hormonal and nutritional imbalance, subclinicaluterine infections and early embryonic mortality may also contribute repeat breeding.
4. Inaccurate estrus detection frequently leads to cows becoming repeat breeders.
5. Factors such as breed, body condition score (BCS), number of breedable cows in each farm can influence the occurrence of repeat breeding in population. However, individual factors like age, parity, BCS, and milk yield also impact repeat breeding.

6. Fertilization failure and early embryonic death, influenced by uterine infection, genetics, ovulatory failure, error in estrus detection, improper timing of serviceare the major causes of repeat breeding.
7. Repeat breeding syndrome (RBS) in dairy cows is a complex issue involving the prepartum,peri-partum, and post-partum factors. Factors such as age, BCS, parity number, milk production, lactation length, age of puberty and calving age, number of services, gestation length can influence its occurrence.

The causes of repeat breeding are intricate, but be summarized as:

a) Management factors: improper timing of insemination, unable to detect heat and unskilled insemination.

b) Semen factors: low semen quality or infertile bulls.

c) Cow factors: endometritis, pyometra, mucometra, hydrometra, ovulatory defect, follicular cyst, adhesions, antibodies to seminal antigen, inappropriate uterine involution, infectious diseases, uterine tumours, anovulatory heats.

d) Environmental factors: heat stress, nutritional deficiencies.

Methods of Treatment of Repeat Breeding

Usually repeat breeder cows are diagnosed and treated by the veterinarians on the basis of history of the previous services and clinical examination of the cows. However, achieving accurate and successful treatment for repeat breeder cows is often challenging.

Nutritional treatments:

Feed the animal with nutritionally balanced diet. Diets having higher concentration of inorganic iodine from 8-12 days before estrus improves the stimulation of pituitary gland, reducing the repeat breeding rate.

Hormonal treatments:

Progesterone: essential for the implantation and maintenance of pregnancy. Administration of progesterone 3 to 5 days after insemination and for 2-3 weeks improves conception rate.

GnRH: One common approach is the induction of ovulation through the administration of gonadotrophin-releasing hormone (GnRH). GnRH is frequentlyused during artificial insemination to enhance conception rates in repeat breeding cows. Conducting two AI sessions within a single heat may also improve conception rates.

Prostaglandins: luteolytic effect of prostaglandins aims to achieve better heat detection and to increase the number of cows in heat.

Additionally, the intrauterine infusion of antibiotics, such as penicillin, has shown benefits in treating repeat breeder cows with subclinical uterine infections. The use of double doses of semen during AI has been employed to enhance conception rates in repeat breeding cows. Specific treatments for conditions like endometritis and delayed ovulation may be carried out whenever suspected them as the underlying cause.

If no specific cause is identified, the following guidelines may be followed.

1. Ensure that the animal is in positive nutrient balance.
2. Use good quality semen with more than 50% progressive forward motility.
3. Inseminate the cow at right time of the estrus, conducting AI twice at 12 to 24-hour interval.

4. Follow proper AI technique.
5. After AI, stimulate ovulation through clitoral massage or the administration of 100 micro grams of GnRH or 1500 IU of luteinizing hormone.
6. Skip the AI; administer 1 million units of penicillin in saline twice at 12-hour interval during estrus.
7. Flush the uterus with normal saline under moderate pressure to remove cellular debris/ mild blocks in oviducts.
8. Implement sexual rest for two consecutive cycles before resuming breeding.

Conclusion

In conclusion, addressing repeat breeding in dairy cattle requires a comprehensive understanding of its multifaceted causes and the implementation of diverse treatment strategies to reduce culling rates and enhance reproductive efficiency and overall herd productivity.

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TRANSGENIC FISH IN AQUACULTURE: A CASE STUDY

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Abstract

Aquaculture serves as a crucial method to satisfy the increasing global demand for fishery products but faces obstacles such as dwindling wild fish populations, environmental degradation, and disease susceptibility. In response, researchers have explored innovative strategies, including the utilization of transgenic fish—organisms harboring artificially introduced genes. This case study investigates diverse applications of transgenic fish in aquaculture. Case studies highlight transgenic fish applications: AquaBounty'sAquAdvantage Salmon, engineered for rapid growth with genes from chinook salmon; Tilapia with augmented cold tolerance via antifreeze genes; disease-resistant channel catfish, using CRISPR/Cas9 to integrate antimicrobial peptide genes; and fluorescent GloFish, created by inserting genes from marine organisms. These advancements promise enhanced productivity, disease resilience, and sustainability in aquaculture.

Keywords : Transgenic Fish, Case Study, Aquaculture,

Introduction

Aquaculture, the farming of aquatic organisms, has become essential for meeting the growing global demand for fishery products. However, traditional aquaculture faces challenges such as declining wild fish populations, environmental pollution, and disease outbreaks. In response, scientists have turned to innovative solutions, including the use of **transgenic fish**—fish that carry artificially introduced genes. These genetically modified fish offer exciting possibilities for sustainable aquaculture.

Case Study of different application of transgenic fish in aquaculture

1. Faster Growth and Improved Economics: Fast-Growing Salmon

Salmon is a highly prized fish, but traditional salmon farming has limitations. Slow growth rates mean longer production cycles, increasing costs and resource consumption.

Researchers decided to boost salmon growth using a **growth hormone (GH) gene** from another fish species. By inserting this gene into salmon embryos, they aimed to accelerate growth.

On November 19, 2015, the Food and Drug Administration (FDA) approved AquaBounty Technologies' application to produce AquAdvantage Salmon, a genetically engineered (GE) Atlantic salmon, for human consumption. The GM salmon—whose genome contains an inserted growth gene from Pacific chinook salmon (*Oncorhynchustshawytscha*) and a switch-on gene from ocean pout (*Zoarcesamericanus*). This is the first GE animal that has been approved for human consumption in the United States.

2. Enhanced Cold Tolerance: Cold-Resistant Tilapia

Tilapia, a tropical and subtropical freshwater fish, is one of the most farmed fishes globally due to its rapid growth and high nutritional value. However, Tilapia's sensitivity to cold weather, which can cause severe stress and mass mortalities, limits its cultivation in colder regions.

Scientists have discovered that certain genes, known as antifreeze genes, can enhance the cold tolerance of Tilapia. These genes include Integrin-alpha-2 (ITGA-2), Gap junction gamma-1 protein-like (GJC1), WD repeat-containing protein 59 isoform X2 (WDRP59), NUAK family SNF1-like kinase, G-protein coupled receptor-176 (GPR-176), Actin cytoskeleton-regulatory complex protein pan1-like (PAN-1), Whirlin protein (WHRN), Suppressor of tumorigenicity 7 protein isoform X2 (ST7P), and ATP-binding cassette sub-family A member 1-like isoform X2 (ABCA1).

When expressed, this gene produces an antifreeze protein that helps the fish survive in colder temperatures by preventing ice crystal formation within their cells.the integration of antifreeze genes has shown to significantly enhance the cold tolerance of Tilapia.

3. Disease Resistance: Disease-Resistant Catfish

Channel catfish (*Ictalurus punctatus*) is a popular species in aquaculture, but it is susceptible to various diseases. To enhance disease resistance, scientists have used CRISPR/Cas9-mediated genome editing and transgenesis to integrate antimicrobial peptide genes (AMGs) into the fish's genome.

In one study, researchers integrated the cathelicidin gene from an alligator (Alligator sinensis; As-Cath) into the luteinizing hormone (LH) locus of channel catfish using two delivery systems assisted by double-stranded DNA (dsDNA) and single-stranded oligodeoxynucleotides (ssODNs). The resulting transgenic catfish line (LH–_As-Cath+) displayed heightened disease resistance and reduced fecundity compared to the wild-type sibling fish.

4. Ornamental Fish: Glowing Zebrafish

The creation of GloFish involves the insertion of a gene from a marine organism into the Zebrafish's genome. This gene causes the fish to produce a fluorescent protein that makes them glow. The green fluorescent protein (GFP) gene, originally extracted from the jellyfish *Aequoreavictoria*, was one of the first genes used to create GloFish.

In addition to the GFP gene, other fluorescent protein genes have been used to create GloFish of different colors. For example, the red fluorescent protein (RFP) gene, found in Discosoma sp. mushroom anemones, has been used to create red glowing GloFish.

Once the genes are inserted, they become a permanent part of the Zebrafish's genome and are passed on to future generations. This means that once a GloFish is created, it will continue to glow throughout its life, and its offspring will also inherit the ability to glow.

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OPTIMIZING SEED STORAGE: PRINCIPLES, OBJECTIVES, AND STRUCTURES

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Abstract

Seed storage is crucial for preserving seed viability and ensuring successful plant growth. This article explores the importance, principles, and purposes of seed storage, emphasizing factors affecting storage, seed classification, and stages of storage. It delves into steps for effective seed storage, including protection from pests and labeling. Additionally, the article discusses various storage structures, from traditional to modern, highlighting their roles in maintaining seed quality.

Seed storage may be defined as the preservation of viable seed from the time of collection until they are required for sowing. Seeds should be stored in such a manner, that its germination capacity and vigour should not decline.

Importance

1. To preserve seeds finer conditions that best retain germinative energy during the interval between collection and time of sowing.
2. To protect seeds from damage by rodents, birds, and insects.
3. To preserve qualities of seeds collected during a year of heavy seed crops to furnish a supply during years of little or no crop.

Principles

1. Seed storage conditions should be dry and cool
2. Effective storage pest control
3. Proper sanitation in seed stores
4. Before placing seeds into storage, they should be dried to safe moisture limits.
5. Storing of high-quality seed only i.e., well cleaned treated as well as high germination and vigour.

Purpose

The purpose of seed storage is to maintain the seed in good physical and physiological condition from the time they are harvested until the time they are planted. It is important to get adequate plant stands in addition to healthy and vigorous plants.

Objectives

To maintain initial seed quality viz., germination, physical purity, vigour etc., all along the storage period by providing suitable or even better conditions.

Different Stages of Seeds Storage

The storage of seeds is initiated at the time of attainment of physiological maturity and maintained till the next sowing season. Hence, the different stages involved in seed storage are as follows:

1. Period from physiological maturity to harvest

2. Period from harvest to packaging
3. Period from packaging to storing
4. Period from storing to marketing of seeds.
5. On farm storage (Purchased seeds used for planting in the field). Storage in the godown is highly influenced by external environmental conditions. All other stages should be monitored, and care should be taken to ensure the physical purity, germination viability and vigour of the seeds.

Steps in Seed Storage

The major steps involved in seed storage are:

1. Store only new, mature, healthy and well-dried seeds.
2. Keep them in dry and cool place to extend their viability.
3. Seeds easily re-absorb moisture. To maintain dryness, keep seeds in air-tight containers like tin cans or glass jars with tight fitting lids.
4. Put in some moisture absorbing material. Dry wood ash, dry charcoal, powdered milk, toasted (cooled) rice, or small pieces of newspaper are all good. The drying material should take up about one-fourth of the container space.
5. Label the containers with the type of seed, place, and date of collection.
6. If possible, include the initial percent viability of the seeds. To do this, plant some seed to see how many germinate. If 8 of 10 germinate, for example, percent viability is 80%. This information will help you to learn about how much each type of seed loses viability between collection and planting.
7. Protect seeds from insects and fungi. Before storing in containers, mix with dry ash, powdered seeds of black pepper or neem leave. Or use extract of neem, peanut, castor bean, or cotton: 1 teaspoon oil/1 kg seed or use naphthalene balls: 1 or 2 pieces/10 kg seed.
8. Protect from rodents and birds during storage.

Factors Affecting Storage

1. Biotic factors

a. Factors related to seed

i. Genetic make-up of seed
ii. Initial seed quality
iii. Provenance
iv. Seed moisture content.

b. Other biotic factors

i. Insects Fungi
ii. Rodents
iii. Mishandling during sampling, testing.

2. Abiotic factors:

a. Temperature
b. Relative humidity
c. Seed store sanitation
d. Gaseous atmosphere
e. Packaging material
f. Seed treatment.

Classification of Seeds

Based on storage seeds can be categorized into three types based on the longevity of the seeds during storage.

1. Orthodox seeds: Seeds that can be dried, without damage to low moisture contents (5 – 10%). They can be stored at subfreezing temperature 2 to 5 OC. Their longevity increases with reductions in both moisture content and temperature. Eg. Rice, Maize etc.

2. Intermediate seeds: These seeds can also be stored for longer period, but it cannot withstand low temperature. It tolerates the drying to low moisture level.Tolerate desiccation to about 10-12 % moisture content. Eg.Legumes, Papaya, Citrus etc.

3. Recalcitrant seeds: These seeds do not survive drying to any large degree and are thus not amenable to long term storage. Recalcitrant seeds killed by desiccation to 15-20% moisture content. e.g., Mango, Jack etc.

Storage Godowns& their Maintenance

Seeds undergo deterioration due to aging in storage. This is accelerated by climatic factors and external biotic factors like insects and pathogen. Clean and hygienic godowns protect the seed from external insects and preserve the seed. Hence care should be taken in construction of godown.

Selection of Storage Godown

For loading and unloading operations, the storage area should be freely accessible. The seed moisture content must be maintained; hence the storage environment must be reasonably moisture proof. It is necessary to keep the godown clean and dry. Termite and rodent proof storage should be provided. There should be no fractures or holes in the storage godown's wall or floor.

Spraying a neem oil solution using 200 ml of neem oil and 2 litres of water will eliminate the infestation. It is recommended for a single 200-square-feet storage space. After spraying neem oil solution, the rooms can be fumigated with the powder of sweet flag rhizome (Acorus calamus). Before stacking the seeds or grains, the storage godowns or rooms and storage structures or receptacle should be cleaned and made free from insects.

Seed Storage Structures

1. For good seed storage, always use sealed containers
2. After seed has been dried properly, store it in tin cans, metal boxes, glass jars, or plastic bags or container with lids that can be sealed.

Modern Storage Structures

1. Pusa bin: It is constructed from unburned brick. To make it airtight, a polyethylene sheet is inserted between two brick walls. For loading and unloading, the inlet is at the top of the bin, and the outlet is at the bottom. To prevent rat damage, bins are made of a few layers of burnt bricks plastered with cement at the bottom.

2. Storage in metal drums: Metal drums are used by farmers to store sorghum, maize, millets, and groundnuts. The drum's capacity is 600 kg, and it should be clean and dry before being stored. A funnel is used to load the drum with seeds, which are then snugly sealed with a cap. Seeds can be secured from rodents, and the drums can be readily fumigated to keep pests away from the seeds.

3. Pucca kothi: It's an indoor building made from charred bricks and cement. It is built on an elevated floor, and after embedding the polythene sheet, the walls should be plastered to make it airtight. The structure's inlet is at the top and its outflow is at the bottom. For wall reinforcement, the inner layer should be reinforced with iron bars. This structure is utilised to keep the stored product's moisture level at the same level as when it was first stored. The capacity of rural houses varies depending on the amount of space available.

4. Ghareluthekka: This structure has a storage capacity of 1 to 3 metric tonnes. Metal base with fabricated 22-gauge sheets, rubberized cloth container, and bamboo poles for lateral support make up the structure. The construction stands at a height of 2 metres. The building is waterproof and airtight, and it may be fumigated on a regular basis.

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USING BIODYNAMIC TECHNIQUES IN ORGANIC AGRICULTURE [BD 501]

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Introduction

An ethical, ecological, and holistic approach to farming, gardening, food, and nutrition is known as biodynamics. Since the 1920s, biodynamics has developed and changed thanks to the cooperation of numerous farmers and researchers. Biodynamics is practiced in hundreds of flourishing gardens, farms, vineyards, ranches, and orchards across the globe. Anywhere food is cultivated, biodynamic principles and practices can be used with careful consideration for size, environment, climate, and culture.

Bios=life dynamic=energy

He clarified how the study of dead objects in labs, as opposed to the observation of living nature and the complex connections that are always shifting within it, is the foundation of modern research and, by extension, chemical agriculture. He mentioned the universe's orbiting planets and stars as part of this web of life, and he talked about how, in the past, farmers had an innate understanding of how these movements affected plant, animal, and human life. In order to learn how to best cooperate with nature, we contemporary humans need to rediscover this connection—but this time, in a very deliberate, measurable way.

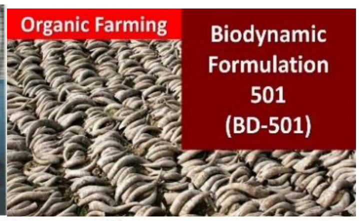
Life is the study of energy from coarse to fine, and Biodynamics focuses on the higher forces, the finer energies, and how they affect plants, animals, and humans. This knowledge and labour with the life forces restores balance and healing to the soil, as well as to everything that grows in it and consumes the plants.

Biodynamic agriculture has several benefits

- Including increasing food vitality,
- Regenerating natural resources like soil, seeds, and water,
- Fostering a personal relationship with nature, and promoting collaboration.
- It also serves as a service to the Earth and its inhabitants by addressing areas of weakness due to constant use.

Preparation

Particular The application of biodynamic measures dates back more than 65 years. Many gardeners and farmers have firsthand knowledge of their impacts. Additionally, experimental data has been generated, expanding the body of empirical information already in existence. Two categories of specially fermented substances, referred to as preparations, are part of the measures. The first group, which has six distinct herbal compounds with the numbers 502–507, is introduced in little amounts to composts and manures. Thus, they are referred to as compost as a group getting ready. The people who initially developed the preparations chose these arbitrary numbers. The sprays, which have the numbers 500 and 501, are part of the second group. A ninth preparation, often known as 508, is created by boiling the horse tail plant and is applied exclusively in extremely wet years to prevent fungal illnesses, even though it is not one of the eight primary preparations.




Filling cow horns with fresh cow dung


Burying the horns with base downwards


Horn manure removed from the horns after 4 months


Horn silica removed from horns filled with silica crystals, 6 months after burial

Cow horn silica (BD 501)

These are specially manufactured, finely powdered quartz crystals. The crystal needs to be clear, well-shaped, and of high quality. Similar to preparation 500, it is buried, but this time it is done in the summer (buried in April/May and lifted in September). During summer, when the planet is exhaling the most, cosmic light energy is at its peak.

Materials

- Cow horn
- The silica quartz crystal needs to be well-formed and transparent. 200–300 grammes on average of powdered quartz crystal or horn

Procedure for preparation

- Crush silica quartz with a pounding rod, mortar and pestle, or hammer.
- Finely grind between two plate glasses.
  First glass - 12" square, 9 mm thick, with a wooden frame.
  Second glass: 4" square glass plate set in a hardwood block (handle).
- Avoid inhaling quartz dust, as it might cause silicosis. It is recommended that masks be provided during the preparation.
- Mix with water to form a firm paste.
- Fill the horns with silica paste.
- From March/April (spring equinox) to September (autumn equinox), place horns in a soil pit 1 inch apart with the base facing downwards. Cover with 50% compost and soil.

Procedure for applications

Only apply 501 following one or two BD 500 applications. Use in the early morning, between 6 and 8 a.m., at sunrise, during the ascending Moon or Moon opposition Saturn, when the dew is rising (the earth is exhaling).

- Mix 1 gramme silica (enough to cover a little fingernail) in 15 litres of warm water.
- To create a vortex, dissolve silica in water and mix for 1 hour before sunrise, rotating clockwise and anti-clockwise alternately.

- Spray plants using a low-pressure sprayer (Knapsack 80-100 psi). Spray into the air to fall as a soft mist on the plants.
- Spray twice during the planting cycle: at the start and immediately before harvest.

Storage

For up to three years, store in a glass jar with a loose-fitting lid and place it in an open space that gets sunshine.

Impact/outcome

- Enhances photosynthesis, light metabolism, and chlorophyll.
- Aids in improving plant colour, flavour, and preservation.

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LEVERAGING AI AND IOT BASED TECHNOLOGIES FOR SUSTAINABLE WATER MANAGEMENT IN RESERVOIR COMMAND AREA

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ABSTRACT
India faces a unique water crisis, impacting agriculture and sustainability. This article explores the potential of AI and IoT to address challenges in command area water management, reservoir operations, and canal water release. AI optimizes irrigation scheduling, forecasts demand, and predicts pest outbreaks, while IoT sensors monitor water levels, flow rates, and quality in real-time. These technologies can optimize reservoir releases, prevent leaks, and guide data-driven decisions. However, cost, data security, and infrastructure limitations exist. Blockchain and advanced AI offer future opportunities for enhanced security, real-time optimization, and community engagement. By embracing these technologies and addressing challenges, India can move towards a future of sustainable and efficient water management.

Keywords : Water Crisis, AI, IoT, Water Management, Sustainable Agriculture, Real-time Data, Block chain

1. INTRODUCTION

1.1 Water crisis

India is not only facing the global water crisis, but also experiencing its **unique complexities**, making agriculture particularly vulnerable. India is home to 18% of the world's population but only 4% of its freshwater resources. This disparity, coupled with uneven distribution, creates water stress in many regions. Overreliance on groundwater for irrigation has led to alarming depletion rates, with some states exceeding sustainable limits.Monsoons are the primary source of water, but their erratic nature leaves vast areas vulnerable to droughts and floods.Traditional flood irrigation methods waste a significant amount of water, further exacerbating the crisis (Kelaiya and Rank, 2019; Kumar and Rank, 2021; Rank et al., 2020; Kumar and Rank, 2023).

1.2 Impact on agriculture

Water scarcity directly impacts crop yields, threatening food security for millions. Shifting to less water-intensive crops is difficult due to market demands, farmer knowledge, and infrastructure constraints (Patel *et al,* 2014, Patel *et al,* 2019, Rank *et al.,* 2016, Patel, 2019, Patel and Rank, 2020, Patel *et al.,* 2023a, Patel *et al,* 2023b,). Overexploitation of groundwater leads to salinization of soil, rendering it unproductive. Water scarcity and crop failures contribute to farmer debt and suicides, posing a significant social and economic challenge. Strategic land and water management is equally crucial for productivity and sustainable water resource management (Allen*et al*, 1998, Patel and Rank, 2020; Vekariya*et al.*, 2022; Patel *et al.,* 2023a, Patel *et al.,* 2023b; Rank *et al.*, 2023b; Vekariya*et al.*, 2023). Paghadal*et al.*, 2019a). Managing water resources effectively for such a large and diverse population requires innovative solutions. Lack of adequate infrastructure like canals and storage facilities hinders efficient water distribution and management.Implementing effective water policies and ensuring their enforcement across different states is crucial (Rank *et al.,* 2019; Rank *et al.,* 2022a, Rank *et al.,* 2022b, Rank *et al.,* 2022c; Rank and Satasiya, 2022; Rank and Vishnu, 2019, Rank and Vishnu, 2021a, Rank and Vishnu, 2021b, Rank and Vishnu, 2023c).

1.3 Challenges in reservoir operations and command area water management

Traditional flood irrigation methods lead to high water losses (up to 50%) through evaporation, seepage, and runoff. Aging canals and distribution systems suffer from leaks and blockages, further reducing water delivery efficiency. Manual monitoring of water levels and demand makes it difficult to optimize water allocation based on real-time needs. Lack of defined water entitlements for farmers leads to inequitable distribution and disputes. Top-down water management excludes farmers' knowledge and needs, hindering adoption of efficient practices. Many reservoirs are not designed for current demand, leading to overflow during monsoons and insufficient water during dry periods. Sedimentation reduces storage capacity and impacts water quality. Reliance on historical data for inflow predictions limits preparedness for extreme weather events. Multiple agencies manage different reservoirs, hindering optimal water sharing and release decisions. Manual gate control is inefficient and prone to human error, leading to water level fluctuations and uneven distribution. Real-time monitoring of canal water levels and flow is absent, making it difficult to detect and address leaks promptly. Over long distances, evaporation losses further reduce water utilization during canal transport. Poor canal maintenance leads to siltation and damage, impacting water flow.

The climate change have increased the extremities of droughts and floods which have posed new challenges for water management (Paghdal*et al,* 2019a, Paghdal*et al,* 2019b). Urbanization and industrial growth put additional pressure on limited water resources. Inadequate funding hinders infrastructure upgrade and adoption of modern technologies.These traditional challenges significantly impact water efficiency, equity, and sustainability in India's water management system. Addressing them through innovative solutions like AI and IoT is crucial for ensuring water security and agricultural productivity in the face of growing demands and climate change threats.

2. AI FOR COMMAND AREA WATER MANAGEMENT

AI analyses factors like crop type (thirsty rice vs. drought-tolerant millet), weather data (upcoming heat wave vs. predicted rainfall), and real-time soil moisture to create precise, dynamic irrigation schedules. This ensures crops receive the perfect amount of water they need, not a drop more or less, maximizing yield while minimizing water waste, leading to a more sustainable and productive future for agriculture.AI empowers dynamic adjustments based on actual water needs. By analysing historical patterns, weather forecasts, and even crop health data, AI forecasts future water demand with remarkable accuracy. This allows for real-time adjustments to irrigation schedules, ensuring water availability even when faced with unexpected downpours or scorching heat waves. No more overwatering healthy crops or leaving thirsty ones parched- AI ensures every drop counts, leading to smarter, more efficient water management. By analysing historical data and weather patterns, it predicts potential outbreaks before they strike. This allows for targeted water application – only affected areas receive irrigation, minimizing unnecessary waste. Imagine: thirsty crops get their drink, while pests and diseases face a drought of their own. This intelligent approach not only optimizes water use but also protects crops, leading to healthier yields and a more sustainable agricultural future.

3. IOT FOR RESERVOIR OPERATIONS AND CANAL WATER RELEASE

Imagine a network of tiny sentinels strategically placed across fields, canals, and reservoirs. These aren't mythical creatures, but IoT sensors, acting as the eyes and ears of water management. These intelligent devices continuously collect data, offering a real-time glimpse into the world of water. For water levels, multiple sensors like ultrasonic and pressure sensors can be deployed.

Ultrasonic sensors emit sound waves and measure their bounce-back time, accurately gauging water depths in canals, reservoirs, and even wells. Similarly, pressure sensors placed at specific points can detect changes in water levels, providing valuable insights into flow rates and overall water volume. Flow rates are another critical parameter monitored by IoT. Flow meters, often featuring electromagnetic or ultrasonic technology, can be installed within canals or pipes. They measure the speed and volume of flowing water, enabling real-time tracking of water movement and potential leaks. But it's not just quantity, it's also quality. IoT sensors can be equipped with specialized probes to monitor various water quality parameters. Turbidity sensors measure water clarity, while pH sensors assess its acidity or alkalinity. Dissolved oxygen sensors track the health of aquatic ecosystems, and even nitrate and phosphate sensors can detect potential contamination. These sensors aren't just passive observers. They transmit data wirelessly to centralized platforms where it's processed and visualized in real-time. Imagine dashboards displaying live water levels, flow rates, and quality readings from across your entire water management system. This empowers informed decisions, allows for immediate response to fluctuations, and ultimately leads to efficient and sustainable water management.

Real-time data from IoT sensors becomes the lifeblood of optimizing reservoir releases and preventing the costly extremes of overflow or depletion. Water level and inflow: Sensors continuously monitor water levels and inflows, providing a dynamic picture of reservoir status. This replaces reliance on infrequent manual readings, offering immediate insights into potential changes. Weather data integration: Real-time weather data from nearby stations feeds into the system, allowing predictions of upcoming rainfall or droughts, crucial for anticipating future inflows and adjusting releases accordingly. AI-powered algorithms analyze historical data, current sensor readings, and weather forecasts to create predictive models of future water availability. These models anticipate potential scenarios like overflow risks during heavy rains or depletion during prolonged dry spells. Based on these predictions, the system can recommend optimal release schedules. During high inflows, controlled releases can prevent overflow, while during droughts, releases can be adjusted to conserve water and prioritize critical needs. Automated release systems can be integrated, translating recommendations into action. This allows for real-time adjustments to releases based on changing conditions, eliminating the need for manual intervention and ensuring swift responses to critical situations. The system can trigger alerts for potential overflow or depletion risks, allowing authorities to take proactive measures like evacuating downstream areas or seeking additional water sources. Overall, real-time data empowers proactive, data-driven reservoir management, preventing costly extremes and ensuring sustainable water use. This not only protects lives and infrastructure but also optimizes water availability for various needs, leading to a more resilient and water-secure future.

Canals, the arteries of our water systems, are unfortunately prone to leaks, silently draining precious resources. These listen for the tell-tale gurgling of escaping water, pinpointing leaks even underground. Detecting sudden drops in flow at specific points can indicate a leak further downstream.Monitoring pressure changes along the canal can reveal leaks that disrupt water flow patterns. Leaks are detected in real-time, triggering alerts to maintenance teams for prompt action. Sensor data helps pinpoint the exact location and severity of the leak, guiding repair efforts efficiently.Teams can monitor repairs remotely, optimizing resource allocation and reducing response times.Analysing sensor data over time can predict potential leaks before they occur, enabling preventive maintenance and further reducing water loss.Automated valves can isolate leaks, minimizing water loss during repairs and optimizing water distribution.By implementing these solutions, IoT can significantly reduce canal water loss, a major challenge in water management. This translates to conserved water resources, improved system efficiency, and ultimately, increased water security for communities and agriculture.

4. INTEGRATING AI AND IOT FOR HOLISTIC WATER MANAGEMENT

Imagine a system that can predict your water needs before you even ask. That's the power of AI combined with IoT sensors. These sensors collect a treasure trove of data - water levels, flow rates, weather patterns, and even crop health information. But raw data is just the beginning. AI steps in, wielding its analytical prowess to unlock hidden patterns and trends. It analyses historical data, real-time sensor readings, and even external factors like weather forecasts to create predictive models of water demand and availability. These models are like crystal balls, peering into the future to anticipate potential droughts, floods, or even seasonal fluctuations in crop water needs. With this foresight, water management becomes proactive, not reactive. Releases from reservoirs can be optimized, irrigation schedules can be tailored precisely, and potential water shortages can be identified and addressed before they become crises. This is not just efficient water management, it's a glimpse into a future where water security is a reality, not a dream.

Imagine a war room for water, where real-time data flows in from sensors and AI analyses it alongside historical records and weather forecasts. This is the future of water management, where AI and IoT join forces with decision-support systems (DSS) to guide informed choices. These DSS act as intelligent assistants, crunching vast amounts of data from sensors and AI models to present clear insights and recommendations. Think of it like having a personalized water advisor, highlighting potential issues like low reservoir levels or high crop water demand days in advance. Stakeholders can then use this foresight to optimize reservoir releases, adjust irrigation schedules, or even trigger early interventions in case of droughts or floods. This collaborative approach between AI, IoT, and DSS empowers data-driven decisions, leading to a more proactive, efficient, and ultimately sustainable management of our precious water resources.

The integration of AI and IoT in water management holds immense potential, unlocking a future of harnessing the ultimate potential of project, enhanced water use efficiency, improved crop yields, and reduced environmental impact. AI-powered systems optimize irrigation based on real-time needs, eliminating overwatering and saving precious water. IoT sensors instantly detect leaks, enabling swift repairs and minimizing water loss in canals and distribution systems. AI predicts future demand and availability, allowing for optimized reservoir releases and proactive measures during droughts.AI tailors irrigation and nutrient application to individual crop needs, maximizing yield potential.AI-powered models identify potential threats early, enabling targeted interventions and reducing crop losses. Farmers gain valuable insights from real-time data to optimize crop management and boost productivity.Efficient water use conserves valuable resources and protects vulnerable ecosystems. Precise water and nutrient application reduces agricultural runoff, promoting healthier soil and water quality. Data-driven water management allows for better adaptation to changing weather patterns and promotes long-term sustainability.By integrating AI and IoT, we can move beyond traditional water management practices towards a future where every drop counts. This not only secures water resources for generations to come but also fosters a more sustainable and productive agricultural sector, benefitting both farmers and the environment.

5. CHALLENGES

While the potential of AI and IoT in water management is undeniable, there are challenges that need to be addressed. Implementing these technologies, including sensor installation, AI software, and data management systems, can be expensive, especially for resource-constrained regions. Creative financing models and subsidies are crucial to bridge this gap and ensure wider adoption.With vast amounts of sensitive data collected, robust cyber security measures are essential to prevent cyber-attacks and protect critical water infrastructure. Investing in data encryption, access control, and incident response protocols is crucial.Many regions lack the necessary infrastructure, such as reliable internet connectivity or well-maintained sensor networks, to fully utilize these technologies. Upgrading and expanding infrastructure requires significant investment and collaboration between stakeholders.Farmers and water management personnel need training to understand and utilize these technologies effectively. Capacity-building programs, knowledge sharing initiatives, and user-friendly interfaces are essential for successful implementation.Concerns around data privacy and equitable access to water resources need to be addressed. Transparency, responsible data governance, and inclusive participation from all stakeholders are crucial for ethical implementation.Despite these challenges, overcoming them through collaborative efforts, innovative solutions, and a commitment to responsible development can unlock the immense potential of AI and IoT for revolutionizing water management. By addressing these challenges head-on, we can pave the way for a future where water security, efficient agriculture, and environmental sustainability are no longer dreams, but realities.

6. FUTURE OPPORTUNITIES

The integration of AI and IoT in water management is still in its early stages, but the future holds exciting possibilities for further innovation. Block chain-based systems can securely store and share water data, ensuring immutability and tamper-proof records, critical for sensitive water management information. Block chain can empower communities and stakeholders to participate in data governance and decision-making, fostering transparency and trust in water management systems. AI can analyse diverse data like satellite imagery and sensor readings to provide hyperlocal weather predictions, enabling more precise water management decisions at the field level.AI-powered pricing models can adjust water tariffs based on real-time demand and availability, promoting efficient water use and cost recovery. Integrating robots with AI and IoT can automate tasks like dam inspection, leak repair, and data collection, improving efficiency and safety in water management.Utilizing satellite imagery and drone data alongside IoT sensors can provide a comprehensive picture of water resources and infrastructure, enabling holistic management strategies.Citizen science initiatives can leverage mobile apps and sensors to collect real-time water data from individuals, contributing to broader water management insights.By integrating citizen feedback and local knowledge with AI and IoT data, water management can be more responsive to community needs and priorities.

While these opportunities are promising, it's crucial to address ethical concerns, data privacy issues, and ensure equitable access to these technologies. By fostering collaboration among researchers, policymakers, farmers, and communities, we can leverage AI and IoT to create a future where water management is sustainable, efficient, and inclusive.Remember, this is just a glimpse into the future. As technology continues to evolve, we can expect even more innovative solutions to emerge, shaping a water management landscape that is dynamic, responsive, and resilient in the face of growing challenges.

CONCLUSION

The path of optimizing irrigation to predicting reservoir needs, AI and IoT explore a promising picture for water management. In command areas, they personalize irrigation, ensuring optimal crop yields with minimal waste. Real-time data empowers reservoir operations with foresight, preventing overflow and depletion. Canal water releases become data-driven, minimizing losses and ensuring equitable distribution. These smart solutions are not just drops in the bucket, they hold the potential to revolutionize water management, addressing the global water crisis and paving the way for a sustainable future. As we hug these technologies and address implementation challenges, we move closer to a world where every drop counts, and water security is a reality for all of us at present and future.

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UNDERSTANDING THE DYNAMICS OF THE FLAVOURED MILK MARKET: A COMPREHENSIVE MARKET ANALYSIS

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Abstract

The flavoured milk market represents a dynamic sector within the dairy industry, experiencing steady growth and innovation fuelled by evolving consumer preferences and health consciousness. This article provides a concise overview of the Market size and opportunities within the flavoured milk segment by details statistical Data Analysis of consumer preferences. Emphasizing market trends, Flavour Analysis, and consumption trends, the article outlines emerging market dynamics.Flavour Analysis indicates total number of launches increased from 20 in Q1 2023 to 152 by Q1 2024, indicating growth in Flavour Launches over time. The most in demand flavour chosen by respondents during the study was Chocolate followed by almond, vanilla, mango, butterscotch and strawberry. Article also gives analytical study on consumer preference in packaging selection- PET, TetraPak or Plastic Cups. By understanding the intersection of consumer demand, industry innovation, and market expansion, manufacturers and retailers can navigate the flavoured milk landscape with agility and seize opportunities for sustained growth and competitiveness in the years ahead.Overall, these positive market dynamics and consumer trends are projected to sustain the flavoured milk industry's growth trajectory in India. The market is anticipated to grow even more in the upcoming years as businesses keep investing in marketing and product development.

Introduction

FSSAI defines Flavoured Milk as a product prepared from milk or other products derived from milk, or both, and edible flavourings with or without addition of sugar, nutritive sweeteners, other non-dairy ingredients including, stabilisers and food colours.

Among Indians, Traditional Flavors such as chocolate, strawberry, and mango remain popular choices, while newer variants like elaichi (cardamom) and kesar (saffron) cater to regional taste preferences. Market research indicates a promising outlook for the segment, with projections of sustained growth in the coming years.

Market Size & Growth Trends

The flavoured milk market in India reached **INR 41.6 billion in 2022**. Looking forward, it is expected to reach **INR 158.6 billion by 2028**, exhibiting a growth rate **(CAGR) of 25.8% during 2023-2028**

The strong growth of the market can be attributed to the rising health consciousness among consumers which has led to a shift towards dairy based products. Some of the other growth inducing factors include increasing disposable incomes and growing population.Moreover, the expansion of cold-chain infrastructure in the country is enabling easier distribution and storage of flavoured milk, thereby expanding its reach in remote areas. This expansion in distribution channels is also increasing by aggressive marketing strategies adopted by key players, including attractive packaging and promotional campaigns.

DATA ANALYSIS:

Understanding Consumer Behaviour and Preferences by Data Analysis through Statistical Methods:

Based on Results collected after analysing reports from Mintel- A Global Market Intelligence & Research Agency,
In a research survey, a sample population of 3000 respondents, when asked if they had consumed any packaged flavoured milk in past 3 months, 60% responded as yes
Several questions were asked and data was analysed.

1) How often did you consume flavoured milk? (Fig 1.1)

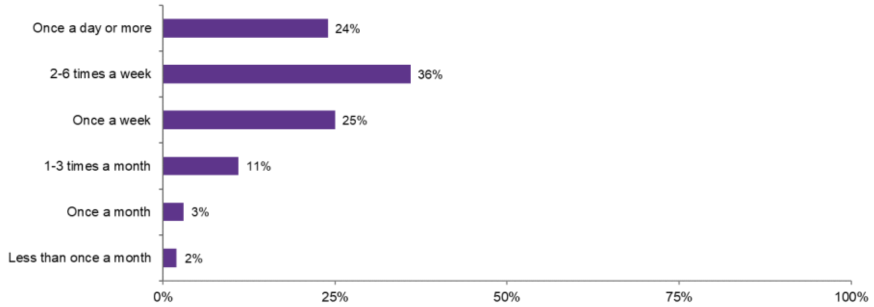

Fig 1.1: Base: 1,813 internet users aged 18+ who have consumed packaged flavoured milk in the last 3 months.

2) Why have you consumed flavoured milk in past 3 months? (Fig 1.2)

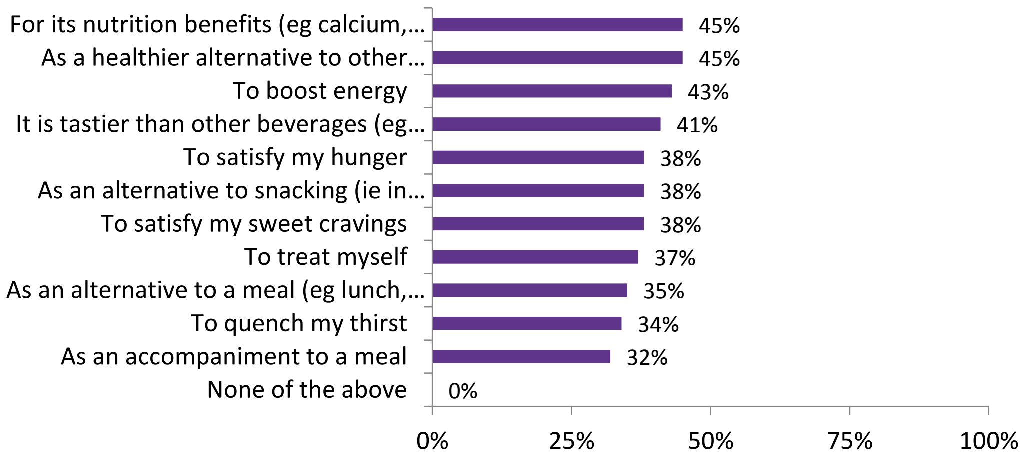

Fig 1.2: Base: 1,813 internet users aged 18+ who have consumed packaged flavoured milk in the last 3 months.

3) Which of the following statements do you agree with? (Fig 1.3)

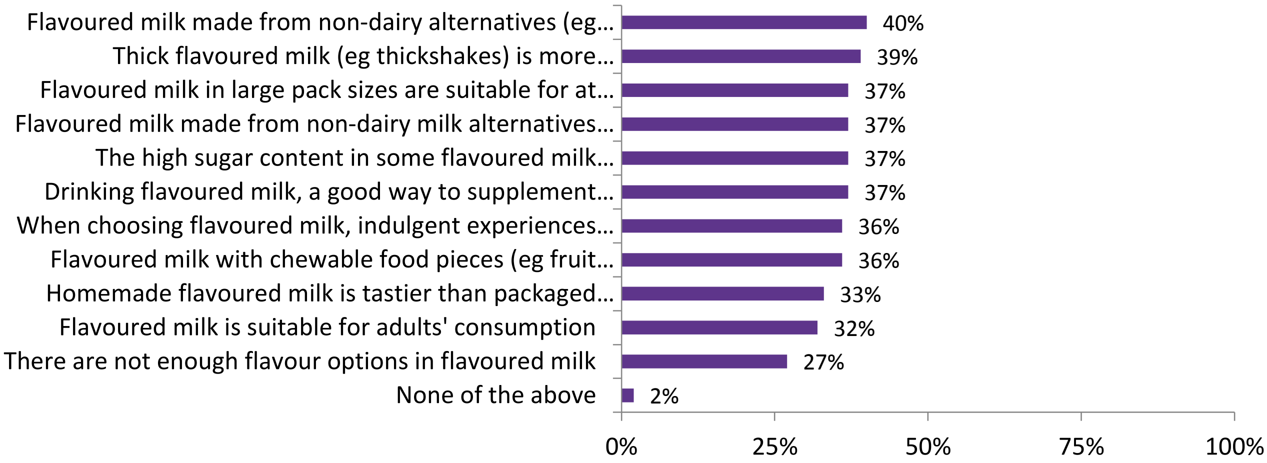

Fig 1.3: Base: 3000 internet users aged 18+ who have consumed packaged flavoured milk in the last 3 months.

4) Which of the following are you most interested in when choosing flavoured milk product? (Fig 1.4)

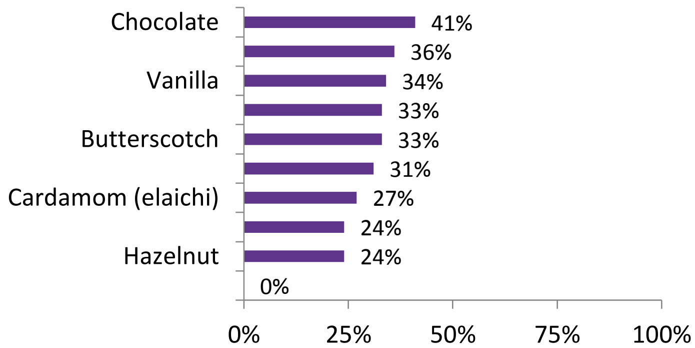

Fig 1.4: Base: 1813 internet users aged 18+ who have consumed packaged flavoured milk in the last 3 months.

5) Which of the following are you most interested in when choosing flavoured milk product?

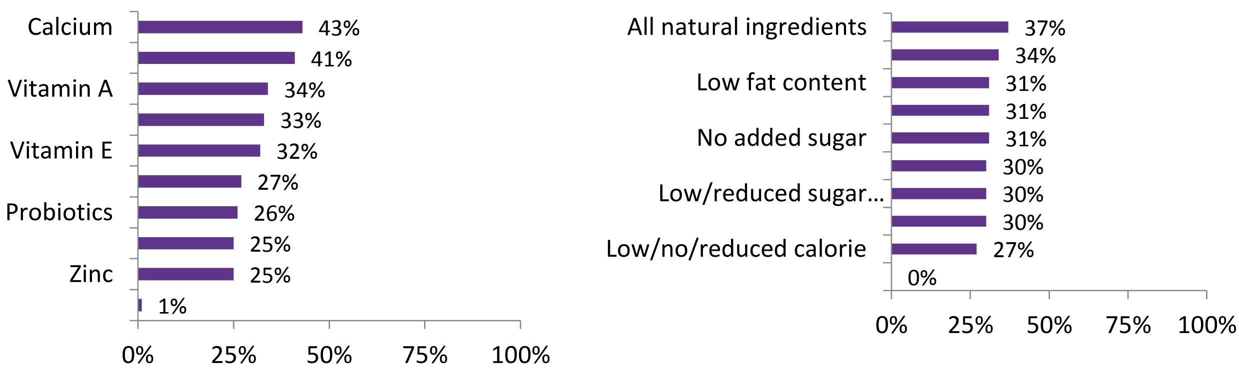

Fig 1.5: Base: 1813 internet users aged 18+ who have consumed packaged flavoured milk in the last 3 months.

6) Which of the following are you most interested in when choosing flavoured milk product? (Fig 1.6)

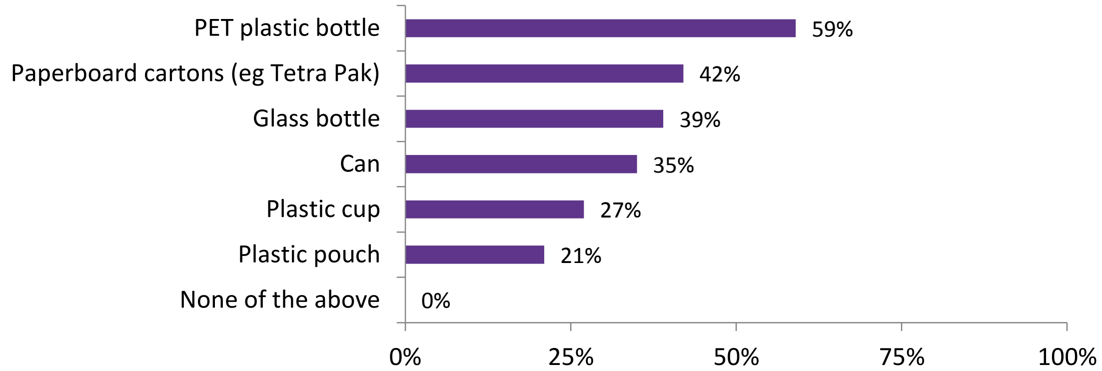

Fig 1.6: Base: 1813 internet users aged 18+ who have consumed packaged flavoured milk in the last 3 months.

FASTEST GROWING FLAVOURS:

Overall Trends: The total number of launches increased from 20 in Q1 2023 to 152 by Q1 2024, indicating growth in Flavour Launches over time.

Flavour Preference: Unflavoured is consistently the most popular flavour across all quarters, followed by Chocolate. Strawberry, Vanilla, Almond, and Saffron have fewer launches compared to Unflavoured and Chocolate.

Changes Over Quarters:

Unflavoured and Chocolate maintain a relatively consistent number of launches over quarters, with slight decreases in Q1 2024.

Strawberry shows fluctuation, with a peak in Q4 2023 and no samples in Q1 2024. Vanilla remains relatively stable.

Almond has a peak in Q2 2023 and then declines gradually.

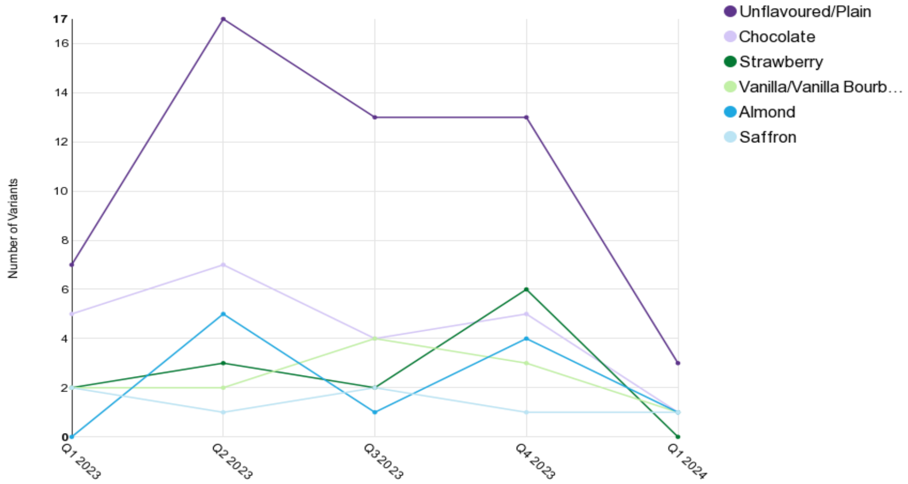

Fig 1.8: Graphical Analysis

Flavour	Q1 2023	Q2 2023	Q3 2023	Q4 2023	Q1 2024	Total Sample
Unflavoured/Plain	7	17	13	13	3	53
Chocolate	5	7	4	5	1	22
Strawberry	2	3	2	6	0	13
Vanilla/Vanilla Bourbon/Vanilla Madagascar	2	2	4	3	1	12
Almond	0	5	1	4	1	11
Saffron	2	1	2	1	1	7
Total Sample	20	47	37	36	12	152

Fig 1.9: This Table indicates number of flavours launches in 2023 and 2024

CONCLUSIONS

It can be concluded from the analytical study that flavoured beverages is a promising sector having growing demand and people mostly consume flavoured beverages 2-6 times a week largely for its nutritional benefits, as a healthier alternative to other beverages, to boost energy and to satisfy ones sweet cravings.Most of the population agrees with flavoured milk from non-dairy alternatives, thick flavoured milk, flavoured milk with chewable food pieces etc.

The most in demand flavour chosen by respondents during the study was Chocolate followed by almond, vanilla, mango, butterscotch and strawberry.Most of the respondents considered checking Calcium content, Protein, vitamin A and Iron content while consuming a drink.

It can also be concluded that Respondents are interested in a flavoured milk derived from all natural ingredients and natural sweetener as compared to artificial ones.

While moving over to Packaging, a major conclusion can be drawn that most consumers (Almost 59%) while choosing flavoured milk preferred PET Plastic Bottle & 42% preferred Tetra Pak. Plastic cup and Plastic Pouch are the least preferred Packaging materials.

In conclusion, the flavoured milk market in India presents a lucrative opportunity for manufacturers and retailers to cater to the diverse tastes and preferences of consumers across the country. By understanding local preferences, embracing innovation, and adopting robust marketing strategies, stakeholders can position themselves for success in this dynamic and rapidly evolving market landscape.

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A GUIDE TO TOMATO CULTIVATION

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Abstract
Tomato cultivation is a vital aspect of agricultural production worldwide, demanding precise techniques for optimal outcomes. This abstract synthesizes essential cultivation practices for tomatoes, including land preparation, spacing, irrigation, pest control, harvesting, and yield management. Emphasizing sustainability, it underscores the importance of crop rotation and soil fertility. This succinct guide aims to empower growers with actionable insights to enhance productivity and quality in tomato farming.

Keyword : Cultivation practices, tomato farming, sustainability, yield optimization, pest management.

Introduction

Tomatoes hold the title of being the largest vegetable crop globally and are renowned for their nutritional value and widespread cultivation. They are highly prized for their fleshy fruits and are considered a vital crop both commercially and in terms of dietary importance. Botanically known as Lycopersicon esculentum and belonging to the Lycopersicae family, tomatoes are often regarded as a protective dietary supplement due to their rich nutrient content. With their short growth duration and high yield, tomatoes have become economically significant, leading to an expansion in cultivation area over time. Beyond consumption as a fresh vegetable, tomatoes are extensively used in various preserved products such as ketchup, sauce, chutney, soup, paste, and puree.

In terms of dietary significance, tomatoes are a valuable source of essential minerals, vitamins, organic acids, amino acids, and dietary fibers. Recognized for their richness in vitamins A and C, as well as minerals like iron and phosphorus, tomatoes also contain beneficial pigments such as lycopene and beta-carotene.

In the past, tomatoes were traditionally cultivated seasonally, but in the last three years, this pattern has shifted significantly. Nowadays, tomatoes are grown throughout the year, thanks to advancements in farming practices. With the expansion of growing regions such as Gujarat, Punjab, and Haryana, tomatoes have become readily available across India. Farmers now receive prices ranging from Rs 1.00/kg to Rs 1.50/kg during the season. The increasing demand for tomato products indicates a promising future for this crop.

Selecting Suitable Tomato Varieties:

Choosing the right tomato variety is crucial for a successful harvest, and understanding the distinctions between determinate and indeterminate tomatoes is essential.

Determinate Tomatoes

Determinate tomatoes come from plants that produce fruit earlier in the growing season, typically at the ends of a small bush. These tomatoes usually grow to about 3-4 feet tall and can be easily supported by a tomato cage or they might support themselves. They're great for growing in containers, especially for people with limited space. Since all the fruit ripens together, they're perfect if you want to make sauces or can your tomatoes without having to gather fruit at different times. Some well-known determinate tomato varieties include: [list popular determinate tomato varieties here].

Roma (EC-13513), Rupali, MTH-15, Ptom-18, VL-1, VL-2, HS 101, HS 102,
HS 110, Pusa Early Dwarf, Pusa Sheetal, Floradade, Arka Meghli, Co.1, Co.2, Co.3
(Marutham), PKM.1, Py1

Indeterminate Tomatoes

Indeterminate tomato plants keep producing fruit along their stems for a longer time, continuously until the frost hits. They yield smaller amounts of fruit consistently throughout the growing season, which is great if you don't need to use or cook a lot of tomatoes all at once. These plants grow like vines and need proper pruning and support to reach their full height of 8 feet or more. Popular varieties of indeterminate tomatoes include: [list popular indeterminate tomato varieties here].

“Amish Paste” – heirloom, paste tomato
Pusa Ruby, Solan Gola, Yaswant (A-2), Sioux, Marglobe, Naveen,
Ptom-9301, Shalimar- 1, Shalimar-2. Angurlata, Solan Bajr, Solan Sagun, Arka
Vikas. Arita Saurbh.

Climate

1. The best temperature for tomato seeds to sprout is between 26 to 32°C.
2. Tomatoes grow best in warm climates without frost. The ideal temperature for their growth ranges from 15 to 27°C. When it gets too hot, above 27°C, their flowers can fall off, especially when dry winds are present, leading to poor fruit development.
3. Tomato color, particularly redness from lycopene pigment, peaks between 18 to 26°C. However, above 30°C, lycopene production decreases rapidly and stops completely above 40°C.
4. High temperatures promote rapid development of carotene in tomatoes.
5. Direct sunlight can cause sunscald on tomato fruits, especially in late varieties during the summer. This leads to whitish-yellow tops and a leathery texture.
6. Tomatoes thrive in warm and sunny weather, which is essential for proper ripening, color, quality, and high yields.

Soil

Sandy loam soil with a well drained clay sub soil is best suited. Light soils are good for early variety. While clay loan or silt loam soils are well suited for heavy yield (Late variety), grows at pH 6.0 to 7.0 satisfactorily. The soil should be well prepared & leveled by ploughing the land 4 – 5 times.

Propagation

Nursery Bed preparation

Tomato seeds are planted in nursery beds to grow seedlings for later transplantation in the field. The beds, measuring 3 x 0.6 meters with a height of 10-15 cm, are raised and spaced about 70 cm apart to facilitate watering and weeding. It's important to ensure the surface of the beds is smooth and level. Before planting, add a mixture of sieved farmyard manure (FYM) and fine sand to the seedbed. Raised beds help prevent waterlogging in heavy soils, while sandy soils may allow for flat bed planting. To prevent seedling loss from damping off, first moisten the seedbed and then apply Bavistin (15-20 g/10 liters of water).

Season of Planting

Seeds are sown in June July for autumn winter crop and for spring summer crop seeds are sown in November. In the hills seed is sown in March April.

Raising of Seedlings

For one hectare of land, approximately 250-300 grams of seeds are adequate for raising seedlings. Before planting, seeds are treated with either Trichoderma viride fungal culture (4 g/kg of seed) or Thiram (2 g/kg of seed) to prevent damping-off disease. Sow seeds thinly in rows spaced 10-15 cm apart, at a depth of 2-3 cm, and cover them lightly with soil followed by gentle watering. After planting, cover the beds with dry straw, grass, or sugarcane leaves to maintain optimal temperature and moisture levels. Watering should be done as needed until germination is complete, and remove the cover immediately after germination. During the final week in the nursery, slightly reduce watering to harden the seedlings. Seedlings with 5-6 true leaves are ready for transplanting within four weeks of sowing.

Land Preparation

Land preparation involves ploughing the field multiple times to achieve a fine tilth, with adequate intervals between each ploughing. Levelling is ensured through planking, followed by opening furrows at recommended intervals. Incorporation of well-decomposed FYM (25 t/ha) is crucial during land preparation.

Spacing

Spacing of plants varies based on the variety and planting season, typically ranging from 75-90 x 45-60 cm for transplanting seedlings.

Method of Planting

Seedlings are transplanted either in furrows for light soils or along the sides of ridges for heavy soils. Pre-soaking irrigation is administered 3-4 days before transplanting. Prior to planting, seedlings are immersed in a solution containing Nuvacron (15ml) and Dithane M-45 (25g) diluted in 10 liters of water for 5-6 minutes. It is preferable to conduct transplanting in the evening.

Intercultivation

Weed Control

Maintaining a weed-free field, especially during the initial growth stages of the plants, is crucial as weeds compete with the crop, significantly reducing yield. Regular shallow cultivation is necessary to prevent weed growth, promote soil aeration, and ensure proper root development. Deep cultivation should be avoided as it can damage roots and expose moist soil. Implementing two to three hoeing sessions and earthing up helps in weed control. Pre-emergence application of Basalin (1kg a.i./ha) or Pendimethalin (1kg a.i./ha), followed by hand weeding 45 days after transplanting, is effective in weed management. Plastic mulching, either black or transparent, can also aid in weed control. Combining mulching with herbicides like Pendimethalin (0.75 kg a.i./ha) or Oxyfluorfen (0.12 kg a.i./ha) proves successful in weed suppression.

Crop Rotation

To prevent the depletion of soil nutrients and reduce disease incidence, it's advisable not to cultivate tomatoes successively in the same field. A gap of at least one year is necessary before planting tomatoes or other Solanaceous crops (e.g., chillies, brinjals, capsicum, potato, tobacco, etc.), cucurbits, and various other vegetables. Suitable crops that can follow tomatoes include cereals (e.g., rice, corn, sorghum, wheat, millets), cruciferous crops (e.g., cabbage, cauliflower, kohlrabi), radish, watermelon, onion, garlic, groundnut, cotton, safflower, sunflower, sesame, sugar beet, and marigold.

Intercropping

Tomatoes integrate well into various cropping systems involving cereals, grains, pulses, and oilseeds. Popular cropping combinations in different parts of India include rice-tomato, rice-maize, okra-potato-tomato, and tomato-onion. Spinach or radish can also serve as successful intercrops with tomatoes.

Staking

Staking is essential for tall and heavy-bearing hybrid tomato varieties. It aids in intercultural operations and maintains fruit quality. Staking typically occurs 2-3 weeks after transplanting and can involve wooden stakes or overhead wires to which individual plants are tied. For indeterminate types, two or three wires are stretched parallel to each other along the row, and plants are secured to these wires.

Irrigation

Tomatoes require careful irrigation management due to their sensitivity to water. Heavy watering following a prolonged drought can lead to fruit cracking and should be avoided. Instead, a light irrigation should be applied 3-4 days after transplanting. The frequency of irrigation should be adjusted based on soil type and rainfall. During the kharif season, irrigation should be provided at 7-8 day intervals, during rabi at 10-12 day intervals, and during summer at 5-6 day intervals. It's crucial to avoid water stress during flowering and fruit development stages to ensure optimal yield.

Manuring & Fertilization:

Fertilizer requirements are determined by soil fertility and the amount of organic manure applied. Incorporating 15-20 tonnes of well-decomposed FYM per hectare is recommended for a good yield. Typically, for optimum yield, 120 kg N, 80 kg P_2O_5, and 50 kg K_2O per hectare are applied. Half of the N and the full dose of P and K are applied at planting, with the remaining N provided as top dressing 30 days after transplanting.

For hybrid varieties, the recommended dose per hectare is 180 kg N, 100 kg P_2O_5, and 60 kg K_2O. Sixty kilograms of N and half of P & K are applied at transplanting, with the remainder of P & K and 60 kg N top dressed 30 days after transplanting. An additional 60 kg N is applied 50 days after transplanting.

Integrated Pest Management (IPM) Practices for Tomato Pests:

Nursery

- Begin by establishing a Marigold (Tall African Variety Golden Age with Yellow and Orange Flowers) nursery 15-20 days before the tomato nursery.

- One week after seed germination, spray the seedlings with either Imidacloprid 200 SL at 0.3 ml/L or Thiomethoxam 25 WP at 0.3 g/L.

Before Transplanting

- Apply Neem Cake at a rate of 250 kg/ha on ridges during land preparation.
- Dip the roots of seedlings (avoiding foliage to prevent leaf burning) in a solution of Imidacloprid 200 SL at 0.3 ml/L or Thiomethoxam 25 WP at 0.3 g/L for 5 minutes.

Main Field

- Simultaneously transplant tomato seedlings at 20-25 days old and Marigold seedlings at 45-50 days old in a pattern of one row of Marigold for every 16 rows of tomato. The first and last rows of the plots should be Marigold to attract fruit borers.
- Fifteen days after planting, spray Imidacloprid 200 SL at 0.4 ml/L or Thiomethoxam 25 WP at 0.3 g/L for whitefly (leaf curl vector) control.
- Apply Neem Cake at 250 kg/ha to ridges at 20-25 days after planting (DAP) or at flowering to reduce nematode, fruit borer, and leaf miner incidence.
- Spray Ha NPV (250 LE/ha) with 1% jaggery as a sunscreen at 28, 35, and 42 DAP in the evening.
- Spray Marigold flowers with HaNPV or destroy fruit borer larvae found in them.
- As an alternative to HaNPV spray, release egg parasitoids TrichogrammaChilonis, T. Braziliensis, and T. Pretiosum at 2.5 lakhs/ha (five releases at 50,000/ha/release), starting at flower initiation of the crop.
- If red spider mite incidence is observed, spray Neem Soap 1% or Neem Oil 1%, or any synthetic acaricide like Dicofol 18.5 EC (1.5 ml/L), Ethion 50 EC (1.5 ml/L), or Sulphur 80 WP (3 g/L). Spray the lower surface of the leaves.
- Mechanically collect and destroy bored fruits periodically (3-4 times after fruit set) to minimize fruit borer incidence.
- Destroy virus-affected plants showing symptoms as soon as they appear to minimize their spread.

Harvesting

The timing of harvesting depends on the intended use of the tomatoes. Here are the different stages:

1. Dark green color: Fruits exhibit a change from dark green to a reddish pink shade. Tomatoes destined for shipping are harvested at this stage. Before shipping, these fruits are sprayed with ethylene 48 hours in advance to induce ripening. It's crucial not to harvest immature green tomatoes as they will ripen poorly and result in low-quality produce. One simple method to determine maturity is by slicing the tomato; if seeds are cut, the fruit is too immature for harvest and won't ripen properly.
2. Breaker stage: A slight pink color appears on about a quarter of the fruit. Fruits are harvested at this stage to ensure the highest quality. These fruits are less susceptible to damage during shipment and often command a higher price than less mature tomatoes.
3. Pink stage: Pink color is observed on approximately three-quarters of the fruit.
4. Reddish pink: Fruits become firm, and nearly the entire fruit turns reddish pink. Tomatoes intended for local sale are harvested at this stage.
5. Fully ripened: Fruits are fully ripe, soft, and have a dark red color. These fruits are typically used for processing.

Harvesting is typically done early in the morning or evening. Fruits are harvested using a twisting motion of the hand to separate them from the stem. Harvested fruits should be placed only in baskets or crates and kept in the shade. Since not all fruits mature simultaneously, harvesting is done at intervals of 4 days. Generally, there are 7-11 harvests during the crop's lifespan.

Yield

Yield per hectare varies significantly depending on the variety and season. On average, yields range from 20-25 t/ha. Hybrid varieties may yield up to 50-60 t/ha.

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FUTURE IN AGRICULTURE AND AGRICULTURE IN FUTURE

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ABSTRACT

The future of agriculture presents both challenges and opportunities. This article explores the impact of technological advancements like precision agriculture, technological interventions in land and water management, vertical farmingetc to enhance the productivities per unit of land and water inputs, while emphasizing the importance of sustainable practices like regenerative agriculture and organic farming. It delves into the potential impact on rural communities, food security, and human health, addressing ethical concerns around data privacy and job displacement. Ultimately, it emphasizes the crucial role of collaboration between policymakers, businesses, and consumers in shaping a sustainable and equitable future for agriculture, ensuring a secure food system for generations to come.

Key Words : Technology, Sustainability, Rural Communities, Food Security, Collaboration

1. INTRODUCTION

Two phrases, one crucial distinction: "Agriculture in the Future" and "Future in Agriculture" both explore the changing landscape of our food system, but with a subtle shift in focus. "Agriculture in the Future" dives into the specific technologies and practices that will transform how we grow food, analysing robots in fields, vertical farms in cities, and gene-edited crops. It's a deep dive into the toolbox of the future farmer. Conversely, "Future in Agriculture" takes a broader perspective, examining the societal and economic implications of these changes. It asks how these innovations will impact rural communities, food security, and our relationship with the land itself. It's about the wider ripples the future of agriculture will create. While both approaches are crucial, understanding this subtle difference allows you to navigate the complex and fascinating world of agriculture's evolution.

In India, the land of vibrant festivals and fertile plains, agriculture is not just a profession, but a lifeline. It nourishes over half the population, shapes traditions, and fuels the economy. Yet, dark clouds loom on the horizon. A burgeoning population demands more food, while climate change throws erratic weather and water scarcity at its feet. Land degradation adds to the woes, threatening the very foundation of this vital sector. Can India navigate these challenges and ensure food security for its future generations? This article explores the critical role of agriculture in India's survival, the formidable challenges it faces, and the potential solutions that offer a glimmer of hope amidst the storm (Kelaiya and Rank, 2019; Kumar and Rank, 2021; Rank et al., 2020; Kumar and Rank, 2023). The entire future of an agriculture was, is and will be depended on the basic inputs of land and water.

India's agricultural heart beats for over half its population, providing sustenance and shaping its cultural tapestry. But a storm gathers. By 2050, feeding millions more will demand a 70% rise in food production. Climate change throws punches of erratic weather, water scarcity, and extreme events, jeopardizing harvests. Land, the very foundation, erodes, salinizes, and shrinks. These challenges are not distant worries, but an urgent call to action. Failure to adapt could lead to food insecurity, malnutrition, and social unrest, jeopardizing not just livelihoods, but the nation's future. Water scarcity will be the critical issue in the agriculture for the future (Patel *et al,* 2014, Patel *et al,* 2019, Rank *et al.,* 2016, Patel, 2019, Patel and Rank, 2020, Patel *et al.,* 2023a, Patel *et al,* 2023b,). This needs efficient water use in the agriculture, which consumes the lion share of total water use.

The interweaving of innovative and suitable technologies of land and water management along with policy supports can strengthen the agriculture in future and build the future in agriculture (Paghadal*et al.*, 2019a, Patel and Rank, 2020; Gupta *et al.*, 2021, Vekariya*et al.*, 2022, Patel *et al.,* 2023a, Patel *et al.,* 2023b, Rank *et al.*, 2023b,Vekariya*et al.*, 2023). There are two distinct faces :Agriculture in the Future and Future in Agriculture which delves into the specific technologies and practices shaping how we grow food (e.g., robotics, vertical farming, gene editing), while also exploring the broader societal and economic implications of these changes (e.g., impact on rural communities, food security, ethical considerations).

The increasing population pressure, standard of living, infractural development, climate change and increasing demands of land and water resources from competing sectors would be the prime drivers for the agriculture in future and future in agriculture (Paghdal*et al,* 2019a, Paghdal*et al,* 2019b, Rank *et al.,* 2019; Rank *et al.,* 2022a, Rank *et al.,* 2022b, Rank *et al.,* 2022c; Rank and Satasiya, 2022; Rank and Vishnu, 2019, Rank and Vishnu, 2021a, Rank and Vishnu, 2021b, Rank and Vishnu, 2023c). Thus, land and water resource availability would be the foundation of development in agriculture. The agriculture sector is of prime importance to India's economy as it contributes 14%–15% to the country's gross domestic product and provides employment opportunities to over 55% of the population (Chand et al., 2017).

2. CHALLENGES AND OPPORTUNITIES

2.1 Challenges

Population growth and increasing food demand

India's burgeoning population, projected to reach 1.5 billion by 2050, demands a significant increase in food production. This puts immense pressure on existing agricultural resources, potentially outpacing the ability to meet growing needs.

Climate change and its impact on agriculture

Erratic weather patterns, rising temperatures, and extreme events like droughts and floods are already disrupting agricultural production. Water scarcity, a critical challenge exacerbated by climate change, threatens irrigation and jeopardizes crop yields. These factors combined pose a significant risk to India's food security.

Land degradation and loss of biodiversity

Soil erosion, salinization, and overuse are diminishing fertile land, shrinking the area available for cultivation. This land degradation not only reduces agricultural output but also impacts the ecosystem's ability to support vital pollinators and maintain soil health.

Resource depletion (water, soil nutrients)

Water scarcity is a major concern, with agriculture being the largest user. Unsustainable practices are depleting groundwater reserves, further jeopardizing irrigation and agricultural sustainability. Additionally, soil nutrient depletion due to excessive use of fertilizers and inadequate replenishment threatens long-term crop productivity.

Social and economic inequalities in access to food and resources

Unequal access to land, water, technology, and financial resources creates disparities in agricultural productivity and income. Marginalized communities often struggle to access resources and adapt to changing climatic conditions, exacerbating food insecurity and social inequities.

2.2 Opportunities

Technological advancements

From precision agriculture using sensors and data analytics to optimize resource use to robots automating tasks and AI-powered pest control, technology promises increased efficiency, productivity, and sustainability. Vertical farming, with its controlled environments and efficient resource utilization, offers solutions for urban areas and limited land. These advancements require careful integration and equitable access to avoid exacerbating existing inequalities.

Sustainable farming practices

Regenerative agriculture aims to rebuild soil health and biodiversity, while organic farming eliminates harmful chemicals and fosters healthier ecosystems. Agroforestry integrates trees with crops, providing multiple benefits like shade, nitrogen fixation, and improved soil health. These practices offer long-term sustainability and environmental benefits, but require knowledge sharing, infrastructure development, and addressing economic viability concerns.

Innovation in food systems

Alternative protein sources like plant-based meat and insect protein offer solutions to meet growing protein demands while reducing environmental impact. Personalized nutrition, tailoring food intake to individual needs, can optimize health outcomes and reduce food waste. These innovations require robust research, regulatory frameworks, and consumer education to ensure safety and acceptability.

Increased consumer awareness

Growing demand for sustainable food choices drives market forces towards more responsible practices. Consumers are willing to pay premiums for ethically and environmentally sourced products. This shift in consumer behaviour incentivizes farmers and businesses to adopt sustainable practices, creating a virtuous cycle for positive change.

Policy and investment

Supportive policies promoting sustainable practices, research, and infrastructure development are crucial. Investments in farmer education, access to technology, and market linkages can empower farmers to adopt sustainable solutions. Collaborative efforts between governments, businesses, and research institutions are essential to create an enabling environment for a sustainable future of agriculture.

The harnessing of these opportunities and overcoming challenges, we can navigate towards a future where agriculture is not only productive but also sustainable, resilient, and equitable, nourishing both humanity and the planet.

3. AGRICULTURE IN THE FUTURE

The future of agriculture gleams with the promise of innovative solutions that will transform how we grow food. **Precision agriculture**, armed with sensors, drones, and data analytics, promises to optimize resource use, tailoring water and fertilizers to individual plants' needs. Robots are taking over tedious tasks like weeding and harvesting, while **artificial intelligence** is optimizing irrigation systems and predicting crop yields. **Vertical farms**, towering structures in urban areas, defy space constraints, producing fresh food with minimal environmental impact.

These advancements, however, are not without their **drawbacks**. Reliance on technology can create dependencies and potential vulnerabilities. Concerns exist about data privacy, access, and ownership in a world of sensor-driven agriculture. The initial cost of implementing these technologies can be high, potentially widening the gap between large and small farmers. Ethical considerations surrounding automation and potential job displacement in rural communities require careful attention.

The **impact of these changes** will be multifaceted. Farmers will need to adapt to new technologies, acquiring digital skills and embracing data-driven decision-making. Rural communities may face challenges as traditional farming practices evolve, requiring investment in reskilling and diversifying local economies. The food system itself will likely see increased efficiency, potentially lower food prices, and wider access to nutritious food, but concerns about corporate control and the potential homogenization of agricultural practices need to be addressed.

Globally, examples are emerging of these solutions taking root. In Israel, precision agriculture is being used to optimize water usage in arid regions. Rwanda is embracing vertical farming to address food security challenges in its urban areas. India is promoting regenerative agriculture practices to improve soil health and farmer livelihoods. These diverse examples showcase the adaptability and potential of these technologies across different contexts.

Navigating the future of agriculture requires a **balanced approach**. Embracing innovation can unlock immense potential for sustainability and efficiency, but it is crucial to mitigate potential drawbacks. Investing in farmer education, ensuring equitable access, and fostering inclusive rural development are key to shaping a future where technology empowers both farmers and consumers, leading to a more resilient and sustainable food system for all.

4. FUTURE IN AGRICULTURE

Shifting our focus beyond the farm itself, future agriculture will have profound societal and economic implications. Rural communities, often dependent on traditional farming practices, face potential challenges as automation and technological advancements reshape the landscape. While these changes may offer opportunities for diversification and skill development, ensuring equitable access to technology and education is crucial to avoid widening existing inequalities. Policymakers must invest in rural infrastructure, skills training, and alternative income sources to ensure vibrant and resilient rural communities.

The impact on food security, nutrition, and human health is multifaceted. Increased efficiency and productivity have the potential to make nutritious food more accessible and affordable, contributing to improved global food security and nutrition. However, concerns about corporate control, homogenization of food systems, and potential disruption to traditional food cultures must be addressed. Sustainable practices that prioritize biodiversity and nutrient density can lead to healthier food choices and improved human health outcomes.

Ethical considerations surrounding future technologies in agriculture cannot be ignored. The potential for job displacement, data privacy concerns, and ethical implications of gene editing require careful consideration and open dialogue. Transparency, responsible development, and inclusive decision-making are essential to ensure these technologies benefit all stakeholders.

Finally, the role of policymakers, businesses, and consumers in shaping a sustainable future for agriculture is critical. Policymakers must create regulatory frameworks that encourage responsible innovation, support research and development, and invest in sustainable infrastructure. Businesses need to adopt ethical practices, prioritize fair compensation for farmers, and promote transparency in their supply chains. Consumers have the power to drive change through their purchasing decisions, supporting sustainable and ethical food choices. By working together, we can ensure that future agriculture nourishes not only our bodies, but also our communities and the planet.

CONCLUSION

The future of agriculture peers a tapestry of challenges and opportunities unfolds. Climate change, resource depletion, and population growth cast long shadows, demanding innovative solutions. Yet, advancements in technology, sustainable practices, and a growing awareness of the need for change offer glimmers of hope. Embracing these advancements, while ensuring equitable access and mitigating potential drawbacks, is crucial. Collaboration is the key. Policymakers, businesses, farmers, and consumers must work hand-in-hand to build a food system that is not only productive and efficient, but also resilient, sustainable, and equitable. By prioritizing sustainable practices, fostering rural development, and ensuring ethical considerations are addressed, we can ensure that future agriculture nourishes not just our bodies, but also our communities and the planet. Let us embrace innovation, cultivate collaboration, and collectively shape a future where agriculture thrives, ensuring a secure and sustainable food system for generations to come. In future, there will be a world where lush fields and innovative farms coexist, where technology empowers farmers and nourishes communities.

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BROOD STOCK NUTRITION OF FISH WITH THE EMPHASIS OF NOVEL INGREDIENTS AND DIETARY NUTRIENTS REQUIRED FOR EGG AND SPERM QUALITY AND REPRODUCTIVE EFFICIENCY

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Introduction

In many cultured fish species, particularly in those new for aquaculture, unpredictable and variable reproductive performance is an important limiting factor for the successful mass production of juveniles. An improvement in broodstock nutrition and feeding has been shown to greatly improve not only egg and sperm quality but also seed production. Gonadal development and fecundity are affected by certain essential dietary nutrients, especially in continuous spawners with short vitellogenic periods. Thus, during the last two decades, more attention has been paid to the level of different nutrients in broodstock diets. However, studies on broodstock nutrition are limited and relatively expensive to conduct. Lipid and fatty acid composition of broodstock diet have been identified as major dietary factors that determine successful reproduction and survival of offspring. Some fish species readily incorporate dietary unsaturated fatty acids into eggs, even during the course of the spawning season. Highly unsaturated fatty acids HUFA with 20 or more carbon atoms affect, directly or through their metabolites, fish maturation and steroidogenesis. In some species, HUFA in broodstock diets increases fecundity, fertilization and egg quality.

As in higher vertebrates, vitamin E deficiency affects reproductive performance, causing immature gonads and lower hatching rate and survival of offspring. For example, elevation of dietary a-tocopherol levels has been found to reduce the percentage of abnormal eggs and increase fecundity in the gilthead seabream *Sparus aurata*. Ascorbic acid has also been shown to play an important role in salmonid reproduction, where the dietary requirement of broodstock was higher than that of juveniles. Among different feed ingredients, cuttlefish, squid and krill meals are recognized as valuable components of broodstock diets. The protein component of cuttlefish and squid together with their optimal concentration of HUFA appear to be responsible for their positive effect on reproductive performance. Both polar and nonpolar lipid fractions of raw krill were found to effectively improve egg quality.

Broodstock nutrition is without doubt one of the most poorly understood and researched areas of finfish nutrition. To a large extent, this has been due to the necessity of suitable indoor or outdoor culture facilities for maintaining large groups of adult fish and the consequent higher cost of running and conducting extended broodstock feeding trials. However, as in human and livestock nutrition Leboulanger, 1977, it is clear that the dietary nutrient requirements of broodstock will be different from those of rapidly growing juvenile animals. Moreover, as in other animals, it is also clear that many of the deficiencies and problems encountered during the early rearing phases of newly hatched finfish larvae are directly related to the feeding regime including nutrient level and duration of the broodstock. The aim of this paper is to review the major studies conducted to date on the effects of broodstock nutrition on reproductive performance of farmed fish.

Effects of nutrition on fecundity of broodstock fish

Several methods have been developed to assess the egg quality of fish Kjorsvik et al., 1990; Fernandez-Palacios et al., 1995. One of the parameters, fecundity, has been used to determine egg quality, which is also affected by a nutritional deficiency in broodstock diets. Fecundity is the total number of eggs produced by each fish expressed either in terms of eggs spawn or eggs body weight. Reduced fecundity, reported in several marine fish species, could be caused either by the influence of a nutrient imbalance on the brain–pituitary–gonad endocrine system or by the restriction in the availability of a biochemical component for egg formation.

The elevation of dietary lipid levels from 12% to 18% in broodstock diets for rabbitfish *Siganus guttatus* resulted in an increase in fecundity and hatching Duray et al., 1994, although this effect could also be related to a gradual increase in the dietary essential fatty acid content. Indeed, one of the major nutritional factors that has been found to significantly affect reproductive performance in fish is the dietary essential fatty acid content Watanabe et al., 1984. Fecundity in gilthead seabream *Sparus aurata* was found to significantly increase with an increase in dietary n-3 HUFA polyunsaturated fatty acids with 20 or more carbon atoms, essential for marine fish levels up to 1.6%.

A positive correlation was observed between the levels of n-3 HUFA in the diet and the eggs with the EPA concentration being more readily affected by dietary n-3 HUFA than DHA docosahexaenoic acid. Rainbow trout *Oncorhynchus mykiss* fed an n-3 deficient diet during the last 3 months of vitellogenesis produced a moderate effect on the incorporation of DHA into egg lipid whereas EPA concentration decreased by 50% Fremont et al., 1984 . However, the levels of other fatty acids in the eggs were not affected by the fatty acid composition of the diet. Selective retention of DHA has also been found during embryogenesis Izquierdo, 1996 and during starvation Tandler et al., 1989 denoting the importance of this fatty acid for the developing embryo and larvae.

Table 1: Biochemical composition of gilthead seabream eggs on broodstock fed several vitaminE and n-3 HUFA levels (mg/kg and % dry weight)

Vit E/HUFA	Total lipids (% d.w.)	$n-3$ HUFA (area %)	EPA (area %)	DHA (area %)	Vit E (mg/kg)
22/1.6	28.2^{a}	27.1^{a}	3.72^{a}	21.36^{a}	101.3^{a}
55/1.7	27.4^{a}	27.1^{a}	3.6^{a}	21.23^{a}	106.7^{a}
125/1.6	24.9^{ab}	25.9^{a}	4.58^{ab}	19.18^{a}	106.7^{a}
2010/1.4	24.8^{b}	25.3^{a}	4.04^{a}	19.03^{a}	207.1^{b}
190/2.2	23.0^{b}	27.5^{a}	5.32^{b}	19.62^{a}	115.5^{a}

In other fish species such as cod *Gadus morhua* a clear effect of essential fatty acid on fecundity was not observed in fish fed commercial diets coated with different types of oils Lie et al., 1993. In a long-term feeding trial with cod, broodstock were fed diets coated with soybean, capelin or sardine oils. It showed a relatively small effect on the fatty acid composition of eggs from fish fed the fish oils, however, the egg n-3 HUFA concentration was significantly reduced in fish fed soybean oil Lie et al., 1993 . These results may be due to a low essential fatty acid EFA requirement of cod broodstock, compared with sparids, which possibly allowed them to derive EFA from the residual lipid present in the fish meal component of the experimental diet in order to satisfy their physiological needs.

However, the reduced fecundity observed in broodstock fed a diet deficient in a-tocopherol was not associated with reduced vitamin E content of eggs, and only very high dietary vitamin E levels 2020 mg/kg were found to increase egg a-tocopherol content Table 1; authors' unpublished data . In other species such as turbot Hemre et al., 1994 or Atlantic salmon Lie et al., 1993 , vitamin E was mobilized from peripheral tissues during vitellogenesis although the plasma vitellogenin content was not affected, suggesting that lipoproteins may be involved in the transport of vitamin E during this period Lie et al., 1993 . Vitamin C content of rainbow trout eggs reflected the content of this nutrient in the diet and was associated with improved egg quality. Supplementation of 0.1% tryptophan in the diets of ayu *Plecoglossus altivelis* resulted in a significant increase in the serum testosterone levels thus advancing time of spermiation in males and induced maturation of females Akiyama et al., 1996.

Effect of broodstock nutrition on fertilization

Certain dietary nutrients also exert a marked effect on fertilization. Dietary eicosapentaenoic EPA and arachidonic acid AA levels show a correlation with fertilization rates in gilthead seabream broodstock Fernandez-Palacios et al., 1995, 1997. Since sperm fatty acid composition depends upon the essential fatty acid content of broodstock diet in species such as rainbow trout Watanabe et al., 1984d, Labbe et al., 1993 and European seabass Asturiano, 1999, it is possible that sperm motility and in turn fertilization would be affected. Particularly in salmonids, where cryopreservation of sperm is currently utilized, sperm fatty acid composition could be a factor that determines the membrane integrity after freeze-thawing. However, Labbe et al. 1993 did not find any effect of dietary fatty acids n-3 and n-6 polyunsaturated fatty acids on sperm freeze–thaw fertilizing ability, whereas low membrane cholesterol phospholipid ratios were correlated with a better sperm freezing resistance Labbe and Maisse, 1996. Another hypothesis to explain the beneficial effect of EPA and AA on fertilization rates has been proposed by several investigators.

Effect of broodstock nutrition on embryo development

Several nutrients are essential for the normal development of the embryo, and their optimum level in broodstock diets improves egg morphology and hatching rates. The percentage of morphologically normal eggs as a parameter to determine egg viability has been found to increase with an increase in the n-3 HUFA levels in broodstock diets and an incorporation of these fatty acids into the eggs Fernandez-Palacios et al., 1995, thus indicating the importance of EFAs for normal development of gilthead seabream eggs and embryo. These fatty acids play an important structural role as components of phospholipids in fish biomembranes and are associated with the membrane fluidity and correct physiological functions for bound membrane enzymes and cell functions in marine fish Bell et al., 1986. In some species, such as halibut *Hippoglossushippoglossus*, the n-3 PUFA polyunsaturated fatty acids are also regarded as major energy sources during early embryonic development Falk-Petersen et al., 1989.

Nevertheless, fatty acid composition of fish egg lipids is not only determined by the broodstock diet but is also related to species and stock differences Pickova et al., 1997. Essential fatty acid requirements for sparids broodstock range between 1.5% and 2% n-3 HUFA in diet Watanabe et al., 1984a,b,c, 1985a,b; Fernandez-Palacios et al., 1995 , being higher than those determined for juveniles which range between 0.5% and . 0.8% n-3 HUFA in diet Izquierdo, 1996. These values are higher than the optimum essential fatty acid levels determined for salmonids which are approximately around 1% n-3 HUFA Watanabe, 1990.

Increased levels of dietary vitamin E up to 2000 mg/kg in red seabream diets improved percentages of buoyant eggs, hatching rates and percentage of normal larvae Watanabe et al., 1991. An increase in the level of dietary a-tocopherol from 22 to 125 mg/kg also significantly reduced the percentage of abnormal gilthead seabream eggs Fernandez-Palacios et al., 1997 and resulted in an improvement in the percentage of normal eggs.

Effects of broodstock nutrition on larval quality

Few studies have been able to show the improvement of seed quality through implementation of broodstock nutrition. Increasing lipid levels from 12% to 18% in broodstock rabbitfish produced large newly hatched larvae and an increase in survival 14 days after hatching Duray et al., 1994. Increased n-3 HUFA particularly docosahexaenoic acid levels in broodstock diets were reported to significantly enhance the weight of fish larvae and their resistance to osmotic shock Aby-ayad et al., 1997. In a similar way, increasing n-3 HUFA levels in broodstock diets for gilthead seabream significantly improved the percentage of live larvae after yolk reabsorption. Moreover, growth, survival and swimbladder inflation in gilthead seabream larvae were improved when fish oil was used instead of soybean oil in broodstock diets Tandler et al., 1995. However, excessive levels of n-3 HUFA in broodstock diets over 2% caused yolk sac hypertrophy in gilthead seabream larvae and a decrease in larval survival rates; Fernandez-Palacios et al., 1995 . This is probably associated with an increase in antioxidant nutrient requirement since an increase in dietary a-tocopherol levels from 125 to 190 mg/kg prevented the appearance of yolk sac hypertrophy and larval mortality; Fernandez-Palacios et al., 1998.

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DIAGNOSIS AND IMPROVEMENT OF B DEFICIENCY IN FRUIT CROPS

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Abstract

Boron (B) plays an important role in the growthand development of plants. Various crops,in particular, fruits are recently exhibiting symptoms of Bdeficiency on a large scale in India. Therefore, it isimperative to know precisely the visual symptoms of B deficiency in various fruits and adopt corrective measures timely to ensure desired yield. As there is a thin line between the deficiency and toxicity of available B in soil and its content in leaves, optimum application of B is essential and inevitable. Even a slight aberration may create problem. Therefore, optimum requirement of B by specific crops should be met through soil and/or foliar application. This paper focusses on diagnosis and improvement of B deficiency in important subtropical fruits of India.

Introduction

The fruits grown under a climatic condition between temperate and the tropical are known as subtropical fruit crops. They may be either deciduous or evergreen and are usually able to withstand a low temperature but not the frost. They are also quite adoptive to fluctuations of light and dark period during day and night. Most of the Northeast India and much of North India are subject to a humid subtropical climate and a subtropical highland climate. Farmers of this region deal with poor soil, and an abundance of pests. Additionally, subtropical agriculture is a big cause of deforestation. Important fruits of subtropical region are: mango, banana, guava, jackfruit, papaya, litchi, bael (stone apple), orange, citrus, orange, sweet lime, grapefruit, grape, pomegranate, ber (jujube), aonla (Indian gooseberry), pine apple, strawberry, jamun (Indian blackberry), fig, dragon fruit, Sharifa (custard apple), coconut, date palm, melon etc.

Boron deficiency is the second most widespread micronutrient deficiency in India but it is not considered so important from application view point only because of lack of the knowledgeabout B deficiency symptoms. As the soil's B capital is being exhausted due to continuous uptake by the crops in absence of desired replenishment, B deficiency in soil-plant system is being frequently observed..The authorshave noticed a largescale existence of Bdeficiency in fruit crops in Uttar Pradesh and other parts of the country and also experienced hidden hunger effect. It is important to mention that Bis needed in small amount and due to its small concentration-range in soil-plant systems, there is a very thin line between the deficiency and toxicityvalues. Therefore, precisely standardised dose of Bis needed for optimum nutrition to ensure proper growthof the plants/trees, and quality yield.Nowadays, optimum B management is being emphasized as one of the efficient approaches for optimum and marketable yields in view of its increasing deficiency in soils and plants. This paper is focussing on the diagnosis and improvement of B deficiency in important subtropical fruits.

Factors Affecting Boron Deficiency in Soils

Boron availability in the soil is influenced by numerous factors such as soil reaction, soil moisture, active calcium and organic matter content. B is most available for uptake by plants in neutral soils, and becomes less available in acidic or alkaline soil. B deficiency is frequently observed in acidic (which have limited silica and high Fe and Mn) and alkaline (calcareous) light textured soils with low organic matter contentas it is susceptible to leaching. and in soil with low moisture content. Although alkaline soils are rich in total B but poor in available B for plants. Boron deficiency is also found in laterite soils. Similarly, in peat soils and acid sludge and soil with low clay composition, B deficiency is evident. Soils arising from igneous and metamorphic sandstone rocks are found to be naturally low in B. Certain environmental conditions can also lead to low availability of soil B. High rainfall can cause leaching of available B from the root zone which is a major problem, especially in coarse-textured soils and when plants are at or just before the rapid growth of leaves and flower development stages. The other adverse environmental condition is when less rainfall or drought period occurs just prior to, or during flowering and seed set. Consequently, in dry soils, B uptake may be reduced or unavailable at a time of maximum B requirements in plants.

Leaf analysis, supplemented by soil analysis, can be reliable diagnostic tool for analysis of B availability and status in plants. In soils, a B level below 0.5 mg/kg of water-soluble B is considered low or deficient. An optimal or medium range of B falls within the range of 0.5–2 mg/kg, while soils containing more than 2 mg/kg are deemed to have a high or excessive B content. Consequently, soils containing less than 0.5 mg/kg of hot water-soluble B are generally incapable of providing sufficient B to support normal growth and yield in most plant species.In the case of most crops, a B content ranging from 15 to 100 mg/kg in plant tissue is considered sufficient for regular growth. Conversely, levels exceeding 200 mg/kg may be excessive, leading to a potentially toxic or inhibitory impact on crop growth and yields. When the concentration of B in plant tissue falls below a critical threshold, it hinders the optimal growth and yield of the crop.

Role of Boron in Plant Nutrition

Boron is crucial as a vital micronutrient for achieving optimal crop growth, development and highqualityfruit yield. It plays a key role in forming and stabilizing cell walls, promoting lignification, and facilitating xylem differentiation [2]. Moreover, B is essential for enhancing the protein and enzymatic functions of cell membranes, thereby improving membrane integrity. It’s worth noting that sexual reproduction in plants is more vulnerable to B deficiency compared to vegetative growth. During the pollination of flowers, B supports pollen tube growth, ensuring successful seed set and fruit development. Additionally, B contributes to increased nectar production in flowers, attracting pollinating insects. Boron is important in improving calcium mobility and the transport of sugars and plant growth regulators. Where supplies of B are not limiting, skin is more elastic, thereby minimizing fruit cracking and improving storability. Lack of B, or heavy infrequent watering at fruiting are also the usual cause of internal cracking. Furthermore, B imparts drought tolerance to plants.**Fig. 1** displays the important functions of B in plants.

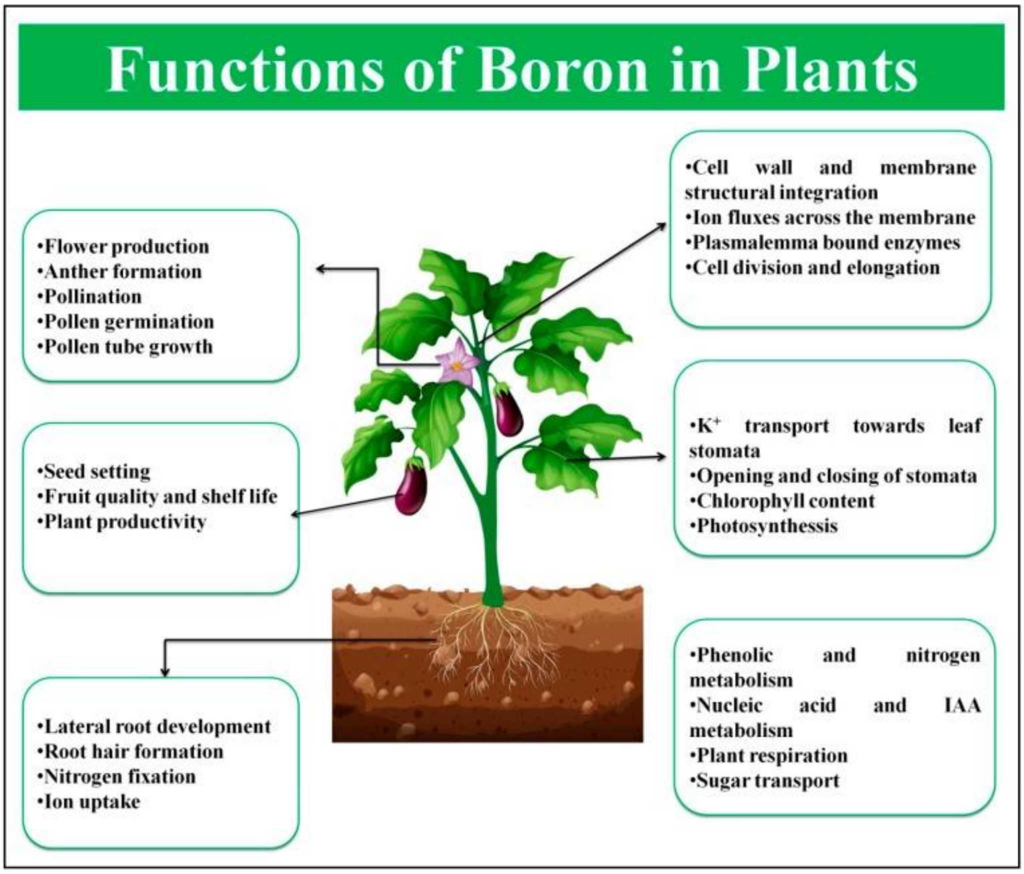

Figure 1. Important functions of boron in plants

Diagnosis of Boron Deficiency

Crop-wise symptoms of B deficiency are described below:

Papaya: *Leaves* of *B-deficient* plants may be deformed and bunchy at the apical meristem. They also may be excessively brittleand claw-like. Fruits are deformed and the symptoms usually start when fruit are young, but becomes most obvious on the mature fruit (**Photos 1**). Seeds, if present, fail to germinate.

Photo 1: Boron deficiency symptoms in papaya plants plants (left) and fruits

Banana: Leafveins are very close, raised above the lamina and become chlorotic from their margins, and become brittle in the early stage, and are curled inward. Chlorotic spots parallel to midrib and corrugation and laddering symptoms at later stage also appear.Breaking of leaf tip, followed by torning and browning at the end may be seen. Unfolding of leaf is delayed in addition to the yield reduction. Severe B deficiency may be confused with the symptoms of Ca deficiency. The pronounced thickening of secondary veins in Ca deficient plants can differentiate these two. The deficiency leads deformation of fruit bunches and under severe deficiency, fruit cracking is observed (**Photo 2**).

Photo 2: Boron deficiency symptoms in banana plants (left) and fruits (right)

Mango: Stunted growth with shortened internodes, bud necrosis, rosette, upward curling and thickened leathery younger leaves. Fruits become brown in colour. Flesh may become soft and watery which cracks down to the centre (**Photo 3**).

Photo 3: Boron deficiency symptoms in mango trees (left) and fruits (right)

Citrus, Orange and Sweet Lime: The first visual symptoms of B deficiency are generally the death of the terminal growing point of the main stem. Further symptoms are a slight thickening of the leaves, a tendency for the leaves to curl upward, and sometimes chlorosis. Fruit symptoms are the most constant and reliable tool to diagnose B deficiency. Immature fruits become hard and somewhat misshaped. Because the fruits become hard and dry due to lumps in the rind caused by gum impregnations, B deficiency is known as "hard fruit"(**Photo 4**).

Photo 4: Boron deficiency symptoms in citrus trees (left) and fruits (right)

Guava: Stunted growth, first showing symptoms on the growing point and youngerleaves. The young leaves tend to be thickened and may curl and become dry and brittle.The tree may also exhibit dieback, where the branches and twigs are weak and easily breakable (**Photo 5**).Boron deficiency may result in a reduction in the number of flowers produced and can cause internal corking of the fruit, affecting the fruit's texture. Boron deficiency can lead to fruit cracking.

Photo 5: Boron deficiency symptoms on guavaleaves (left) and fruits (right)

Grapes: In grapes, the young leaves show an interveinal chlorosis, and under severedeficiency,they may be deformed. Internodes are short and ultimately the growing points die. Unlike most nutrient deficiencies that typically exhibit symptoms uniformly across the crop, B symptoms can appear randomly. In severe cases of B deficiency, no normal fruit develops. The presence of small sized fruits and large sized fruits in the same bunch is known as *hen and chicken* disorder (**Photo 6**). The fruits are sour in taste.


Photo 6: Boron deficiency symptoms on grape leaves as interveinal chlorosis (left) and hen and chick syndrome during fruit development(right)

Pomegranate: Chlorotic leaf tips, leaf necrosis, and later leaves falling and even plant death, are the characteristic symptoms. Growth cease at the growing point and poor development of roots, premature shedding of male flowers and impaired pollen tube development leading to poor fruit setting. Fruit cracking is a serious problem of pomegranate (**Photo 7**). Cracking in young fruits is due to B deficiency but if it develops in developed fruits and not on the young fruits then it may be caused due to extreme variations in day and night temperatures. At the time of fruit ripening, if the soils become too dry followed by heavy irrigation or rains, cracking may occur.

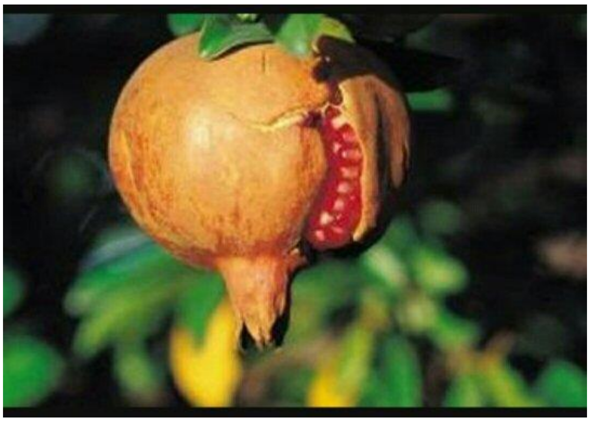

Photo 7: Fruit cracking of pomegranate due to boron deficiency

Litchi: The symptoms appear in younger shoots with inward curling of leaves with necrosis, emerging shoots tips die, poor fruit set and severe fruit drop, fruit cracking with brown discoloration in the pulp (**Photo 8**). Since B and calcium are jointly involved in mobility of B in plants, deficiency of B and calcium often overlap. Early cultivars are more susceptible than late cultivars.

Photo 8. Fruit cracking in Litchi

Bael: Curling of younger leaves, fruit drop and cracking (**Photo 9**).

Photo 9. Curling of upper leaves (left), fruit dropping (middle) and fruit cracking (right)

Custard Apple (Sharifa): Leaves near growing point yellowed, growth bud looks white or brownish dead tissue.Boron deficiency is known as "hard fruit" because the fruit is hard and dry due to lumps in the rind caused by gum impregnations. The chief fruit symptoms include premature shedding of young fruits and cracking under severe deficiency (**Photo 10**).

Photo 10. Boron deficiency symptoms on custard apple leaves (left) and fruits (right)

Jackfruit: Leaves show chlorosis and brittleness. Terminal shoot poorly developed. Fruits show splitting or cracking with characteristic reddish purple colour (**Photo 11**).

Photo 11. Boron deficiency symptoms on jackfruit leaves (left) and fruits (right)

Aonla: Fruit necrosis which begins with the browning of inner most part of the mesocarpic tissues at the time of endocarp hardening. This is extended towards the epicarp resulting into brownish black areas on the fruit surfaces depending of the severity of the disorder, mesocarp of affected fruits turns black from brown which later turns into corky and gummy pockets (**Photo 12**).

Photo 12. Boron deficiency symptoms on Aonla and fruits

Sapota: The disorder is identified with appearance of red spots on the newly emerged leaves. Leaves become dry and brittle. The tip burning of young leaves and splits or crack on the midrib and large veins on the underside of the leaf, leaves cupped, shrivelled, and become brittle, bud necrosis, reduced flowering and fruit set are the characteristic symptoms. Sapota has the problem of low fruit setting, shedding and cracking. Only about 10-12 per cent of the total fruits set, develop and retain until maturity. Most of the fruit-drop occurs immediately after fruit setting (**Photo 13**).

Photo 13. Boron deficiency symptoms on sapota leaves and fruits

Melons: Plants are stunted or dwarfed as the internodes are shortened. Growing points die back and upward curling of younger leaves. Flowering and fruit set is poor. Fruits are distorted with a poor skin finish(**Photo 14**).Under severe deficiency coupled with wetting and drying, fruit cracking is observed. Hollow heart is more common

Photo 14. Symptoms as white and rolled leaf tip of young leaves (left), fruit mortality (middle) and fruit cracking (right) in melon

Strawberries: The first symptom of B deficiency appears on the young leaves as distorted and chlorotic, develop tip burn and as leavesexpand they become cupped and distorted. Marginal leaf yellowing can also occur with more severe deficiencies.Deficiencies can also affect the flowers and fruit. Flowers are smaller, petals deformed or fail to develop. Fruits fail to fully expand and are deformed and bumpy which may split before ripening and corky patches may develop. The flesh has a leathery texture (**Photo 15**).

Photo 15. Symptoms curling of young leaves and deformed young fruits (left) deformed mature fruits (middle and right in strawberry.

Correction of Boron Deficiency

Boron Fertilizers : There are eight different sources of boron [borax ($Na2B4O7.10H2O$ with 11% B), solubor-$Na_2B_8O_{13}.4H_2O$ (20% B), sodium borate ($Na_2B_4O_7.5H_2O$ with 20% B), sodium tetraborate ($Na_2B_4O_2.5H_2O$ with 14% B), boric acid (H_3BO_3 with 17% B), Colemanite ($Ca_2B_6O_{11}.5H_2O$ with 10% B), boron frits containing 2-6% B, and boronated superphosphate being used to prevent/correct boron deficiency in crops. Borax, solubor, sodium borate and sodium tetraborate have been most commonly used for soil application. Boric acid, colemanite and B- frits are considered to be more promising on highly leached sandy soils as well as for long duration field crops including perennial forages and fruit plants owing to their low solubility and slow release of boron. Boronated superphosphate has also been tried to correct boron deficiency in crops. Among these boron fertilizer sources, borax is the most commonly used boron fertilizer to prevent and/or correct boron deficiencies in crops.

Figure 2. Most common boron fertilizers

Doses and method of Application : Boron may safely be applied to orchard crops at a rate of 0.56 kg B per ha as a maintenance dose and at a rate of 1.12 kg B per ha as a deficiency dose and its residual effect has generally been reported for at least two years. In the case of borax, application rates should not exceed 90 g borax per orchard tree. Since B undergoes less leaching in fine-textured soils, single application may produce residual effect. In view of very sharp and narrow difference between optimum and toxic levels of B, more precaution is needed in its repeat application, particularly in medium- to fine-textured soils. Boron deficiency is also invariably corrected by its soil application depending upon soil type. Solid or granular forms of boron fertilizer may be mixed together with other mineral (inorganic) fertilizers. In some cases, farmers may apply too much, and see `tip-burning' of the leaf margins. This is due to the concentration of boron in the leaf margins (the natural behavioral movement of boron in leaves) and should not be a cause for alarm. It is better to correct the deficiency and have some level of toxicity, than ignore the deficiency which eventually makes the crop unproductive and farming marginal.

Because of the narrow margin between boron sufficiency and toxicity, an excess dose can easily occur and harm plant growth. Therefore, extreme care is needed to apply the correct dose of boron fertilizer and to distribute it uniformly. As boron is highly toxic to most plants at quite low rates, trial foliar sprays are advisable. Take care with soil treatments to ensure an even spread, and be aware that excess boron can be toxic. An application of 10 kg borax per hectare to deficient soil before planting will prevent boron deficiency. Foliar sprays of borax (100-200 g/100 L) may also be used.

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