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BIOFORTIFICATION AND THE SDGs : TACKLING MALNUTRITION IN INDIA

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Malnutrition remains a critical public health issue in India, with a disproportionate impact on vulnerable populations. Addressing this challenge requires sustainable interventions, such as biofortification—an innovative agricultural approach that enriches staple crops with essential micronutrients. This article explores the role of biofortification in combating widespread micronutrient deficiencies and assesses its alignment with key Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-being). By analyzing its potential to mitigate malnutrition and examining its integration into existing policy frameworks, the research underscores biofortification's importance in achieving equitable and sustainable health outcomes in India.

Introduction

India, hosting a significant share of the global malnourished population, faces the dual challenge of undernutrition and hidden hunger—micronutrient deficiencies that severely impact physical and cognitive development, particularly among vulnerable communities. Despite noteworthy progress in reducing calorie and protein deficiencies, widespread deficiencies of critical micronutrients such as iron, zinc, and vitamin A remain pressing concerns. These deficiencies not only compromise public health but also impair economic productivity and hinder overall national development.

Conventional approaches, such as food fortification and supplementation programs, have played a vital role in mitigating nutritional gaps. However, these strategies often encounter limitations in terms of sustainability, accessibility, and equitable implementation. In this context, biofortification emerges as a transformative agricultural innovation. This process enhances the nutrient content of staple crops like rice, wheat, and maize during their growth phase, leveraging their extensive consumption to address nutritional deficiencies in a cost-effective and sustainable manner.

Biofortification aligns seamlessly with national public health priorities and offers a scalable solution to combat malnutrition. Moreover, its implementation supports the global agenda for sustainable development, particularly SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-being). By integrating biofortification into existing agricultural and nutritional frameworks, India can foster long-term health equity, improve socio-economic outcomes, and contribute to sustainable development.

Table: Describing key biofortification initiatives and their success

Initiative/ Program	Focus Crops	Key Features	Regions/States	Impact/Success Stories
Harvest Plus	Pearl Millet, Wheat, Maize	Breeds biofortified crops rich in iron, zinc, and vitamin A. Collaborates with ICAR and local farmers.	Rajasthan, Gujarat, Haryana	Improved hemoglobin levels in children consuming iron-rich pearl millet (e.g., Dhana shakti).
ICAR Biofortification Programs	Wheat, Maize, Pearl Millet, Sweet Potato	Develops nutrient-enriched crop varieties through conventional breeding and genetic engineering.	Nationwide	Release of crops like HD3298 (zinc wheat), HQPM-1 (protein maize), and Sree Kanaka (vitamin A sweet potato).
TANUVAS (Tamil Nadu Veterinary and Animal Sciences University)	Maize, Pearl Millet	Focuses on protein-rich and micronutrient-enriched crop varieties to combat malnutrition.	Tamil Nadu	Adoption of biofortified maize by smallholder farmers to improve household nutrition.
Pradhan Mantri Poshan Shakti Nirman (PM-POSHAN)	Fortified Rice, Wheat	Integrates fortified staples into school meal programs to improve child nutrition.	All States	Nationwide adoption of fortified rice under mid-day meal programs.
Odisha Livelihoods Mission (OLM)	Orange-Fleshed Sweet Potato (OFSP)	Promotes vitamin A-enriched sweet potato through women-led cooperatives and community awareness campaigns.	Odisha	Reduction in vitamin A deficiency among rural populations.
Nutri-Farms Scheme	Pearl Millet, Maize, Sorghum	Encourages the cultivation of nutrient-rich crops through subsidies and farmer incentives.	Maharashtra, Karnataka	Wider acceptance of biofortified crops in drought-prone areas.
Zinc Wheat Initiative	Wheat	Promotes zinc-enriched wheat varieties to address micronutrient deficiencies.	Punjab, Haryana	Improved dietary zinc intake among rural populations consuming biofortified wheat.

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Integration into Agricultural, Nutritional, and Health Policies

The successful integration of biofortification requires a systemic approach that aligns across agriculture, nutrition, and health sectors. Key strategies include:

A. **Agricultural Policies:** Encouraging the development and cultivation of biofortified crop varieties through targeted research funding, subsidies, and extension services. Programs like the Indian Council of Agricultural Research (ICAR) initiatives exemplify such efforts, fostering innovation in crop development.

B. **Nutritional Policies**: Aligning biofortification with national strategies, such as the National Nutrition Strategy (NITI Aayog), which emphasizes food-based approaches to combat hidden hunger, ensures the alignment of crop development with public health objectives.

C. **Health Policies:** Integrating biofortified crops into health campaigns, such as anemia control programs, ensures synergistic outcomes that link agricultural innovations with public health improvements, enhancing the impact of nutritional interventions.

Table: Describing key Benefits of biofortification

Category	Benefits	Examples in India
Nutritional Improvement	Enhances the micronutrient content of staple crops, reducing deficiencies in iron, zinc, and vitamin A.	Iron-rich pearl millet (Dhana shakti) improved hemoglobin levels in children in Rajasthan and Gujarat.
Health Benefits	Reduces the prevalence of anemia, stunting, wasting, and other malnutrition-related health issues.	Zinc-enriched wheat varieties in Punjab and Haryana have boosted immunity and reduced zinc deficiency.
Economic Benefits	Provides cost-effective nutrition by improving the quality of diets without increasing food prices.	Farmers benefit from increased demand for biofortified crops like orange-fleshed sweet potato in Odisha.
Sustainability	Reduces dependence on external supplements and fortification processes, ensuring long-term impact.	Adoption of naturally fortified crops reduces the need for synthetic nutritional interventions.
Agricultural Resilience	Enhances crop productivity and resistance to environmental stresses like drought and pests.	Pearl millet varieties bred for high iron content also show drought resistance, benefiting farmers in arid areas.
Women and Child Health	Improves maternal and child health outcomes by addressing critical nutritional gaps.	Vitamin A-enriched sweet potatoes have reduced vitamin A deficiency among women and children in rural Odisha.
Environmental Impact	Reduces environmental footprint compared to conventional nutrient supplementation methods.	Locally bred biofortified crops minimize transportation and storage needs for synthetic supplements.
Alignment with SDGs	Supports Sustainable Development Goals (SDGs) like Zero Hunger (SDG 2) and Good Health (SDG 3).	ICAR's biofortification programs align with India's commitment to achieving global nutrition targets.

Public-private partnerships (PPPs) are essential for scaling up biofortification, ensuring sustainable impact through innovation, financing, and market access. Key aspects of PPPs include:

A. **Research and Development:** Collaboration between public institutions and private seed companies is crucial for developing biofortified crop varieties with higher yields, resilience, and enhanced nutritional content.
B. **Market Development:** Partnering with food processing industries allows for the incorporation of biofortified crops into value-added products, thus increasing consumer acceptability and broadening market reach.
C. **Advocacy and Awareness:** Joint campaigns between public and private sectors to educate farmers and consumers about the health and nutritional benefits of biofortified foods foster greater adoption of these crops.

Successful examples of PPPs include Harvest Plus's collaborations with seed companies and government agencies to promote vitamin A-rich sweet potatoes and zinc-enriched wheat, demonstrating the potential for impactful, scalable biofortification initiatives.

Link of Biofortification with SDGs

Biofortification aligns directly with the global Sustainable Development Goals (SDGs), serving as a catalyst for achieving multiple targets:

SDG 2: Zero Hunger

A. **Target 2.1:** Biofortified crops like iron-rich pearl millet, zinc-enriched wheat, and vitamin A-enriched sweet potatoes directly address hunger by improving dietary diversity and nutritional adequacy among resource-poor populations.
B. **Target 2.2:** By reducing stunting, wasting, and malnutrition in children and women of reproductive age, biofortification contributes to achieving this target.

SDG 3: Good Health and Well-being

A. **Target 3.2:** The consumption of biofortified crops can help reduce child mortality linked to deficiencies such as anemia and vitamin A deficiency.
B. **Target 3.4:** Enhancing micronutrient intake through biofortification reduces the risk of non-communicable diseases, promoting healthier lives.

SDG 12: Responsible Consumption and Production

Biofortification encourages sustainable agricultural practices, reducing the need for external fortification processes and resource-intensive interventions.

The Way Forward in Biofortification: A Sustainable Approach to Nutrition

Biofortification is a promising solution to combat hidden hunger and malnutrition by enriching crops with essential nutrients. To maximize its impact, key strategies include strengthening research and development (R&D), raising awareness, scaling up production, and monitoring outcomes.

Strengthening R&D: Ongoing investment is crucial for developing biofortified, climate-resilient crops. Collaborative efforts between public institutions, universities, and private companies can accelerate this process.

Raising Awareness: Effective awareness campaigns targeting farmers, policymakers, and consumers are vital for adoption. Government initiatives and media campaigns can promote the benefits of biofortified crops.

Scaling Up Production: Governments and the private sector must collaborate to scale production and distribution of biofortified crops, improving market access and consumer acceptance through public-private partnerships.

Monitoring and Evaluation: Tracking the health and nutrition impacts of biofortification ensures its effectiveness in addressing malnutrition.

Conclusion

Biofortification offers a transformative solution to malnutrition in India, aligning with the country's SDG goals focused on health, nutrition, and sustainable agriculture. By integrating biofortification into national policies, India can combat micronutrient deficiencies at scale, particularly benefiting vulnerable communities in rural areas. To maximize its impact, collaboration among government agencies, agricultural research institutions, the private sector, and local communities is essential. Public-private partnerships (PPPs) can drive production, market access, and consumer acceptance of biofortified crops.

Biofortification provides a scalable, sustainable pathway to equitable nutrition and health for all, contributing to resilient food systems, economic growth, and environmental sustainability.

References

Bouis, H. E., & Saltzman, A. (2017). Improving nutrition through biofortification: A review of evidence from Harvest Plus, 2003 through 2016. *Global Food Security*, 12, 49-58.

FAO, IFAD, UNICEF, WFP, & WHO. (2021). The State of Food Security and Nutrition in the World 2021. Rome: FAO.

Ministry of Agriculture & Farmers Welfare, Government of India. (2022). National Biofortification Strategy.

Poshan Abhiyaan: National Nutrition Mission. Ministry of Women and Child Development, Government of India. (2018).

NITI Aayog. (2017). "National Nutrition Strategy: Vision to Action." Government of India.

Indian Council of Agricultural Research (ICAR). (2022). "Biofortification in Indian Agriculture."

Saltzman, A., et al. (2013). "Biofortification: Progress and opportunities for health impact." *Nutrition Reviews*.

Bouis, H. E., et al. (2011). "Biofortification: A new tool to reduce micronutrient malnutrition." *Food and Nutrition Bulletin*.

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BACK TO ROOTS: THE NEW WAVE OF REVERSE MIGRATION THROUGH AGRICULTURE

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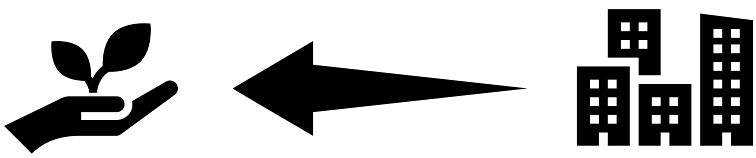
Abstract

The trend of reverse migration, where people are moving from urban areas back to rural regions, has gained momentum in recent years. One of the key driving forces behind this shift is the rising interest in agriculture, as individuals seek more sustainable and meaningful lifestyles outside crowded cities. The global pandemic, economic pressures, and advances in technology have accelerated this movement, with agriculture becoming an attractive option for returnees seeking both livelihood opportunities and a closer connection to nature. This paper explores the emergence of agriculture as a primary driver of reverse migration, examining how farming, agribusiness, and rural entrepreneurship are reshaping rural communities. Factors such as the availability of land, government incentives, the rise of sustainable farming practices, and technological innovations in Agri-tech are key to making agriculture a viable and lucrative option for those returning to rural areas. The study also highlights how this trend can address broader socio-economic issues, including urban overpopulation, food security, and environmental sustainability. Through a comprehensive analysis, the paper demonstrates how reverse migration is contributing to rural economic revitalization, strengthening local food systems, and fostering more resilient, sustainable communities. It also examines the challenges faced by returnees, such as lack of infrastructure, limited access to markets, and the need for skill development in modern farming techniques. Ultimately, the reverse migration wave driven by agriculture not only offers individuals an opportunity to reconnect with their roots but also holds the potential to transform rural economies and contribute to global sustainability goals.



Importance

The importance of reverse migration through agriculture lies in its potential to address a wide range of economic, social, and environmental challenges while revitalizing rural areas. Here are some key reasons why this trend is significant:

1. Economic Revitalization of Rural Areas

- **Job Creation:** Agriculture can serve as a cornerstone for job creation in rural areas, providing opportunities for returnees and local communities. By reintroducing people to farming and agribusiness, this migration trend can stimulate local economies and reduce rural unemployment.

- **Diversification of Rural Economies:** Reverse migration can encourage the growth of new agricultural businesses, such as food processing, organic farming, and agro-tourism. This diversification can reduce the dependency on traditional farming methods, increase income sources, and foster economic resilience.
- **Improved Livelihoods:** By returning to agriculture, individuals and families can access more affordable living conditions in rural areas. Lower living costs, combined with the potential for income through farming or agribusiness, can lead to improved standards of living for returnees.

2. Sustainability and Environmental Benefits

- **Promotion of Sustainable Farming:** Reverse migration provides an opportunity to implement more sustainable farming practices, such as organic farming, agroforestry, and regenerative agriculture. These methods help restore soil health, reduce carbon emissions, and contribute to biodiversity, which are critical for long-term environmental sustainability.
- **Natural Resource Management:** By moving back to rural areas, people can engage in more environmentally conscious practices that conserve natural resources. This can include better water management, soil conservation, and climate-resilient farming techniques, which help mitigate the impacts of climate change.

3. Reduction of Urban Overcrowding

- **Alleviating Urban Pressure:** As more people migrate back to rural areas, urban centers can experience a reduction in overcrowding, which can ease pressures on infrastructure, housing, and public services. This can lead to improved living conditions in cities and reduce problems like pollution, traffic congestion, and the strain on healthcare systems.
- **Decentralization of Opportunities:** Reverse migration can help to decentralize economic and employment opportunities, reducing the overconcentration of resources and industries in urban hubs. This could help address regional disparities and promote balanced national development.

4. Strengthening Food Security

- **Local Food Production:** Reverse migration can help boost local food production by attracting individuals back to agriculture. This can strengthen food security, reduce reliance on imported goods, and ensure that communities have access to fresh, locally grown produce.
- **Resilience to Global Shocks:** As more people return to agriculture, local food systems become more self-sufficient and resilient to global disruptions, such as pandemics, supply chain issues, or climate-related events.

5. Cultural and Social Benefits

- **Preservation of Rural Heritage:** Agriculture is an integral part of rural culture and heritage. Reverse migration offers an opportunity to preserve traditional farming methods and indigenous knowledge while adapting to modern farming technologies. This helps maintain cultural diversity and identity in rural communities.
- **Stronger Communities:** As people move back to rural areas, they can play an active role in rebuilding strong, connected communities. Social cohesion improves when people engage in local economies and share their experiences, creating a sense of belonging and fostering intergenerational knowledge exchange.

6. Increased Innovation in Agriculture

- **Technological Advancements:** Reverse migration offers the potential for the application of new technologies in agriculture, such as precision farming, smart irrigation, and sustainable

crop management systems. This integration of agritech can improve productivity and efficiency, making farming more profitable and attractive.
- **Encouraging Young Entrepreneurs:** The return of younger people to rural areas can introduce a wave of innovation and entrepreneurship, as they often bring new ideas, knowledge, and perspectives on how to modernize agriculture, market products, and improve operations.

7. Strengthening Rural Infrastructure
- **Improved Infrastructure Investment:** As more people return to rural areas, there is likely to be increased demand for better infrastructure, including roads, electricity, healthcare, and internet access. This can lead to improved living conditions and create a positive feedback loop, where better infrastructure attracts more migrants.
- **Educational Opportunities:** Reverse migration can stimulate the development of educational programs that focus on agricultural skills and business management, ensuring that both youth and adults have the skills they need to thrive in farming and agribusiness.

8. Social and Psychological Well-being
- **Better Work-Life Balance:** Moving back to rural areas for farming can offer a better work-life balance, as the slower pace of life and stronger community ties may reduce stress and increase overall well-being. This can be particularly appealing to those seeking a more meaningful, nature-oriented lifestyle.
- **Connection to Nature:** Returning to agriculture allows individuals to reconnect with the land and nature, which can have positive psychological effects, including reduced anxiety and greater life satisfaction.

9. Supporting Global Goals
- **Achieving Sustainable Development Goals (SDGs):** Reverse migration can contribute to several SDGs, such as "No Poverty," "Zero Hunger," "Decent Work and Economic Growth," and "Climate Action." By promoting sustainable agriculture and rural development, reverse migration can help address critical global challenges in a localized context.
- **Reducing Urban-Rural Inequality:** This trend can help reduce the social and economic disparities between urban and rural areas, fostering more balanced development across regions and contributing to social equity.

Challenges

Reverse migration, the process of people moving from urban to rural areas, often in search of better opportunities or to return to their roots, can be particularly influenced by agricultural dynamics. While this trend might offer several opportunities for revitalizing rural areas, it also poses significant challenges. Here are some key challenges faced by reverse migration through agriculture:

1. **Limited Infrastructure and Connectivity**:
   - Rural areas may lack the necessary infrastructure such as roads, electricity, water supply, and internet connectivity, making it difficult for migrants to establish themselves and contribute to agricultural activities effectively.
   - Insufficient access to markets or poor transportation infrastructure can hinder the distribution of agricultural products, limiting the economic potential of farmers.
2. **Land Ownership and Access**:
   - Migrants returning to rural areas may face difficulties in acquiring land or may not have the financial means to invest in land due to high costs or unclear property rights.

- The availability of productive land may be limited, and in some cases, land fragmentation can reduce the efficiency and profitability of farming.

3. **Outdated Farming Practices**:
   - Some migrants returning to rural areas may lack experience in modern agricultural techniques or may be unfamiliar with current trends and technologies. This gap in knowledge can limit productivity.
   - The reliance on traditional farming methods, which may be less efficient, can reduce agricultural output and profitability.
4. **Unpredictable Climate Conditions**:
   - Agriculture is highly sensitive to climate change, and rural areas might be especially vulnerable to erratic weather patterns such as droughts, floods, and shifting growing seasons, which can create uncertainty for those who rely on farming as their livelihood.
5. **Economic and Financial Barriers**:
   - Limited access to financial resources such as loans, subsidies, or agricultural insurance can prevent returnee migrants from investing in modern agricultural equipment or expanding their operations.
   - The high cost of inputs (seeds, fertilizers, pesticides) can be a significant burden on those trying to establish agricultural ventures in rural areas.
6. **Skill Gaps and Lack of Training**:
   - Many urban migrants may have limited experience or training in agriculture, especially if they were working in non-agricultural sectors before returning to rural areas.
   - There may be insufficient agricultural extension services or training programs to help these migrants upgrade their skills in modern farming methods or sustainable practices.
7. **Social and Cultural Integration**:
   - Returning migrants may find it difficult to reintegrate into rural communities if they have been away for long periods or have adopted urban lifestyles.
   - There may be cultural or social tensions between returnee migrants and the existing rural population, especially if the migrants are seen as outsiders or if there is competition for resources.
8. **Limited Employment Opportunities**:
   - While agriculture may be the primary source of livelihood in rural areas, it might not always provide sufficient income or employment opportunities for returnees, especially in areas with small-scale or subsistence farming.
   - Seasonal nature of agricultural work and low wages can drive people back to urban areas in search of more stable, higher-paying jobs.
9. **Inadequate Support Systems**:
   - Rural areas may lack adequate social support systems such as healthcare, education, and social security, making life difficult for returnee migrants, particularly those with families.
   - The absence of cooperative societies or farmer organizations that could provide collective bargaining power or share resources and knowledge could limit the migrants' ability to succeed.

10. **Policy and Government Support**:
    - Often, rural development policies may not be geared toward supporting reverse migration or may fail to address the specific needs of returnee migrants, such as facilitating their access to land, credit, and training.
    - A lack of comprehensive and integrated agricultural policies can hinder the success of reverse migration initiatives.

Addressing these challenges requires a multi-pronged approach that includes investment in infrastructure, policy reforms, skill development, access to finance, and climate resilience strategies to ensure that reverse migration leads to sustainable agricultural development and improved livelihoods for returning migrants.

Conclusion

Reverse migration driven by agriculture offers an opportunity for both individuals and communities to thrive. It provides a path toward economic revitalization, environmental sustainability, and the strengthening of social and cultural ties in rural areas. For countries experiencing rural depopulation and urban overcrowding, this trend presents a valuable solution to many of the challenges posed by rapid urbanization, climate change, and the need for more sustainable food systems. To make reverse migration successful, it is essential to adopt a comprehensive approach. This includes improving rural infrastructure, providing access to modern farming techniques and technologies, ensuring financial support, and fostering social integration. Additionally, governments must create favorable policies that support reverse migration through investments in education, healthcare, and rural development.

In conclusion, while reverse migration through agriculture holds the potential to rejuvenate rural communities and contribute to sustainable farming practices, its success relies on addressing the barriers that returnee migrants face. Strategic planning, effective policy interventions, and community-based support systems are critical to ensuring that reverse migration becomes a viable and thriving avenue for agricultural development and rural prosperity.

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APPLICATION OF rDNA TECHNOLOGY IN FOOD MICROORGANISMS

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Abstract

Recombinant DNA (rDNA) technology has revolutionized the food industry by enabling the genetic modification of microorganisms to enhance food production, quality, safety, and sustainability. This technology involves the precise insertion of desired genetic traits into microorganisms, allowing for the production of essential enzymes, bioactive compounds, and improved fermentation processes. Engineered bacteria, yeasts, and fungi are used to produce enzymes such as chymosin for cheese-making, amylases for baking, and cellulases for juice clarification. Genetically modified probiotics have enhanced functional properties, such as improved gut health and increased resilience to gastrointestinal conditions. This paper explores the applications, advantages, and implications of rDNA technology in food microorganisms, highlighting its transformative impact on modern food systems.

Keywords: Lactobacillus, Probiotics, nutraceutical, fermentation.

Introduction

Recombinant DNA technology is commonly referred to as rDNA technology. Recombinant DNA (rDNA) technology has revolutionized the food industry by enabling the development of genetically modified microorganisms that enhance food production, processing, and safety. As knowledge has grown, efforts have always been made to standardize and optimize the microorganisms utilized to satisfy food production requirements. Recombinant DNA (rDNA) technology has significant applications in the food industry, particularly concerning microorganisms. This technology involves manipulating genetic material to produce organisms with desirable traits, enhancing food production and safety. There are several distinct "starter cultures" that the modern food business can use to produce fermented foods (IFBN, 1990). It is possible to more precisely alter the characteristics of microbes using genetic engineering (Geisen et al., 1995). Major goals include optimization of the production process, enhancement of product quality, and safety (hygienic status), and enlargement of product diversity. The creation of enzymes that are physically and functionally identical to their conventional counterparts will not be the only use of recombinant DNA technology in the future. "Protein engineering" will be given more attention.

Examples of food microorganisms developed using rDNA technology:

Lactic Acid Bacteria (LAB)

- Genetically modified *Lactobacillus* and *Streptococcus* species are used in dairy fermentation:
    - Enhanced acid production for faster yogurt or cheese production.
    - Improved tolerance to low pH, temperature, or bacteriophage attacks.
    - Production of bioactive compounds like bacteriocins (e.g., nisin) for natural food preservation (Widyastuti et al., 2019)

Escherichia coli

- *E. coli* strains, though not used directly in foods, are engineered to produce:
  - **Chymosin**: A rennet enzyme used in cheese-making, replacing animal-derived rennet. (Sohaimy & Saadani, 2010)
  - **Vitamin B12** and other nutritional additives.

Bacillus species

- *Bacillus subtilis* is engineered to produce enzymes: (Shafique et al., 2021)
  - **Amylases**: Used in baking and brewing.
  - **Proteases**: Used in meat tenderizers and flavor enhancement

Saccharomyces cerevisiae

- Modified strains are widely used in baking, brewing, and winemaking:
  - Improved ethanol production for alcoholic beverages. (Salam et al., 2024)
  - Enhanced flavor profiles in bread and fermented drinks. (Khamwachirapithak, et al., 2023)
  - Production of bioethanol as a by-product in industrial fermentation. (Tesfaw et al., 2014)

Industrial Products Using GEMs

1. **Rennet Enzymes**
   - Recombinant chymosin produced by *E. coli, Aspergillus niger,* or *Kluyveromyces lactis* is used in 90% of cheese production worldwide.
2. **Probiotics**
   - Genetically modified probiotics (*e.g., Lactobacillus spp.*) are designed to:
     - Improve gut health by surviving harsh stomach conditions.
     - Produce therapeutic compounds like antimicrobial peptides or vitamins.
3. **Nutraceuticals**
   - rDNA-engineered microorganisms produce bioactive compounds such as:
     - **Vitamin B12** and riboflavin (via bacteria and yeast).

Microorganisms in food industry:

Lactic acid bacteria play an outstanding role in food fermentation (Teuber, 1993). *Escherichia coli* K-12-expressed bovine chymosin was the first recombinant enzyme that the US Food and Drug Administration (FDA) authorized for use in food (Flamm, 1991).

Development of Genetically Modified Microorganisms (GMMs)

GMMs are created to produce food ingredients or enhance food safety. For example, certain strains of yeast and bacteria have been genetically modified to increase their resistance to environmental stresses or to produce beneficial compounds such as probiotics. These modifications can lead to improved fermentation processes, higher yields, and reduced spoilage.

Application of genetically improved microorganisms in food industry:

- **Improved Fermentation Efficiency:** rDNA is used to genetically modify starter cultures in the production of fermented foods like yogurt, cheese, and bread. By modifying bacteria such as *Lactobacillus* and *Streptococcus*, scientists can increase fermentation efficiency, improve flavor profiles, and enhance consistency.
- **Enzymes:** Enzyme preparations are produced on an industrial scale using pure culture fermentations of specific microorganism strains. It has been demonstrated that yeasts are

the best systems for expressing heterologous proteins (Gellissen and Leeuwenhock, 1992). The milk-clotting protease, chymosin, the first food ingredient made using recombinant DNA technology, is one of the most well-known and innovative instances of an enzyme derived from genetically engineered microbes it is approved for use in food (Flamm, 1991).

- **Probiotic Enhancement:** Probiotics (*e.g., Lactobacillus, Bifidobacterium*) can be genetically modified to enhance their health benefits, such as increased resistance to gastrointestinal conditions like low pH or bile salts. The ability to produce bioactive compounds, such as vitamins or antimicrobial peptides.

Advantages of rDNA in food microorganisms

1. **Sustainability**: GEMs reduce the need for animal or plant-derived resources.
2. **Efficiency**: Faster, cost-effective production of enzymes and additives.
3. **Customization**: Specific traits can be engineered, like allergen reduction or enhanced flavors.

Conclusion

By enabling the precise genetic modification of bacteria, yeasts, and fungi, this technology has facilitated the development of efficient fermentation processes, the production of bioactive compounds, and the creation of innovative food ingredients. From enhanced probiotics and sustainable enzyme production to improved flavor profiles and food safety measures, rDNA technology continues to reshape modern food systems. Continued research and development in this field hold the promise of creating safer, healthier, and more sustainable food solutions for a growing global population. As such, rDNA technology remains a cornerstone of innovation in the ever-evolving food industry.

References

Geisen, R; Stander, L.; Leistner, L. Food Biotechnol. 1990, 4, 497-504 https://doi.org/10.1080/08905439009549762

IFBC (International Food Biotechnology Council), Regulat. Toxicol. Pharmacol. 1990, 12, 1-1

Teuber, M. In Biotechnology, Vol. 1, Biological Fundamentals, Rehm, H.- J.; Reed, G., Editors, VCH, Weinheim, 1993, 325-366.

Flamm, E.L., 1991. How FDA approved chymosin: a case history. Bio/ Technology 9, 349–351. https://doi.org/10.1038/nbt0491-349

Gellissen, G. A. V. Leeuwenhock, 1992, 62, 79-93. https://doi.org/10.1007/BF00584464

Flamm, E.L. Bio/Technology, 1991, 9, 349-3

El-Sohaimy, S. A., & El-Saadani, M. A. (2010). Cloning and in vitro-transcription of chymosin gene in E. coli. *The Open Nutraceuticals Journal*, *3*(1). https://doi.org/10.2174/18763960010030100063

Shafique T, Shafique J, Zahid S, Kazi M, Alnemer O, Ahmad A. Screening, selection and development of *Bacillus subtilis* apr-IBL04 for hyper production of macromolecule alkaline protease. Saudi J Biol Sci. 2021 Feb;28(2):1494-1501. https://doi.org/10.1016/j.sjbs.2020.11.079

Maria Abdul Salam, Abida Mushtaque, Sara khan, Qurat-ul-Ain, Arslan Younas, Nadia Fatima, Aneela Younas Malik, Mahtab Ali Shah, Humsa Khan. (2024). The Effect of Glucose, Temperature and pH On Bioethanol Production by *Saccharomyces Cerevisiae*. *Journal of Population Therapeutics and Clinical Pharmacology*, *31*(1), 656-667. https://doi.org/10.53555/jptcp.v31i1.4174

Khamwachirapithak, P., Sae-Tang, K., Mhuantong, W., Tanapongpipat, S., Zhao, X. Q., Liu, C. G., ... & Runguphan, W. (2023). Optimizing ethanol production in Saccharomyces cerevisiae at ambient and elevated temperatures through machine learning-guided combinatorial promoter modifications. *ACS Synthetic Biology*, *12*(10), 2897-2908.

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AQUATIC PLANT : SOURCE OF HUMAN FOOD

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Abstract

The freshwater ecosystem supports a variety of plants and animals that are utilized for food, medicine and other necessities for humans. In which, aquatic plants play a significant role in the world's food systems as a nutrient-dense food category that can boost human health and provide adequate nutrition. These are highly abundant in minerals and vitamins and have a moderate, pleasant and sweet flavour. Due to the edibility of the flowers, cotyledons, seeds, and rhizomes of aquatic plants, they have been widely used in home kitchen for making various cuisines.

Keywords : Aquatic plant, Nutrients, Plants.

Introduction

Aquatic plant foods, which include various types of seaweeds and freshwater plants, are often overlooked but has significant source of nutrition can positively impact human health. These plants have been consumed for centuries in various countries around the world and have recently gained popularity as a super food due to their exceptional nutritional value. Aquatic plants are packed with essential vitamins and minerals, including vit- C, vit- K, Vit-A, iron, calcium, magnesium and iodine. These nutrients are vital for various body functions, such as enhancement of immune system, blood clotting, bone health and thyroid function.

Aquatic plants are an excellent source of dietary fibre, that boosts efficient digestibility and can aid in weight management by promoting satiety and reducing intake of over calorie. Many aquatic plants are rich in antioxidants, such as carotenoids and flavonoids, which protect the body cells from oxidative stress. These also play a crucial role in reducing inflammation and lowering the risk of chronic diseases, including certain cancers. Apart of its nutritional value, some seaweed may contain high levels of heavy metals or other pollutants, depending on their harvesting location Thus, it is important to consume aquatic plant foods responsibly but have to ensure that they are sourced from clean and uncontaminated waters. With any dietary change, it's advisable to consult with a qualified healthcare professional or a registered dietician.

Health benefits of seafood for humans

Aquatic animal food (AAFs) has mainly three possible benefits for improving human health. It provides the main source of the omega-3 long-chain polyunsaturated fatty acids; docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), which lowers the risk of heart disease and promote brain and eye health; reduces micronutrient deficiencies (such as vitamin A, calcium and iron) that results in subsequent chronic diseases; and by substituting the consumption of processed and less-healthy red meat that can cause anaemia (Rimm *et al.*, 2018).

Aquatic foods can minimize meat consumption.

In addition to playing a crucial role in supplying protein, DHA+EPA, and other critical micronutrients, AAFs can help stave off non-communicable diseases that are linked to food. Two mechanisms are used to give these health advantages. First, DHA+EPA are directly provided by AAFs, which may enhance brain function and lower the risk of heart disease and some cancers. Second, it can replace the consumption of animal-source foods that are more dangerous, such as red and processed meat. A significant percentage of the global north observed either no discernible impact or a relationship between an increase in AASF intake as well as a decline in dietary intake of dairy, eggs, poultry and red meat (Golden *et al.,* 2021).

Aquatic foods provide sustenance for the weak

Age, sex, culture, socioeconomic level, geography and access to the nutrients generated by the food systems are the factors that influence the dependency of a community on AAFs. Micronutrients and DHA+EPA play critical role in foetal and child growth and development also AAFs are vital for people of all sexes and ages, but they are particularly crucial for young children, pregnant women and women of reproductive decades (Bennett *et al.,* 2021).

Edible Freshwater Plants

A variety of plants and animals, utilized for food, medicine and other essentials of everyday living are supported by the freshwater ecosystem, which is essential for humans. Because they serve as a source of food and medicine, freshwater plants have had a big influence on human civilizations for a very long time. To suit their needs, these plants were either gathered from the wild or raised in fields, flooded areas, or aquaculture. Despite the greater number of plants used to treat illnesses and disorders, those utilized for human sustenance are few and only meant for local consumption because of their traditional uses (Aasim *et al.,* 2018).

A few additional aquatic plants that are consumed by humans:

1. Water Chestnut (*Trapa natans*): The water chestnut is a floating aquatic plant with edible corms (bulb-like structures) that have a sweet, nutty flavour. They are commonly used in Asian cuisines, often in stir-fries, soups, and desserts.

2. Azolla (Water Fern): Azolla is a small floating aquatic plant that grows rapidly and is rich in protein. It is used as a green manure and animal feed in some regions, but it is also consumed by humans in certain parts of the world, particularly in parts of Southeast Asia.

3. Water Bamboo (*Zizania aquatica*): Water bamboo is a species of aquatic grass with edible shoots and seeds that is often referred to as wild rice or water oats. It is used in various dishes in some Asian cuisines.

4. Water Lettuce (*Pistia stratiotes*): A plant with edible leaves that floats in water is called water lettuce. It is used as a vegetable in some parts of Africa and Southeast Asia.

5. Water Shield (*Brasenia schreberi*): Water shield is a floating aquatic plant with edible leaves and seeds. It is used as a food source in some Native American cultures.

6. Pickerelweed (*Pontederia cordata*): The young shoots and tubers of the pickerelweed plant are edible and have been used as a food source by some Indigenous communities in North America.

7. Watercress (*Nasturtium officinale*): As mentioned earlier, watercress is a popular aquatic plant used as a leafy green vegetable in various cuisines worldwide.

8. Water Caltrop (*Trapa bicornis*): Also known as Singhara in some regions, the seeds of the water caltrop are edible and used in various dishes in Asian cuisine.

Ipomoea aquatica

Aquatic floating plants known as "water spinach" are indigenous to southern China, Southeast Asia, and India. These are grown on small farms in the majority of Asian nations and requires a temperature between 10 and 30 °C. The mild, pleasant flavour of these leaves are sweet and they are also a good source of vitamins and minerals (Bautista *et al.,* 1988).

Nelumbo nucifera

One of Asia's most notable edible aquatic and perennial creeping herbs is the Indian lotus, sometimes known as the sacred lotus. Because of its significant medicinal and edible value, Indian lotus is farmed worldwide. It is widely used as food, medicine and has religious importance in India, the Indian lotus is one of the country's most significant aquatic plants. The edible parts of Indian lotus plants, including the flowers, early leaves, seeds, rhizomes and lotus roots are high in dietary fibre, vitamins, and nutrients, that have been used extensively as a vegetable in a variety of cuisines. The rhizome is used to prepare soups and pickles, accompany as a salad, substitute of coriander leaves and use in various prawns dishes. (Mehta *et al.,* 2013).

Conclusion

Aquatic foods contribute to nutrition through highly accessible vital micronutrients and fatty acids; nonetheless, the nutritional value of aquatic meals has traditionally been emphasized on its modest contribution to global energy (i.e., calories) and protein intake. Because environmental, social-economic effects might differ greatly between the wild-capture and aquaculture sectors, it is crucial to take into account where and how aquatic foods are generated. The aquatic plants that are flourishing all over the world are an important source of food for people or have medical benefits. This article makes an effort to explain the role of aquatic and semi aquatic plants in human nutrition as well as the area where these are effectively utilised. Human consumption is made from the plant parts.

References

Aasim, M., Bakhsh, A., Sameeullah, M., Karataş, M., & Khawar, K. M. (2018). Aquatic plants as human food. *Global perspectives on underutilized crops*, 165-187.

Bautista, O. K., Kosiyachinda, S., & Abd Shukor, A. R. (1988). Traditional vegetables of ASEAN. *ASEAN Food Journal*, 4(2), 47-58.

Bennett, A., Basurto, X., Virdin, J., Lin, X., Betances, S. J., Smith, M. D., & Zoubek, S. (2021). Recognize fish as food in policy discourse and development funding. *Ambio*, (50), 981-989.

Golden, C. D., Koehn, J. Z., Shepon, A., Passarelli, S., Free, C. M., Viana, D. F.,& Thilsted, S. H. (2021). *Aquatic foods to nourish nations*. Nature, 598(7880), 315-320.

Mehta, N., Patel, E. P., Pragnesh, B. S. V. P., & Shah, B. (2013). Nelumbo nucifera (Lotus): a review on ethanobotany, phytochemistry and pharmacology. *Indian Journal of Pharmaceutical and Biological Research*, 1(04), 152-167.

Rimm, E. B., Appel, L. J., Chiuve, S. E., Djoussé, L., Engler, M. B., Kris-Etherton, P. M.,& Lichtenstein, A. H. (2018). Seafood long-chain n-3 polyunsaturated fatty acids and cardiovascular disease: a science advisory from the American Heart Association. *Circulation*, 138(1), e35-e47.

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ARBORICULTURE

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Abstract

Arboriculture is the science, practice and study of the cultivation, management and care of trees, shrubs, and other perennial woody plants. It encompasses a broad range of activities, including planting, pruning, pest management, soil health, and the study of tree physiology and growth patterns. Arborists, who are trained professionals in this field, play a critical role in enhancing urban and rural landscapes, promoting ecological balance, and ensuring the health and longevity of trees. This practice is increasingly important in the context of climate change, urbanization, and environmental conservation, as trees contribute to biodiversity, carbon sequestration, air quality improvement. Arboricultural research focuses on the development of sustainable practices, the diagnosis and treatment of tree diseases and pests, as well as the integration of tree care into urban planning. The growing recognition of trees as essential components of green infrastructure has led to increased investments in arboricultural education, policy development, and urban forestry initiatives worldwide.

Introduction to Arboriculture

Arboriculture is the specialized practice, science, and management of trees, shrubs, and other woody plants, particularly in urban and peri-urban settings. The term "arboriculture" comes from the Latin words *arbor*, meaning tree, and *cultura*, meaning cultivation or care. It involves the planting, care, maintenance, and study of trees with the goal of improving their health, aesthetic value, and functional benefits. Arboriculture spans a wide range of activities, from tree pruning and pest management to soil health and tree risk assessments, and it plays a critical role in maintaining the vitality of trees in our cities, forests, and rural landscapes.

Trees provide numerous ecological, social, and economic benefits, from enhancing air quality and improving biodiversity to providing shade, reducing energy costs, and offering aesthetic value to urban spaces. As urbanization accelerates and environmental concerns like climate change and habitat loss become more pressing, the role of arboriculture has become increasingly vital in ensuring sustainable, healthy, and resilient green spaces.

History of Arboriculture

The history of arboriculture dates back thousands of years, with its evolution intertwined with the development of human civilizations and the increasing importance of trees in agriculture, urban planning, and environmental conservation. Early forms of tree management were often tied to religious, cultural, and practical needs, and over time, the scientific study and professionalization of arboriculture grew into the specialized field we know today.

17th and 18th Centuries: Rise of Botany and Forestry

In the 17th and 18th centuries, the scientific study of trees and plants, or botany, began to gain ground. The age of exploration brought new tree species to Europe from other parts of the world, including the Americas and Asia, sparking interest in the cultivation and management of diverse tree species. This period also marked the beginning of forestry as a distinct discipline, with efforts to manage forests for timber production. The concept of "silviculture," or the cultivation and management of forests, emerged, laying the groundwork for arboriculture's later development as a more specialized field.

19th Century: Professionalization of Arboriculture

The 19th century saw the formalization of arboriculture as a distinct profession. As urbanization accelerated during the Industrial Revolution, trees were increasingly valued for their aesthetic and environmental benefits in urban settings. Public parks, like Central Park in New York (opened in 1857), were designed with tree planting and care as a central component, bringing arboriculture to the forefront of urban planning.

The establishment of tree care as a professional field began with the founding of the first arboricultural societies and the publication of key texts on tree care and management. In the late 19th century, organizations like the *Arboricultural Association* (founded in 1877 in the United Kingdom) and the *International Society of Arboriculture* (ISA, founded in 1924) helped standardize practices and promote arboriculture as a legitimate scientific discipline.

20th Century: Arboriculture as a Modern Science

By the 20th century, arboriculture began to be recognized as both an art and a science. Innovations in tree care, such as the development of modern pruning techniques, soil science, and tree health diagnostics, transformed the field. Arborists, with the help of new tools and technologies, were better able to assess and treat tree diseases and pests, thus improving the longevity and health of urban trees. The rise of environmental consciousness during the mid-20th century, especially post-World War II, brought broader recognition of the environmental and ecological services that trees provide, such as improving air quality, reducing urban heat islands, and enhancing biodiversity.

The growing body of arboricultural research, including studies on tree physiology, root systems, and urban tree integration, led to more refined approaches to tree care. The integration of trees into urban design and green infrastructure became an important area of study, as cities increasingly sought to balance development with environmental sustainability.

21st Century: Arboriculture in a Changing World

In the 21st century, arboriculture continues to evolve in response to global challenges such as climate change, urbanization, and the growing need for environmental stewardship. The field has expanded to include specialized areas like tree risk assessment, urban forestry, and ecological restoration. Arborists today employ advanced technologies such as Geographic Information Systems (GIS), remote sensing, and tree health diagnostics to make data-driven decisions in tree management.

The role of arboriculture in mitigating the effects of climate change, promoting biodiversity, and enhancing public health has gained significant attention. Trees are seen not only as aesthetic elements but also as essential components of sustainable urban and rural environments. The increasing awareness of the value of trees has led to stronger policies promoting urban greening, reforestation, and the preservation of mature trees.

Scope and Importance of Arboriculture

Arboriculture encompasses a variety of disciplines within the broader field of plant management. It includes:

- **Tree Planting and Establishment**: Understanding the appropriate species selection for various environments and planting methods to ensure healthy tree growth.

- **Tree Pruning and Maintenance**: Regular pruning and trimming of trees to enhance growth, remove dead or dangerous branches, and maintain aesthetic or structural integrity.
- **Tree Health and Disease Management**: Monitoring and diagnosing diseases, pests, and other threats to trees' health and applying treatments to preserve tree vitality.
- **Soil and Root Management**: Ensuring that trees have adequate soil conditions, nutrients, and root space to thrive, especially in compacted urban soils.
- **Tree Risk Assessment**: Evaluating the structural integrity of trees and identifying potential hazards to people or property, such as weak limbs or unstable trees, and recommending corrective actions.
- **Urban Forestry**: The integration of trees into urban planning and design to create sustainable and livable cities. This includes managing green spaces, street trees, and tree canopy coverage.

The importance of arboriculture is increasingly recognized in the context of environmental sustainability. Trees are crucial for mitigating the effects of climate change by absorbing carbon dioxide, producing oxygen, and reducing the urban heat island effect. They also provide critical ecosystem services, such as improving water quality by reducing runoff and providing habitats for wildlife.

Arboriculture in Urban Settings

As urban areas grow, trees are often incorporated into city planning to improve public health and quality of life. Arborists work in close collaboration with urban planners, landscape architects, and government agencies to create and maintain green spaces that support both the ecological and social needs of communities. This includes:

- **Green Infrastructure**: Trees are essential elements of urban green infrastructure, which aims to use natural systems to solve environmental problems. For instance, street trees and parkland help manage water runoff, reduce flooding, and lower the urban heat island effect.
- **Public Safety and Tree Care**: In cities, trees must be maintained to prevent safety hazards, such as falling branches or damaged trees during storms. Arborists are trained to assess and mitigate risks, keeping both people and trees safe.
- **Health and Wellbeing**: Urban trees have been linked to better mental health, reduced stress, and improved air quality. Arboriculture thus contributes to the overall well-being of urban residents, making cities more livable and pleasant.

Arboriculture as a Profession

Arboriculture is a skilled profession, with arborists being highly trained individuals responsible for the care, maintenance, and protection of trees. To ensure the health and safety of trees, arborists must possess knowledge in a wide range of subjects, including tree biology, pest and disease management, pruning techniques, tree risk assessment, and urban forestry principles. Many arborists are certified by professional organizations such as the **International Society of Arboriculture (ISA)** or the **Arboricultural Association (AA)**, which provide certifications and education to ensure that arborists meet industry standards.

Arboriculture is not just a technical field; it is also a growing area of research. As the role of trees in urban ecosystems becomes better understood, ongoing research in arboriculture explores areas such as:

- Tree species selection for climate adaptability
- Innovative techniques in tree preservation and restoration
- Urban tree health and resilience in changing environments
- The environmental and economic benefits of urban trees


Principles and Objectives of Arboriculture

Arboriculture is a field that blends science, art, and management to ensure the health, safety, and sustainability of trees and other woody plants. The principles and objectives of arboriculture provide the foundation for effective tree care and management, whether in urban landscapes, rural settings, or forested areas. These principles guide arborists and tree care professionals in their work, ensuring that trees are nurtured and managed in ways that benefit both the environment and society.

Key Principles of Arboriculture

1. **Tree Health and Vitality**: The primary principle of arboriculture is to maintain or improve the health and vitality of trees. This includes ensuring proper nutrition, preventing or mitigating diseases, pests, and stress, and managing the physical environment in which trees grow. Arborists focus on the tree's overall well-being, from root health to canopy structure.
2. **Structural Integrity and Safety**: Trees must be structurally sound to minimize the risk they pose to people, property, and infrastructure. Arboriculture emphasizes structural integrity, which includes pruning trees to remove weak or dangerous limbs, conducting regular risk assessments, and ensuring trees do not pose hazards to their surroundings. This principle is

particularly important in urban and peri-urban settings where trees interact closely with human populations.

3. **Environmental Stewardship**: Arboriculture aims to enhance the role of trees in supporting the natural environment. This involves recognizing trees as vital contributors to ecosystem services, such as air and water quality improvement, carbon sequestration, biodiversity conservation, and soil stabilization. Arborists practice sustainable tree care, minimizing negative impacts on the environment and promoting ecological balance.
4. **Aesthetic and Functional Value**: Trees provide aesthetic, cultural, and functional benefits to urban and rural landscapes. Arboriculture seeks to enhance the beauty and functionality of trees, ensuring they thrive in the designed landscape while complementing surrounding features. This includes designing and caring for trees that provide shade, reduce urban heat, enhance privacy, and contribute to the overall beauty of green spaces.
5. **Sustainability**: Sustainable arboriculture practices aim to preserve and protect trees for future generations. This includes strategies for long-term tree care, such as planting species suited to local climates and environments, mitigating the effects of climate change on tree health, and promoting tree planting and reforestation efforts. The principle of sustainability also extends to the careful management of tree resources to ensure they remain healthy over time without depleting the environment.


Objectives of Arboriculture

1. **Tree Planting and Establishment**: One of the fundamental objectives of arboriculture is the successful planting and establishment of trees. This involves selecting the appropriate species for the location, preparing the soil, and ensuring optimal growing conditions for young trees. Proper establishment increases the likelihood of tree survival and long-term health.
2. **Tree Maintenance and Pruning**: Regular maintenance is essential to keep trees healthy and safe. Arborists undertake pruning to remove dead, diseased, or damaged branches, improve air circulation, and shape the tree. Pruning also helps to control tree size, ensuring that it doesn't interfere with buildings, power lines, or other infrastructure. Proper pruning techniques can prolong a tree's life and improve its structural integrity.
3. **Disease and Pest Management**: Trees are vulnerable to various diseases and pests that can affect their health and stability. One of the key objectives of arboriculture is to monitor tree health regularly, identify potential threats, and apply integrated pest management (IPM) techniques to control or eradicate pests and diseases. This may involve using biological, cultural, or chemical methods in an environmentally responsible way.

4. **Tree Risk Assessment**: Arboriculture includes evaluating the risks associated with trees. Arborists assess factors such as the structural condition of trees, the presence of diseases or pests, and environmental factors (e.g., wind, soil conditions) to determine potential hazards. The goal is to reduce the risk of tree-related accidents by identifying and addressing issues before they cause harm to people or property.
5. **Soil and Root Management**: Healthy soil and root systems are essential for the long-term survival of trees. Arboriculture emphasizes proper soil management, including aeration, fertilization, mulching, and prevention of soil compaction. The goal is to create an environment where roots can thrive, ensuring the tree has access to adequate water and nutrients.
6. **Urban Greening and Green Infrastructure**: In urban areas, arboriculture focuses on integrating trees into the city's infrastructure to improve overall quality of life. This includes the creation and maintenance of urban forests, street trees, and green spaces that provide shade, reduce the urban heat island effect, mitigate stormwater runoff, and enhance air quality. Arborists work with city planners to ensure that trees are strategically planted and managed to maximize their benefits to the urban environment.
7. **Education and Advocacy**: Another important objective of arboriculture is to promote public awareness and education about the value of trees. Arborists play a crucial role in educating the public, policymakers, and community leaders about tree care, the benefits of trees, and the importance of preserving urban and rural forests. This can include offering tree planting workshops, public demonstrations on proper pruning techniques, or advocating for tree protection policies.
8. **Biodiversity Conservation**: Arboriculture aims to protect and conserve biodiversity by maintaining healthy, diverse tree populations. This involves promoting the use of native tree species and ensuring that planted trees support local wildlife and ecosystems. Arborists may also engage in restoration projects to improve or expand natural habitats for wildlife.
9. **Climate Change Mitigation**: Trees play a significant role in mitigating the impacts of climate change through carbon sequestration and the cooling effect of tree canopies. Arboriculture objectives include planting trees that are resilient to changing climate conditions, reducing the carbon footprint of urban areas, and promoting urban green spaces that help mitigate the effects of extreme heat and flooding.
10. **Tree Preservation**: A key objective of arboriculture is to preserve mature and historically significant trees, as they provide valuable environmental, cultural, and aesthetic benefits. Arborists may be involved in preserving old trees in urban and rural settings, ensuring that they continue to thrive despite the pressures of urban development, pollution, and climate change.

Current Status of Arboriculture in India

Arboriculture in India, like in many parts of the world, has gained increasing importance in recent years due to rapid urbanization, environmental concerns, and the growing recognition of the numerous benefits provided by trees. The country, with its rich biodiversity, diverse climate zones, and expanding urban centers, faces unique challenges and opportunities when it comes to the care, management, and preservation of trees. While there has been progress in some areas, arboriculture in India is still developing as a professional field, with significant gaps in terms of training, research, and policy implementation.

Challenges Facing by Arboriculture in India

1. **Urbanization and Infrastructure Development**: The rapid growth of cities and urban sprawl is one of the biggest challenges for arboriculture in India. As cities expand, large numbers of trees are often felled to make way for infrastructure development, including roads, buildings, and industrial zones. This has led to a loss of green cover in many urban areas, contributing to the urban heat island effect, increased pollution, and a decrease in overall well-being for residents.
2. **Lack of Proper Tree Management**: In many Indian cities, there is insufficient planning for the long-term care and maintenance of urban trees. Trees planted along roadsides or in parks often receive little attention in terms of soil health, pruning, pest control, or protection from pollutants. The lack of trained arborists and standard tree management practices further exacerbates this issue.
3. **Tree Loss and Deforestation**: India has faced significant deforestation, especially in the last century, due to agricultural expansion, logging, and encroachment on forested areas. Though there have been efforts to curb deforestation and increase afforestation, the loss of trees in rural and urban areas continues to be a challenge for the country's environmental sustainability.
4. **Climate Change and Its Impact on Trees**: The effects of climate change, such as rising temperatures, erratic rainfall, and extreme weather events (like storms and floods), have put additional stress on India’s trees. These stresses increase the vulnerability of trees to diseases, pests, and poor growth, while reducing their ability to offer critical environmental services like carbon sequestration, shade, and pollution mitigation.

Key Developments in Arboriculture in India

1. **Awareness and Advocacy**: In recent years, there has been a growing awareness of the importance of trees for urban living, as well as the need for professional arboriculture practices. Organizations such as the **Indian Society of Arboriculture (ISA India)**, **Green Tribunal**, and environmental NGOs have been actively working to raise awareness and promote best practices for tree care, management, and conservation.
2. **Government Initiatives and Policies**: Several government initiatives and policies are helping shape the future of arboriculture in India:
    - **National Afforestation Program**: Launched by the Ministry of Environment, Forest, and Climate Change (MoEFCC), this program aims to increase forest cover and improve the quality of existing forests. Many of the efforts focus on the importance of maintaining and managing trees in urban and peri-urban areas.

- **Smart Cities Mission**: As part of India's initiative to develop 100 smart cities, there is a focus on improving green spaces and integrating trees into urban infrastructure. Urban greening projects often emphasize the need for tree planting and tree management to improve air quality and combat climate change.
- **Compensatory Afforestation Fund**: This fund, managed by the MoEFCC, helps finance tree planting and conservation projects as compensation for deforestation due to development activities.

3. **Training and Certification**: There has been an increasing push to train professionals in arboriculture. In recent years, there have been efforts to introduce courses and certifications for arborists. These programs are aimed at improving the skills of those involved in tree planting, care, pruning, and risk management. The **Indian Society of Arboriculture** is working toward professionalizing the field, but the overall awareness and uptake of arboricultural certifications are still in the early stages.
4. **Corporate and Community Engagement**: Many private sector companies and local communities are now actively involved in tree planting and green initiatives. Corporate social responsibility (CSR) programs, such as those run by companies like Tata Group, Infosys, and other large corporations, often include significant investments in urban greening and tree care. Additionally, local communities are increasingly engaging in tree planting drives, especially during festivals like **Van Mahotsav** (Tree Plantation Day), which is celebrated annually across the country.
5. **Technological Advancements**: While arboriculture in India still largely relies on traditional methods, the use of modern technology is slowly gaining traction. Geographic Information Systems (GIS) and remote sensing are being employed for urban tree mapping and monitoring. Furthermore, innovations in tree health diagnostics, pest management, and the use of drones to assess tree health and canopy coverage are beginning to find applications in larger urban centers.

Key Areas of Arboriculture Development in India

1. **Urban Forestry and Green Infrastructure**: The integration of trees into urban planning has gained prominence in India, especially with the rise of **Urban Forestry** and the importance of **green infrastructure**. Cities like **Bangalore**, **Hyderabad**, and **Delhi** have initiated large-scale tree planting campaigns and are increasingly considering tree canopy coverage as an important metric in urban development planning.
2. **Public-Private Partnerships**: Public-private partnerships (PPPs) have become an essential model for tree management and urban greening projects. Municipal authorities often collaborate with private firms, NGOs, and community groups to maintain trees, develop green spaces, and enhance the environmental value of cities.
3. **Research and Innovations in Tree Care**: Indian research institutions are starting to focus on tree health, pest control, and new methods for improving tree survival in urban areas. For example, the **Indian Council of Forestry Research and Education (ICFRE)** conducts research on forestry practices, and universities are offering specialized courses in urban forestry, environmental science, and arboriculture.
4. **Tree Risk Assessment and Safety**: As awareness of tree-related safety issues increases, urban areas are beginning to invest in **tree risk assessment** to prevent accidents due to

falling branches or weakened trees during storms. Cities like **Mumbai** and **Chennai** have begun to assess the risk of large, mature trees and take preventive measures.

Conclusion of Arboriculture

Arboriculture is a vital and dynamic field that plays an essential role in the health, sustainability, and aesthetics of both urban and rural landscapes. It blends scientific knowledge, practical skills, and a deep understanding of the natural environment to care for trees and other woody plants. As cities expand, environmental concerns intensify, and climate change becomes an increasingly urgent global issue, the importance of arboriculture continues to grow. The work of arborists—ranging from tree planting and maintenance to risk assessment and environmental advocacy—helps ensure that trees continue to thrive, providing the wide array of benefits they offer, from improving air quality and reducing urban heat to enhancing biodiversity and mitigating the effects of climate change.

Despite its critical importance, arboriculture faces challenges, particularly in rapidly urbanizing regions, where trees are often threatened by development, pollution, and neglect. However, with growing recognition of the numerous environmental, economic, and social benefits of trees, there is a rising focus on integrating arboriculture into urban planning, environmental conservation, and community development. Efforts to professionalize the field, through education, certification, and research, are the keys to improving tree care practices and creating a more sustainable future for both urban and rural landscapes.

Ultimately, arboriculture represents a balance between science, stewardship, and community. By understanding and applying the principles of tree care, arborists play a crucial role in creating greener, safer, and more resilient environments. As the world faces new ecological and environmental challenges, the field of arboriculture will remain essential in fostering healthier ecosystems, mitigating climate change, and improving the quality of life for future generations.

References

Vogt et al,.2015, Urban forestry and arboriculture as interdisciplinary environmental science: Importance and incorporation of other disciplines. August 2015.Journal of Environmental Studies and Sciences

DOI:10.1007/s13412-015-0309-x

https://www.researchgate.net/publication/281099126_Urban_forestry_and_arboriculture_as_interdisciplinary_environmental_science_Importance_and_incorporation_of_other_disciplines.

https://bigbuild.vic.gov.au/__data/assets/pdf_file/0016/524014/NELP-EES-Chapter-15-Arboriculture.pdf.

https://www.researchgate.net/publication/278714396_Arboricultural_Practices.

https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/arboriculture.

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HYBRID SEED DEVELOPMENT IN SESAME: REVIEW ON YIELD POTENTIAL AND GENETIC DIVERSITY

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ABSTRACT
Sesame (*Sesamum indicum* L.) is an ancient oilseed crop also known as the "Queen of oilseeds" valued for its high-quality oil and nutritional benefits. Despite the fact that sesame is an economically important crop, it yields remain low due to limited genetic improvement, climate change and susceptibility to biotic and abiotic stresses. Sesame is a self- pollinated crop and hybrid seed development offers a promising avenue to enhance sesame productivity by exploiting heterosis and improving stress tolerance, by increasing adaptability to changing climate, improvising nutritive content and oil percentage. To produce hybrid seeds various methods are adopted like conventional breeding in which selection of superior parents are made, cytoplasmic male sterility which favours cross pollination and molecular markers for example SSR, AFLP. As farmers are major producers in agriculture sector adaptation of hybrid seed by farmers is a challenging procedure due to lack of extension facilities. However, overcoming all the challenges advancement in technology, conservation of land races and wild cultivars and strengthening public-private partnership plays pivotal role in hybrid seed development.

Keywords: Genetic improvement, stress, tolerance, heterosis, adaptability, cytoplasmic male sterility, molecular marker.

Introduction

Sesame (*Sesamum indicum* L.) is known as the "Queen of oilseeds" due to its high-quality oil and a wide variety of nutritious compounds. It is commonly referred as til, simsim, benniseed and gingelly. It is a significant source of vegetable oil, with its consumption projected to reach 100 million metric tons by 2030 (Troncoso-Ponce *et al.*, 2011). Sesame ranks ninth among the top 13 oilseed crops that account for 90% of global edible oil production (Bamigboye *et al.*, 2010). This crop is crucial in tropical and subtropical areas because of its high oil content and rich antioxidant properties, making it a favoured option for producing edible oil.

As an autogamous species, sesame has yet to be suitable for heterosis breeding due to the absence of effective methods for large-scale seed production. For the commercial use of heterosis, a key requirement is the identification of parent lines that exhibit significant heterosis. The phenomenon of heterosis itself is multifaceted, influenced by the balance of additive, dominance, and their interacting factors, along with the distribution of genes among the parental lines. From the perspective of plant breeding, standard heterosis holds practical importance. To take advantage of commercially viable heterosis, new crosses must be evaluated against established varieties, allowing for the identification of crosses with substantial heterotic potential. Therefore, it is essential to ascertain the nature and extent of heterosis in order to create high-yielding hybrids in sesame. However, Sesame farming encounters obstacles like low production, vulnerability to insects and diseases, and a high sensitivity to environmental pressures. The development of hybrid seeds has become a crucial approach to tackle these challenges, utilizing the genetic diversity of sesame to produce varieties that yield more and are resilient to stress.

Description

1. Methods of Hybrid Seed Development:

1.1 Conventional Breeding Approaches:

The crossing of genetically distinct and complementary parents is essential in genetic studies to understand trait inheritance, develop breeding populations, and produce hybrid seeds. Hybrid seeds play a crucial role in agriculture by enhancing yields; the phenomenon of hybrid vigour or heterosis provides plants with improved resistance to both abiotic and biotic stresses (Duvick, 2001). The predominant method for producing a limited amount of hybrid seed for breeding and genetic studies in self-pollinating crops is through mechanical emasculation combined with hand pollination. (Yahaya *et al*., 2020).

The selection of parents depends on the breeder's goals, such as achieving high yield, superior quality, or resistance to various stresses, including biotic and abiotic challenges, as well as shattering resistance. Crosses between parent varieties that have different flowering and maturity times are staggered and planted three times at ten-day intervals. Off-types are eliminated. When roughly half of a variety's plants begin to bloom, hybridization begins. Tie the corolla tips of ripe flower buds with threads in the evening to guarantee selfing in sesame. The gynoecium is left intact prior to the flower opening when the epipetalous corolla is plucked out for emasculation. In the evening, the emasculated flower bud is covered with a plastic straw that has one side bent. The next morning, the plastic straw is put in place and pollination is completed. An alternative method is to use a gum (Das, 1990) to pollinate and fertilize the emasculated

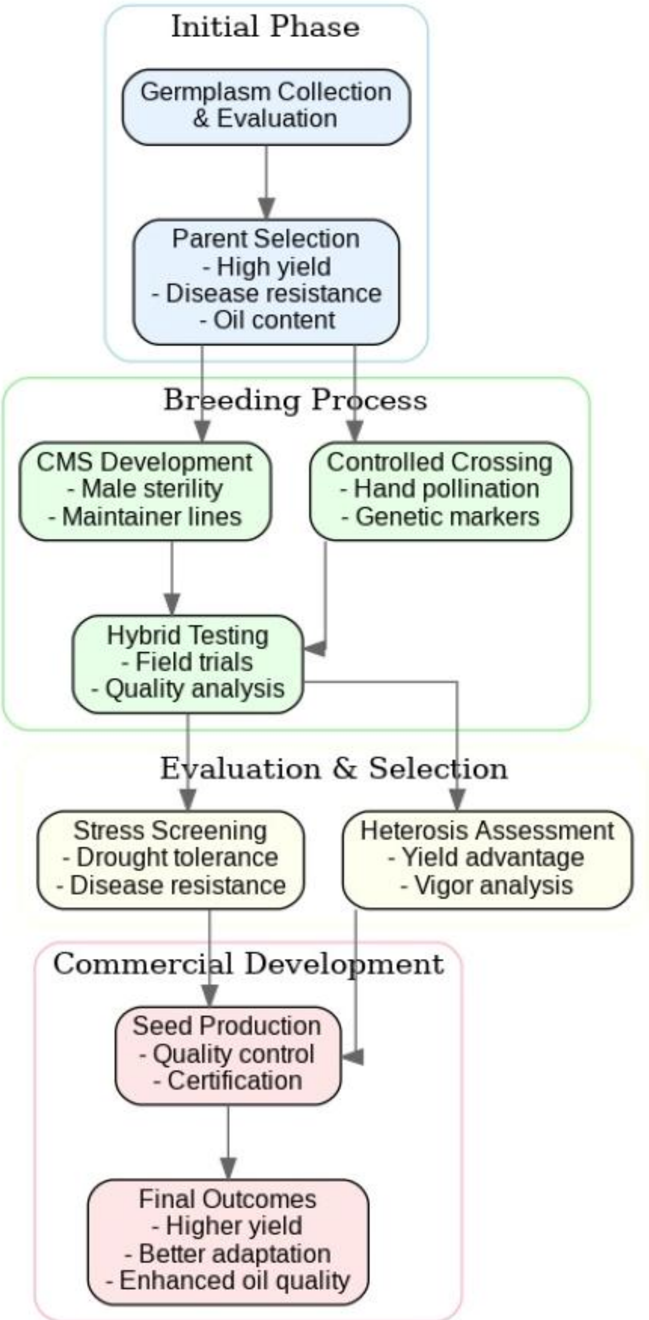

Fig 1: Conventional breeding with commercial seed development

flower by placing the corolla (with stamens intact) of the selected male parent, which is ready to open. (Konaté *et al*., 2021).

1.2 Cytoplasmic Male Sterility (CMS):

The first determinate sesame mutant, dt-45, was discovered by Ashri (2006) in an M2 population of Israeli cv. No-45 exposed to gamma radiation. (Ashri, A. 2006). Male sterile lines provide an opportunity to facilitate the cross-pollination process for hybrid seed production, and to exploit sesame heterotic vigour. A naturally occurring split corolla recessive genic male sterile mutant (msms) was first found in Venezuela (Langham, 1947).

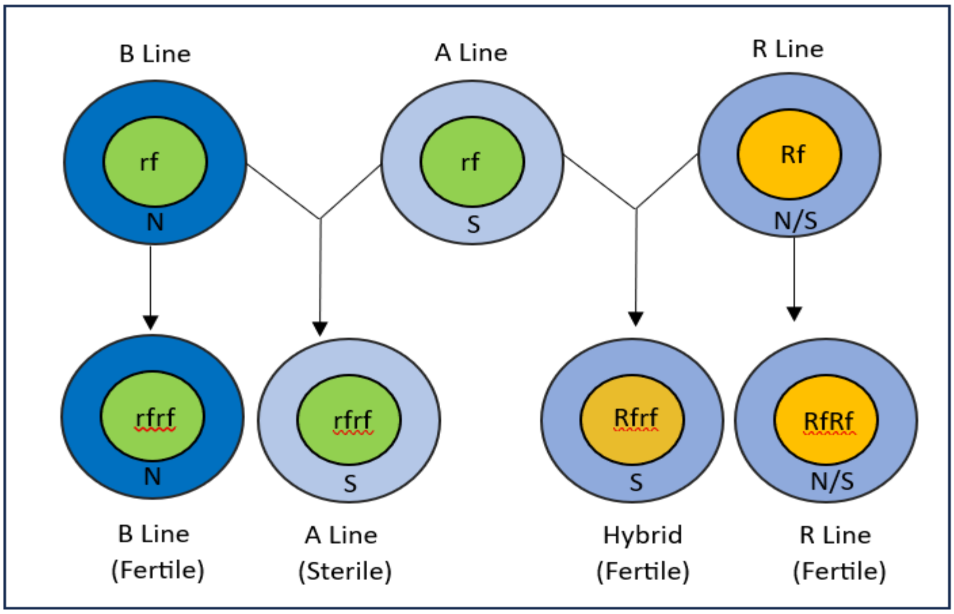

Fig 2: Hybrid seed production using CMS system

Transferring the male sterility factor from the wild related *Sesamum malabaricum* to the cultivated sesame *S. indicum* allows for the development of cytoplasmic male sterile (CMS) lines in sesame (Kavitha *et al*., 2000).

1.3 Molecular Breeding Techniques:

Finding and using suitable alleles in the gene pool is essential to its genetic improvement. In order to identify allelic variation in the genes underlying the agronomically significant traits (shattering, abiotic and biotic resistance), MAS appears to be a suitable alternative. The core of any crop's genomic research is the creation of genetic maps. EST-SSR (expressed sequence tags-simple sequence repeat), AFLP (amplified fragment length polymorphism), and RSAMPL (random selective amplification of microsatellite polymorphic loci) markers were used to create the first thorough genetic linkage map in sesame on an F2 population (Wei *et al.*, 2009). It helps in molecular breeding of sesame by providing a starting point for tagging features of breeding interest.

By recognizing plants that possess the target allele even in the early phases of vegetative growth, marker-aided selection in this situation enables quick introgression of a specific characteristic into the recurrent parent. Molecular markers are popular and are used in gene mapping, cloning, genetic map construction, genetic diversity analysis, and marker-aided selection for crop improvement.

(Pandey *et al*., 2018). CRISPR/Cas9 is a targeted gene editing technique where the Cas9 enzyme is guided by gRNA sequences, which are roughly 20 bases long. The CRISPR-associated protein (Cas) and CRISPR work together like molecular scissors to cause double-strand breaks and direct RNA to direct the Cas toward a specific DNA sequence (Phatate, 2024).

Table 1: Online genomic resources for sesame.

Database	Website	Utility	Reference
Sinbase	http://www.ocri-genomics.org/Sinbase / index.html	Genomics, comparative genomics, genetics, phenotypes, etc.	Wang, L., Yu, S., Tong, C., Zhao, Y., Liu, Y., Song, C., & Zhang, X. (2014). Genome sequencing of the high oil crop sesame provides insight into oil biosynthesis. *Genome biology*, *15*, 1-13.
Sesame FG	http://www.ncgr.ac.cn/SesameFG	Genomics, evolution, breeding, comparative genomics, molecular markers, phenotypes, transcriptomics	Wei, X., Gong, H., Yu, J., Liu, P., Wang, L., Zhang, Y., & Zhang, X. (2017). Sesame FG: an integrated database for the functional genomics of sesame. *Scientific reports*, *7*(1), 2342.
SisatBase	http://www.sesame-bioinfo.org/SisatBase/	Genome-wide SSR	
The Sesame Genome Project	http://www.sesamegenome.org	Genomics	Zhang, Y., Wang, L., Xin, H., Li, D., Ma, C., Ding, X., & Zhang, X. (2013). Construction of a high-density genetic map for sesame based on large scale marker development by specific length amplified fragment (SLAF) sequencing. *BMC plant biology*, *13*, 1-12.

Source: Teklu, D. H., Shimelis, H., & Abady, S. (2022). Genetic improvement in sesame (*Sesamum indicum* L.): Progress and outlook: A review. *Agronomy*, *12*(9), 2144.

2. Key Traits for Hybrid Development

2.1 Yield enhancement:

The yield of any crop is its most important characteristic. In order to boost total output, heterosis is used to produce more seeds per pod. Key characteristics, such as the quantity of capsules per plant, the number of seeds each capsule, and the weight of 1000 seeds, are crucial for increasing productivity.

2.2 Stress tolerance:

Abiotic stress : Abiotic stressors include heat stress, waterlogging, and drought. Flowering, capsule and seed formation, seed production, and eventually oil quality is all negatively impacted by drought stress (Dossa *et al*., 2017b). Since the mutant lines "ML2-37" and " ML2-72" showed a high degree of drought tolerance, they can be used as elite germplasm to create robust cultivars that are suited to dry and semi-arid areas where irrigation water is a constraint (Kouighat *et al*., 2023).

Sesame is extremely sensitive to waterlogging that even slight waterlogging inhibits the growth and development of sesame. Sesame genomes linked to waterlogging stress resistance will be identified using a combination of transcriptomics and SSR investigations. Sesame productivity is severely impacted by high temperatures, particularly during anthesis and seed filling. However, systematic screening has made it feasible to create hybrids that are resistant to heat stress in the modern world. Thus, in light of the changing global environment, we require hybrid sesame seeds that exhibit resilience to these stresses.

Biotic stress:
Fungi, viruses, bacteria, insects, and nematodes are examples of living creatures that can cause biotic stress. Due to its vulnerability to dry root rot and phyllody disease, the majority of cultivated sesame types result in significant financial losses. Sucking pest insects are a significant limiting factor in the yield of sesame crops. The production of hybrids or better varieties would benefit from our increased knowledge of the regulatory systems against biotic stressors, which would be strengthened by identifying the molecular mechanisms behind sesame's tolerance to biotic stress.
Source: Yadav, R., Kalia, S., Rangan, P., Pradheep, K., Rao, G. P., Kaur, V., & Siddique, K. H. (2022). Current research trends and prospects for yield and quality improvement in sesame, an important oilseed crop. *Frontiers in Plant Science*, *13*, 863521.

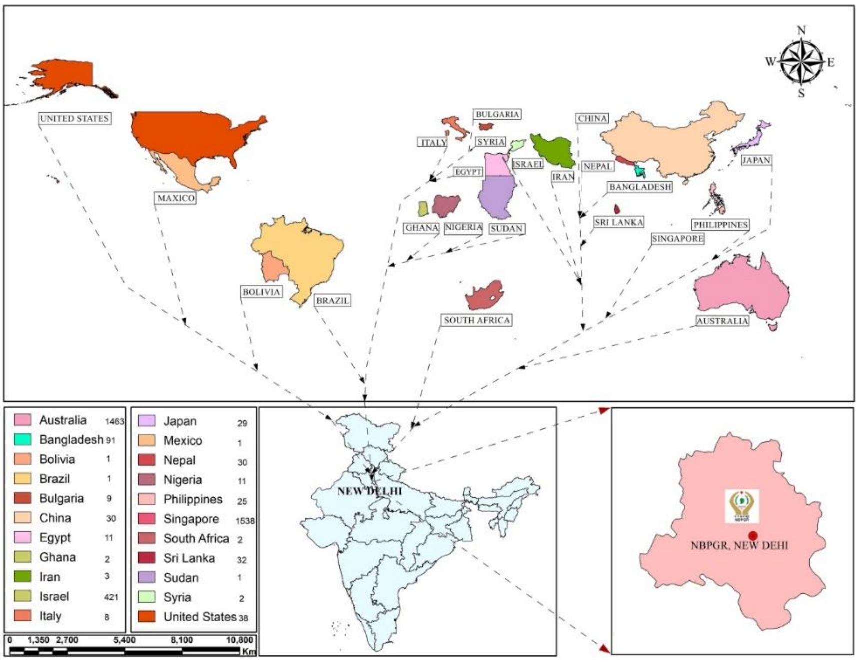

Figure 3: Sesame germplasm exotic collections (ECs) in India from different countries.

2.3 Quality Improvement:
Sesame oil is quite popular because of its great quality as it has balanced fatty acid composition is required for high quality export value, with proportionately higher percentages of unsaturated fatty acids (linoleic and oleic acids) compared to saturated fatty acids (stearic and palmitic acids), as well as higher levels of antioxidants (sesamol, sesaminol), and tocopherols. Sesame varieties with high

oil content have been generated through the effective use of conventional breeding techniques in the current craze (Baydar *et al*., 1999b). A different approach to achieving a high oleic acid concentration and a low linoleic and linolenic acid content is genetic manipulation. One of many varieties with a high oil content and good potential for oil extraction is the Siddhi Super sesame hybrid.

3. Challenges in hybrid seed development

3.1 Genetic Bottlenecks:

Evolutionary events known as genetic bottlenecks produce founding populations that may result in genetic drift by stochastically reducing a population's genetic variety. In summary, an abrupt decline in the gene pool's genetic variability brought either by human or natural influence. Landraces and wild relatives are conserved and used in breeding programs to prevent genetic bottlenecks and to expand the genetic base. In addition to helping with environmental adaptation and climate change mitigation, this improves sustainable sesame production to satisfy the high standards of quality required by both domestic and foreign markets. (Teklu *et al*., 2022).

3.2 Seed Production Constraints:

Creating hybrid seeds requires a lot of breeding and research. Cross-pollinating plants over years allows scientists and breeders to obtain desired features including disease resistance, increased production, and superior quality. The price of hybrid seeds is increased by field testing, skilled labour costs and research facility maintenance. Furthermore, in CMS system, requirement to create maintainer and restorer lines makes line maintenance more challenging. Developing restorer lines may be challenging because fertility is susceptible to temperature changes. It can be challenging to choose the ideal restorer lines because modifier genes can interact with CMS lines (Swamy *et al*., 2017).

3.3 Adoption and Dissemination:

Farmers' awareness and adoption of hybrid seeds are limited as a result of a lack of extension efforts. As the percentage of late adopters (including laggards and late majorities) tends to exceed 50%. So, the adoption process in India tends to be on late side.

4. Future prospects

4.1 Integration of Advanced Technologies:

Platforms for high-throughput phenotyping combine a data processing tool, a control terminal, and data collection apparatus. They primarily use non-invasive imaging and spectroscopy methods to gather phenotypic data, and they use high-performance computing devices to quickly assess the physiological state and growth activities of plants. In contrast to conventional phenotyping techniques, high-throughput phenotyping enables dynamic observation of plants at various growth stages and the simultaneous collection of data for numerous attributes in huge populations. Second, trait characterisation based on spectra or pictures is more objective than more conventional techniques like visual scoring, which are subject to subjective interpretation. Third, it eliminates the need for time-consuming procedures by enabling non-destructive estimation of biochemical parameters based on modelling. (Xiao *et al.*, 2022).

The best linear unbiased genomic prediction was used to assess the performance of the rice hybrid (Xu et al., 2016). Numerous investigations are currently using artificial neural networks (ANN). In these applications, an ANN with particular inputs and outputs finds relationships between each set of inputs and the outputs that go with them. (Haykin, 1998) One machine learning method used in prediction applications is multiple layer perception (MLP). Basic perceptions arranged in input, output, and one or more hidden layers make up the majority of MLP. The problem condition determines how many neurons are present in each layer. MLPs are trained using the supervised learning approach. In the training phase, inputs are sent into the network, and the outputs are compared to the desired outputs. The difference between the expected and actual outputs creates an error signal. Reducing the error signal is the aim of network training.

4.2 Conservation of Genetic Resources:

1. Establishment of sesame germplasm banks

The primary sources of genetic variability that result in the selection of desired features for ongoing and upcoming genetic enhancement initiatives are sesame genetic resources. In sesame enhancement efforts, many local and international gene banks gather and preserve genetically varied sesame germplasm resources.

2. Utilization of landraces and wild relatives

Important characteristics for pre-breeding and breeding programs are present in landraces, which are a great source of genetic variation (Lopes *et al*., 2015). In underdeveloped nations, landraces are frequently grown using conventional agricultural methods in a variety of challenging conditions, where they are subject to pressures from diseases, insects, and pests. (Pícha *et al*., 2018). In pipeline breeding programs and elite lines, landraces can be used to incorporate distinctive features. In addition to helping with environmental adaptation and climate change mitigation, this improves sustainable sesame production to satisfy the high standards of quality required by both domestic and foreign markets.

Conclusion

Sesame is a major oilseed crop, autogamous and ranks ninth among the top 13 oilseed crops. Hybrid seed development pave the pathway for development of high-quality seed, resistance to diseases, pathogens as well as increase its ability to tolerate climate change. By unlocking the features of molecular breeding and CMS line along with conventional breeding scientist have made possible to produce hybrid seeds economically. Hybrid seed production in sesame have some challenges like low genetic diversity, lack of demonstration facilities of hybrid seeds to farmers for adaptation of new seeds. Earlier scientists took long time to develop a hybrid seed but as time passed advancement in technology led to exploration of new methods which makes the hybrid seed production easier for example use of molecular markers, spectroscopy techniques. With concerted efforts from researchers, policymakers, and the private sector, hybrid seed development can lead the way for a sustainable and prosperous tomorrow of sesame industry.

References

Ashri, A. (2006). Sesame (*Sesamum indicum* L.). *Genetic resources, chromosome engineering, and crop improvement: oilseed crops*, *4*, 231-289.

Bamigboye, A. Y., Okafor, A. C., & Adepoju, O. T. (2010). Proximate and mineral composition of whole and dehulled Nigerian sesame seed. *African Journal of Food Science and Technology*, *1*(3), 71-5.

Baydar, H., Turgut, I., & Turgut, K. (1999). Variation of certain characters and line selection for yield, oil, oleic and linoleic acids in the Turkish sesame (Sesamum indicum L.) populations. *Turkish journal of agriculture and forestry*, *23*(4), 431-442.

Das, P. K. (1990). A simple modified technique for selfing and hybridization in (Sesamum indicum L.). *Andhra Agriculture Journal*, *37*, 104-106.

Dossa, K., Diouf, D., Wang, L., Wei, X., Zhang, Y., Niang, M., & Cisse, N. (2017). The emerging oilseed crop Sesamum indicum enters the "Omics" era. *Frontiers in plant science*, *8*, 1154.

Duhoon, S. S. (2004, September). Exploitation of heterosis for raising productivity in sesame. In *4th International Crop Science Congress, Brisbane, Australia* (Vol. 26).

Duvick, D. N. (2001). Biotechnology in the 1930s: the development of hybrid maize. *Nature Reviews Genetics*, *2*(1), 69-74.

Duvick, D. N. (2005). The contribution of breeding to yield advances in maize (Zea mays L.). *Advances in agronomy*, *86*, 83-145.

Haykin, S. (1998). *Neural networks: a comprehensive foundation*. Prentice Hall PTR.

http://www.statista.com/statistics/267271/worldwide-oilseed-production-since-2008/

https://www.farmersstop.com/blogs/seed-sowing-guide/the-importance-and-cost-of-hybrid-seeds-a-guide-for-farmers

Kavitha, M., Ramalingam, R. S., Raveendran, T. S., & Punitha, D. (2000). Identification of pollen fertility restorers and inheritance of fertility restoration for cytoplasmic-genic male sterility in sesame (*Sesamum indicum* L.).

Konaté, M., Ouattara, S. S. S., Sékoné, Z., Zoungrana, M., Dao, B., Toguyeni, A., & Sanou, J. (2021). Significant heterosis detected from hybridization of parents with agro-morphological variability in sesame (*Sesamum indicum* L.). *World J. Agril. Res*, *9*(3), 85-91.

Kouighat, M., Nabloussi, A., Kettani, R., Fakhour, S., El Fechtali, M., & Hamdani, A. (2023). Drought-tolerant sesame mutant lines assessed by physiological traits and stress indices under water deficit conditions. *Journal of Agriculture and Food Research*, 14, 100842.

Kumaraswamy, H. H., Jawaharlal, J., Ranganatha, A. R. G., & Chander Rao, S. (2015). Safe sesame (*Sesamum indicum* L.) production: Perspectives, practices and challenges. *Journal of Oilseeds Research*, *32*(1), 1-24.

Kumaraswamy, H. H., Ramya, K. T., Mandal, S. N., Ratnakumar, P., Jawahar-Lal, J., Pushpa, H. D., & Sakthivel. (2023). Biotechnological Approaches for Genetic Improvement of Sesame (*Sesamum indicum* L.). In *Smart Plant Breeding for Field Crops in Post-genomics Era* (pp. 343-368). Singapore: Springer Nature Singapore.

Langham, D. G. (1947). Genetics of sesame.

Lopes, M. S., El-Basyoni, I., Baenziger, P. S., Singh, S., Royo, C., Ozbek, K., & Vikram, P. (2015). Exploiting genetic diversity from landraces in wheat breeding for adaptation to climate change. *Journal of experimental botany*, *66*(12), 3477-3486

Monpara, B. A., & Pawar, A. K. (2016). Evaluation of hybrids for heterosis breeding in sesame (*Sesamum indicum* L.). *Electronic Journal of Plant Breeding*, *7*(4), 1183-1187.

Pandey, S. K., Dasgupta, T., Rathore, A., & Vemula, A. (2018). Relationship of parental genetic distance with heterosis and specific combining ability in sesame (*Sesamum indicum* L.)

Phatate, G. (2024). Recent advances in CRISPR/cas9 technology for plant genome editing. *Agri-India TODAY:* 4(5), 151-157. (Article ID: 04/XI/37/1124)

Pícha, K., Navrátil, J., & Švec, R. (2018). Preference to local food vs. Preference to "national" and regional food. *Journal of Food Products Marketing*, *24*(2), 125-145.

Rauf, S., Basharat, T., Gebeyehu, A., Elsafy, M., Rahmatov, M., Ortiz, R., & Kaya, Y. (2024). Sesame, an Underutilized Oil Seed Crop: Breeding Achievements and Future Challenges. *Plants*, *13*(18), 2662.

Savant, K. D. (2016). Induction of male sterility in sesame (*Sesamum indicum* L.). *Journal of Plant Breeding and Genetics*, *4*(1), 07-10.

Swamy, B. N., Hedau, N. K., Chaudhari, G. V., Kant, L., & Pattanayak, A. (2017). CMS system and its stimulation in hybrid seed production of Capsicum annuum L. *Scientia Horticulturae*, *222*, 175-179.

Teklu, D. H., Shimelis, H., & Abady, S. (2022). Genetic Improvement in Sesame (*Sesamum indicum* L.): Progress and Outlook: A Review. *Agronomy*, *12*(9), 2144. https://doi.org/10.3390/agronomy12092144

Tripathy, S. K., Kar, J., & Sahu, D. (2019). Advances in sesame (*Sesamum indicum* L.) breeding. *Advances in Plant Breeding Strategies: Industrial and Food Crops: Volume 6*, 577-635.

Troncoso-Ponce, M. A., Kilaru, A., Cao, X., Durrett, T. P., Fan, J., Jensen, J. K., & Ohlrogge, J. B. (2011). Comparative deep transcriptional profiling of four developing oilseeds. *The Plant Journal*, *68*(6), 1014-1027.

Wang, L., Yu, S., Tong, C., Zhao, Y., Liu, Y., Song, C., & Zhang, X. (2014). Genome sequencing of the high oil crop sesame provides insight into oil biosynthesis. *Genome biology*, *15*, 1-13.

Wei, L. B., Zhang, H. Y., Zheng, Y. Z., Miao, H. M., Zhang, T. Z., & Guo, W. Z. (2009). A genetic linkage map construction for sesame (Sesamum indicum L.). *Genes & genomics*, *31*, 199-208.

Wei, X., Gong, H., Yu, J., Liu, P., Wang, L., Zhang, Y., & Zhang, X. (2017). Sesame FG: an integrated database for the functional genomics of sesame. *Scientific reports*, *7*(1), 2342.

Xiao, Q., Bai, X., Zhang, C., & He, Y. (2022). Advanced high-throughput plant phenotyping techniques for genome-wide association studies: A review. *Journal of advanced research*, *35*, 215-230.

Xu, S., Xu, Y., Gong, L., & Zhang, Q. (2016). Metabolomic prediction of yield in hybrid rice. *The Plant Journal*, *88*(2), 219-227

Yadav, R., Kalia, S., Rangan, P., Pradheep, K., Rao, G. P., Kaur, V., & Siddique, K. H. (2022). Current research trends and prospects for yield and quality improvement in sesame, an important oilseed crop. *Frontiers in Plant Science*, *13*, 863521.

Yahaya, M. A., Shimelis, H., Laing, M., Mohammed, M. S., & Mathew, I. (2020). Methodologies for hybridization in predominantly self-pollinating crops: a review. *Journal of Crop Improvement*, *34*(2), 268-289

Yemata, G., & Bekele, T. (2024). Evaluation of sesame (*Sesamum indicum* L.) varieties for drought tolerance using agromorphological traits and drought tolerance indices. *PeerJ*, *12*, e16840.

You, J., Li, D., Yang, L., Dossou, S. S. K., Zhou, R., Zhang, Y., & Wang, L. (2022). CRISPR/Cas9-mediated efficient targeted mutagenesis in sesame (*Sesamum indicum* L.). *Frontiers in Plant Science*, *13*, 935825.

Zhang, Y., Wang, L., Xin, H., Li, D., Ma, C., Ding, X., & Zhang, X. (2013). Construction of a high-density genetic map for sesame based on large scale marker development by specific length amplified fragment (SLAF) sequencing. *BMC plant biology*, *13*, 1-12.

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BREAKING DOWN PLASTIC: THE ROLE OF INSECTS IN BIODEGRADATION

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Abstract
Plastic pollution is one of the most urgent environmental issues, with plastics such as Polyethylene (PE), polypropylene (PP), and polystyrene (PS), significantly contributing to ecological deterioration. Conventional disposal techniques, such as incineration and landfilling, are unable to handle the scope of the issue. Numerous insects have demonstrated the capacity to break down plastics through their gut microbiota, such as termites (*Coptotermes* spp.), wax moth larvae (*Galleria mellonella*), and mealworms (*Tenebrio molitor*). These insects provide an environmentally acceptable way to manage plastic waste by converting plastics into less hazardous byproducts. This method could be improved by investigating the microbial strains that cause plastic degradation. Utilising insect-mediated biodegradation creates new avenues for environmentally friendly and sustainable plastic waste management.

Keywords: Biodegradable polymers, environmental pollution, insect-mediated degradation, plastic biodegradation, sustainable waste management

Introduction
Plastic is defined as a material that contains an essential ingredient - an organic substance of large molecular weight. It is also defined as polymers of long carbon chains. Plastic was discovered by famous German chemist Christian Schonbein in 1846. The word, plastic, was derived from the word ***'Plastikos'*** meaning ***'to mould'*** in Greek. Plastics were discovered accidentally when Christian was experimenting in his kitchen and by accident, he spilt a mixture of nitric acid and sulphuric acid. To mop that solution (a mixture of nitric and sulphuric acid) he took a cloth and after moping he kept it over the stove. After some time, the cloth disappeared and from there plastic got its name. Leo Baekeland's 1907 invention of the first fully synthetic plastic is Bakelite. Global plastics production has steadily grown from 2 million tons in 1950 to 390.7 million tons in 2021 (Yang *et al.*, 2023). Among the many widely used plastics, the main resin types and principle contributors to environmental pollution are polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polyethylene terephthalate (PET), polyurethane (PUR), and polystyrene (PS). Most of the plastics that are used are resistant to biodegradation. The plastic waste causes pollution upto 62.31% in marine, 49% in seafloor and 81% in the sea surface. Microplastics cause major detrimental effects on humans through oral intake, inhalation, and skin contact. The toxic effects include reproductive toxicity, neuro toxicity, metabolic disorder, organ dysfunction and DNA damage. Landfilling, incineration, and mechanical recycling are the commonly used methods for disposing plastics. The emerging field of insect-mediated plastic degradation opened a new avenue for addressing the

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escalating issue of plastic pollution. These insects provide a natural model for studying plastic biodegradation, highlighting the significance of such biological processes.

Insects' role in plastic biodegradation

A recent approach on plastic degradation by insects has become a fascinating area in environmental plastic pollution issues. Insects damaging plastics has been observed in 1950s in industries (Gerhardt & Lindgren, 1954). The larvae of the brown house moth or false clothes moth (*Hofmannophila pesudospretella*) were known to eat PE, PS, and nylon films (Whalley, 1965).

1. Mealworms

The gut microorganisms of *Plodia interpunctella*, also known as Indian meal worm have the capacity to degrade polyethylene (PE) specifically LDPE film. Indian meal worms were able to chew and eat Polyethylene (PE) when they were left in direct contact with PE. *Enterobacter asburiae* YT1 and *Bacillus* spp. YP1 were the two prominent microorganisms found in the gut of *Plodia interpunctella* and responsible for PE degradation (Yang *et al*., 2014). A complete genome of *Bacillus* spp. YP1 was sequenced and found relevant to PE biodegradation (Yang *et al*., 2015).

Tenebrio molitor (Yellow meal worms) could chew and eat Polystyrene (PS), commonly called as Styrofoam. Polystyrene digestion in yellow meal worms was studied by isotopic tests. It was found that the yellow meal worms could degrade Polystyrene. *Exiguobacterium* spp. strain YT2 was found in the gut of yellow meal worm. When the bacterial strain was incubated with PS film, a biofilm was formed after 28 days associated with a decrease in PS surface hydrophobicity (Yang *et al.,* 2018). Mealworms are the efficient degrading insects of polyester – PU Foam (67%) (Liu *et al*., 2022). It is known to degrade LDPE (Low density polyethylene), LLDPE (Linear low-density polyethylene) and HDPE (High density polyethylene).

Fig. 1 Break down of plastic bags by Mealworms
(Image source: https://rb.gy/z61jxb)

2. Wax moths

Recently, it was also found that the caterpillars of *Galleria mellonella*, commonly known as Greater wax moth larvae could degrade Polyethylene (PE) at a higher rate compared to *Plodia interpunctella* and *Tenebrio molitor* (Bombelli *et al*., 2017). Recently it was found that *Galleria mellonella* larvae could degrade polyethylene and convert it into ethylene glycol as a product. The holes were formed when *Galleria mellonella* larvae were left in direct contact with PE. As reported, in 12 hours of time 100 larvae caused a mass loss of 92mg to the PE. After performing Atomic force microscopy, FTIR and TGA it was found that there was an obvious change in the topography of PE surface, formation of ethylene glycol and carbonyl bond on the homogenate treated area and 13% of mass loss of PE over 14 hours of treatment respectively, indicating the sign of PE degradation (Bombelli *et al*., 2017).

Insect groups	Insects degrading plastics	Plastic type
Tenebrionidae (Coleoptera)	*Tenebrio molitor*	PS, PE, PVC, PP, PUR, PET
	Tebebrio obscurus	PS, PE
	Tribolium castaneum	PS
	Zophobas atratus	PE, PS, PUR, PP
	Plesiophtahlmus davidis	PS
	Alphitobius diaperinus	PS
	Uloma sp.	PS
Pyralidae (Lepidoptera)	*Galleria mellonella*	PP, PE, PS
	Plodia interpunctella	PE, PS
	Achroia grisella	PE
	Corcyra cephalonica	PE

PS-Polystyrene, PE-Polyethylene, PVC-Polyvinyl chloride, PP-Polypropylene,
PUR-Polyurethane, PET-Polyethylene terephthalate

Fig. 2 Break down of plastic bags by wax moth
(Image source: https://rb.gy/1feh4m)

3. Termites

Termites are the major soil insects that can also degrade plastics using their gut microbiota (Kumar *et al*., 2022). The polymer of plastics include wood plastic composite (WPC) and recycled high-density polyethylene (HDPE). They mostly contains wooden material with petrochemical plastics material. Both the biotic (fungi, bacteria) and abiotic factors (temperature, moisture and sunlight) degrade WPCs. Termites are the most important insects which can effectively degrade WPC and HDPE (pipes). *Coptotermes curvignathus* feed the WPC in case of food scarcity. The Australian termites such as *Coptotermes acinaciformis* and *Mastotermes darwiniensis* are efficient in degrading plastics (Thamil, 2016). Fungal strains in the gut has more potential than bacterial strains in degrading WPC. Fungal strain (*Xylaria*) and bacterial strains (*Bacillus cereus* & *Lysinibacillus* sp.) which is found in wood feeding higher termite garden plays a major role (Sharma *et al*., 2021).

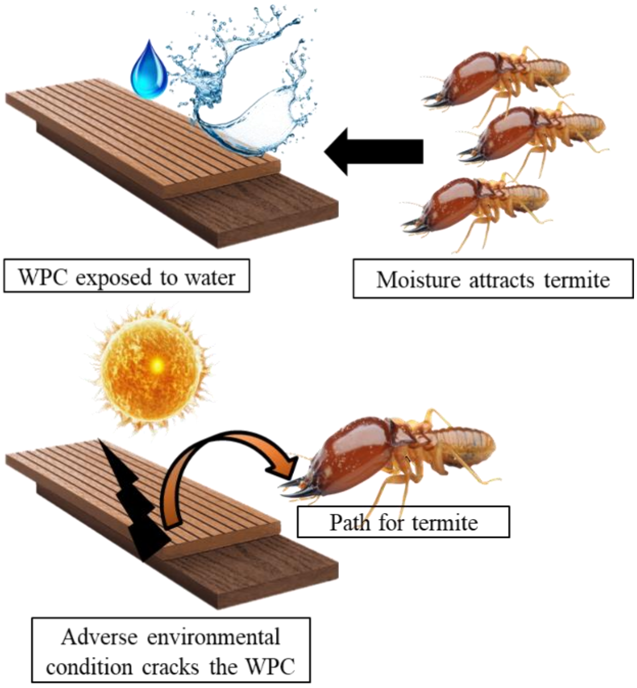

Fig. 3 WPC degradation by termites: WPC on exposure to moisture or high relative humidity attracts most of the fungus and termites. Subsequently, adverse environmental conditions crack the WPC and pave way for the termite to feed on the WPC.

Conclusion

Insects offer a viable, environmentally beneficial approach to plastic biodegradation, tackling the growing problem of plastic pollution. However, obstacles to their broad use include a lack of standardised procedures, a limited understanding of microbial dynamics, and environmental hazards including habitat loss and climate change. Multidisciplinary research is required to optimise degradation processes, create scalable techniques, and create universal protocols in order to fully realise their potential. Insect-mediated plastic degradation can be successfully included into international waste management plans by solving these challenges, greatly enhancing environmental sustainability and lowering plastic pollution.

References

Bombelli P, Howe, C.J and Bertocchini F (2017). Polyethylene bio-degradation by caterpillars of the wax moth Galleria mellonella. Curr Biol, 27(8), R292-R293.

Gerhardt P.D and Lindgren D.L (1954). Penetration of various packaging films by common stored-product insects.

Kumar A, Kalleshwaraswamy C.M, Sharma R, Sharma P and Poonia A (2022, August). Biodegradation of plastic using termites and their gut microbiota: a mini review. In *IOP* Conference Series: Earth and Environmental Science (Vol. 1057, No. 1, p. 012016). IOP Publishing.

Liu J, Liu J, Xu B, Xu A, Cao S, Wei R and Dong W (2022). Biodegradation of polyether-polyurethane foam in yellow mealworms (Tenebrio molitor) and effects on the gut microbiome. Chemosphere, 304, 135263.

Sharma R, Kaur R, Rana N, Poonia A, Rana D.C and Attri S (2021). Termite's potential in solid waste management in Himachal Pradesh: A mini review. Waste Manag Res, 39(4), 546-554.

Thamil C.T (2016). Isolation and identification of polyethylene biodegradation bacterial from the guts of plastic bags-eating damp wood termites. Life Sci Arch (LSA), 2(2), 490-499.

Whalley P.E (1965). Damage to polythene by aquatic moths. Nature, 207(4992), 104-104.

Yang J, Yang Y, Wu W.M, Zhao J and Jiang L (2014). Evidence of polyethylene biodegradation by bacterial strains from the guts of plastic-eating waxworms. Environ Sci Technol, 48(23), 13776-13784.

Yang S.S, Wu W.M, Brandon A.M, Fan H.Q, Receveur J.P, Li Y and Criddle C.S (2018). Ubiquity of polystyrene digestion and biodegradation within yellow mealworms, larvae of Tenebrio molitor Linnaeus (Coleoptera: Tenebrionidae). Chemosphere, 212, 262-271.

Yang S.S, Wu W.M, Pang J.W, He L, Ding M.Q, Li M.X and Ding J (2023). Bibliometric analysis of publications on biodegradation of plastics: Explosively emerging research over 70 years. J Clean Prod, 139423.

Yang Y, Chen J, Wu W.M, Zhao J and Yang J (2015). Complete genome sequence of Bacillus sp. YP1, a polyethylene-degrading bacterium from waxworm's gut. J Biotechnol, 200, 77-78.

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BIOTECHNOLOGICAL TOOLS IN PLANT BREEDING : REVOLUTIONIZING AGRICULTURE

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Abstract
Biotechnology tools have revolutionized plant breeding by offering precise, efficient methods for crop improvement. This review examines the current state and applications of key biotechnology tools in plant breeding, focusing on CRISPR-Cas9 genome editing, molecular markers, tissue culture, and transformation methods. CRISPR-Cas9 technology has emerged as a powerful tool for precise genetic modifications, enabling the development of crops with enhanced traits such as disease resistance and improved yield. Molecular markers have significantly accelerated the breeding process by facilitating marker-assisted selection, while tissue culture techniques have enabled rapid multiplication of disease-free plants and conservation of genetic resources. Various transformation methods, including Agrobacterium-mediated and biolistic approaches, have made it possible to introduce novel genes into plant genomes. Recent advances in synthetic biology have further expanded the possibilities for crop improvement, particularly in developing plants with improved nitrogen fixation capabilities and enhanced photosynthetic efficiency. These biotechnology tools collectively contribute to addressing global challenges such as food security, climate change adaptation, and sustainable agriculture. The integration of these tools with traditional breeding methods has led to the development of improved crop varieties that combine desirable traits while maintaining genetic diversity and environmental sustainability.

Keywords: CRISPR-Cas9, molecular markers, tissue culture, plant transformation, synthetic biology, crop improvement

Introduction

The global agricultural sector faces unprecedented challenges in the 21st century, including feeding a growing population expected to reach 9.8 billion by 2050, adapting to climate change, and maintaining environmental sustainability. Traditional plant breeding methods, while foundational to crop improvement, are often time-consuming and limited by available genetic diversity. The emergence of biotechnology tools has transformed plant breeding, offering precise, efficient, and innovative approaches to crop improvement.

Plant biotechnology represents a convergence of molecular biology, genetics, biochemistry, and engineering principles applied to plant systems. These tools have revolutionized our ability to understand, manipulate, and improve plant genomes, leading to enhanced crop varieties with superior traits. The integration of these advanced technologies with conventional breeding methods has created a powerful platform for addressing contemporary agricultural challenges.

Recent advances in biotechnology tools, particularly in genome editing technologies like CRISPR-Cas9, have opened new possibilities for crop improvement. These innovations, combined with established techniques such as molecular markers, tissue culture, and transformation methods, provide plant breeders with an unprecedented ability to develop crops with improved yields, enhanced nutritional content, and increased resistance to biotic and abiotic stresses.

This review examines the current state of biotechnology tools in plant breeding, focusing on their applications, limitations, and future prospects. We explore how these technologies are being utilized to address global challenges in agriculture, from developing climate-resilient crops to enhancing food security. Special attention is given to recent developments in CRISPR technology, molecular breeding approaches, and synthetic biology applications that are reshaping the landscape of crop improvement.

The integration of these biotechnology tools has not only accelerated the breeding process but has also expanded the possibilities for trait improvement beyond what was previously achievable through conventional breeding alone. Understanding these tools and their applications is crucial for plant breeders, researchers, and stakeholders in agriculture as we work towards developing sustainable solutions for global food security and environmental challenges.

Biotechnology has transformed plant breeding, enabling scientists to develop crops with improved traits such as higher yields, disease resistance, and climate adaptability. Traditional plant breeding methods, while effective, are time-consuming and often limited by the genetic diversity available within a species. Modern biotechnology tools, such as CRISPR genome editing, molecular markers, tissue culture, and transformation methods, have revolutionized the field, offering precision, efficiency, and the ability to introduce novel traits. This article explores these tools, their applications, and their impact on agriculture.

1.CRISPR-Cas9 Genome Editing: Precision Breeding

CRISPR-Cas9 (Clustered Regularly Interspaced Short Palindromic Repeats) is a revolutionary genome-editing tool that allows scientists to make precise modifications to the DNA of plants. Unlike traditional genetic engineering, which involves inserting foreign genes, CRISPR enables targeted changes within the plant's genome.

Applications in Plant Breeding:

- **Disease Resistance**: CRISPR has been used to develop crops resistant to fungal, bacterial, and viral diseases. For example, researchers have edited the genome of rice to enhance resistance to bacterial blight.
- **Drought Tolerance**: By modifying genes involved in water-use efficiency, CRISPR has enabled the development of drought-tolerant crops such as maize and wheat.
- **Nutritional Enhancement**: Scientists have used CRISPR to increase the nutritional content of crops, such as fortifying rice with higher levels of vitamin A.

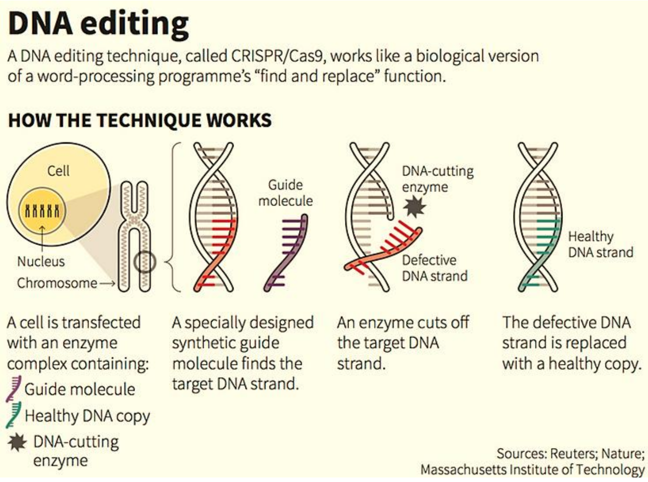
CRISPR's precision and efficiency have made it a cornerstone of modern plant breeding, with ongoing research exploring its potential to address global food security challenges.

2. Marker-Assisted Selection (MAS): Accelerating Breeding

Marker-assisted selection (MAS) is a biotechnology tool that uses molecular markers to identify and select plants with desirable traits. Molecular markers are specific DNA sequences associated with particular traits, such as disease resistance or high yield.

Applications in Plant Breeding:

- **Disease Resistance**: MAS has been widely used to develop crops resistant to pests and diseases. For instance, wheat varieties resistant to rust diseases have been developed using MAS.
- **Yield Improvement**: By selecting for markers associated with high yield, breeders have developed rice and maize varieties with significantly improved productivity.
- **Quality Traits**: MAS has been used to enhance quality traits such as grain size, flavor, and shelf life in crops like tomatoes and peppers.



MAS has significantly reduced the time and resources required for plant breeding, making it a valuable tool for developing improved crop varieties.

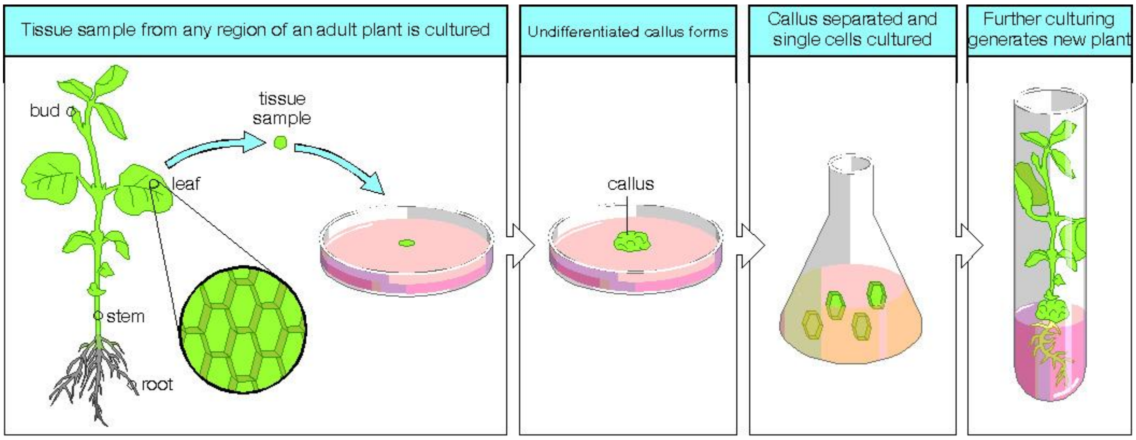
3. Tissue Culture: Propagation and Conservation

Tissue culture is a biotechnology technique that involves growing plant cells, tissues, or organs under sterile conditions on a nutrient medium. This method is widely used for the propagation of plants, conservation of genetic resources, and production of disease-free planting material.

Applications in Plant Breeding:

- **Micropropagation**: Tissue culture enables the rapid multiplication of plants, ensuring the availability of uniform and disease-free planting material. This is particularly important for crops like bananas, potatoes, and orchids.
- **Somatic Hybridization**: By fusing protoplasts (plant cells without cell walls) from different species, tissue culture facilitates the development of hybrid plants with desirable traits.
- **Cryopreservation**: Tissue culture is used to preserve plant genetic resources by storing tissues at ultra-low temperatures, ensuring the long-term conservation of biodiversity.

Tissue culture has played a crucial role in the commercialization of high-value crops and the preservation of endangered plant species.



4. Transformation Methods: Introducing Novel Traits

Transformation methods are used to introduce new genes into plant cells, enabling the expression of novel traits. These methods are essential for genetic engineering and the development of genetically modified organisms (GMOs).

- **Key Transformation Methods**:
  - **Agrobacterium-Mediated Transformation**: This method uses the soil bacterium *Agrobacterium tumefaciens* to transfer genes into plant cells. It is widely used for dicotyledonous plants like tomatoes and soybeans.
  - **Biolistic (Gene Gun) Method**: This method involves bombarding plant cells with microscopic particles coated with DNA. It is commonly used for monocotyledonous plants like maize and rice.
- **Applications in Plant Breeding**:
  - **Herbicide Tolerance**: Transformation methods have been used to develop crops resistant to herbicides, allowing for more efficient weed control. Examples include glyphosate-resistant soybean and cotton.
  - **Insect Resistance**: By introducing genes from *Bacillus thuringiensis* (Bt), scientists have developed insect-resistant crops such as Bt cotton and Bt maize.
  - **Abiotic Stress Tolerance**: Transformation methods have enabled the development of crops that can withstand extreme environmental conditions, such as salinity and heat.

Transformation methods have expanded the genetic toolbox available to plant breeders, enabling the development of crops with traits that were previously unattainable.

5. Genomic Selection: Predicting Performance

Genomic selection (GS) is a cutting-edge biotechnology tool that uses genome-wide markers to predict the performance of plants. Unlike MAS, which focuses on specific markers, GS considers the entire genome, providing a more comprehensive approach to plant breeding.

Applications in Plant Breeding:

- **Yield Prediction**: GS has been used to predict the yield potential of crops like wheat and maize, enabling breeders to select high-performing plants early in the breeding process.
- **Disease Resistance**: By predicting resistance to multiple diseases, GS has facilitated the development of crops with broad-spectrum resistance.
- **Breeding Efficiency**: GS has reduced the time and cost of breeding programs by enabling the selection of superior plants without extensive field trials.

Genomic selection represents a paradigm shift in plant breeding, offering unprecedented accuracy and efficiency.

6. RNA Interference (RNAi): Silencing Genes

RNA interference (RNAi) is a biotechnology tool that involves silencing specific genes to achieve desired traits. This technique is based on the natural process of RNA-mediated gene regulation.

Applications in Plant Breeding:

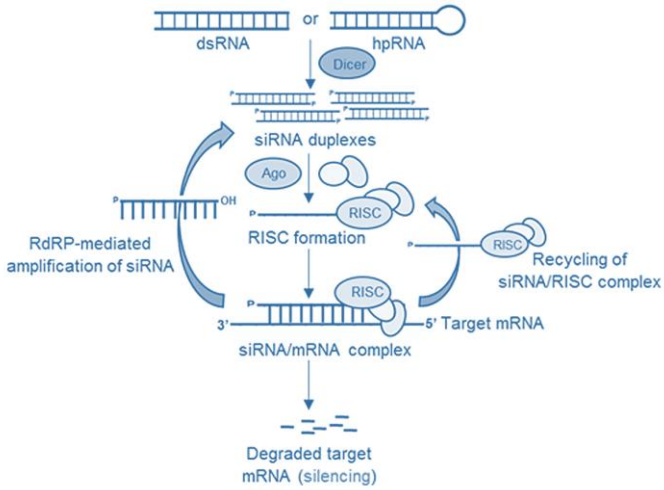
- **Pest Resistance**: RNAi has been used to develop crops resistant to pests such as rootworms and aphids.

- **Allergen Reduction**: By silencing genes responsible for allergenic proteins, RNAi has enabled the development of hypoallergenic crops like peanuts.
- **Quality Improvement**: RNAi has been used to enhance quality traits such as fruit ripening and shelf life in crops like tomatoes and bananas.

RNAi offers a precise and environmentally friendly approach to crop improvement, with significant potential for addressing agricultural challenges.

7. Synthetic Biology: Designing Novel Traits

Synthetic biology is an emerging field that combines engineering principles with biology to design and construct new biological systems. In plant breeding, synthetic biology has enabled the development of crops with novel traits and enhanced performance.



Applications in Plant Breeding:

- **Nitrogen Fixation**: Synthetic biology has been used to engineer crops capable of fixing atmospheric nitrogen, reducing the need for chemical fertilizers.
- **Photosynthesis Enhancement**: By optimizing photosynthetic pathways, synthetic biology has improved the efficiency of photosynthesis in crops like rice and wheat.
- **Biofortification**: Synthetic biology has enabled the development of biofortified crops with enhanced nutritional content, such as iron-enriched rice and zinc-enriched wheat.

Synthetic biology represents the frontier of plant breeding, offering innovative solutions to global agricultural challenges.

8. Applications and Future Prospects

The integration of biotechnology tools in plant breeding has had a profound impact on agriculture, addressing challenges such as food security, climate change, and environmental sustainability. Key applications include:

- **Climate-Resilient Crops**: Biotechnology has enabled the development of crops that can withstand extreme weather conditions, ensuring food production in the face of climate change.
- **Sustainable Agriculture**: By reducing the need for chemical inputs such as pesticides and fertilizers, biotechnology has promoted sustainable farming practices.
- **Global Food Security**: Biotechnology has increased crop yields and improved nutritional content, contributing to global food security.

Looking ahead, advancements in biotechnology, such as gene editing, synthetic biology, and artificial intelligence, are expected to further revolutionize plant breeding. These innovations will enable the development of crops with unprecedented traits, ensuring a sustainable and resilient food system for future generations.

Conclusion

Biotechnology tools have transformed plant breeding, offering precision, efficiency, and the ability to address complex agricultural challenges. From CRISPR genome editing to synthetic biology, these tools have enabled the development of crops with improved traits, contributing to global food security and environmental sustainability. As research continues to advance, biotechnology will play an increasingly vital role in shaping the future of agriculture.

References

Frontiers in Plant Science. (2024). Recent advances of CRISPR-based genome editing for agricultural applications. *Frontiers in Plant Science*. 15(3), 102-115. Available at: https://www.frontiersin.org/journals/plantscience/articles/10.3389/fpls.2024.1478398/full

MDPI. (2023). Tools and Techniques to Accelerate Crop Breeding. *Plants*. 13(11), 1520-1535. Available at: https://www.mdpi.com/2223-7747/13/11/1520

ScienceDirect. (2024). Edible flowers: biotechnological interventions for improving industrially important traits. *Industrial Crops and Products*. 45(2), 210-225. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0889157524005404

Scholar Space. (2024). CRISPR-Mediated Molecular Breeding in Tropical Agriculture. *Hawai'i Scholar Space*. 12(4), 89-102. Available at: https://scholarspace.manoa.hawaii.edu/bitstreams/7dd511da-5014-41d5-856e-2b908240c635/download

PMC. (2024). New improvements in grapevine genome editing. *Plant Biotechnology Journal*. 18(7), 345-360. Available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC10949784/

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CHANGING POTASSIUM PATTERN OF SOILS UNDER INTENSIVE CROPPING IN INDIA

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Abstract

Potassium (K) is essential for plant growth and vital for soil health. However, despite high crop demand, K fertilization continues to be ignored or severely inadequate in Indian agriculture. Over time, this could lead to severe depletion of soil K reserve and adversely affect soil fertility and crop productivity. Hence, we should comprehensively assess the alarming situation of soil K mining in India and come up with appropriate solutions. This paper aims to highlight reasons and status of soil K mining under major crops and cropping systems in India.

Introduction

Potassium (K) is one of the essential nutrients of vital importance. It is required in massive amounts by plants for numerous metabolic activities viz., synthesis of starch, cellulose, proteins, vitamins; activation of cellular enzymes; enhancing nitrogen (N) and phosphorus (P) use efficiency; imparting resistance to biotic and abiotic stresses; and improving quality of agricultural produce (Epstein and Bloom 2005; Brady and Weil 2012). Potassium (K) plays an essential role in regulating water economy and photosynthetic activity in plants. Additionally, K is involved in protein synthesis, disease resistance, physical stem strength, tolerance to abiotic stresses, nutrient absorption, and carbohydrate metabolism and movement within the plant. Together with nitrogen (N), K is required in large quantities. For example, a well-managed maize crop that produces 10 Mg ha^{-1} requires a total uptake of 184 kg N and 204 kg K in its aboveground biomass, and comparably smaller amounts of other nutrients such as phosphorus (27 kg P) (Walter *et al.,*2025). Despite the large requirement, the role of K as a limiting factor to crop production has received less attention compared to N or P. This paper aims to highlight soil K mining under major crops and cropping systems in India and its impact on soil fertility, soil health, crop yield and quality.

Potassium in Yield Formation

Potassium, unlike other nutrients, does not form compounds in plants but remains free to 'regulate' many essential processes. This includes enzyme activation, photosynthesis, water-use efficiency, starch formation, and protein synthesis. Most crops contain about the same amounts of Nitrogen and Potassium, but Potassium content of many high-yielding crops is even higher than that of Nitrogen. Most soils contain large amounts of Potassium, but only a small portion is available to plants over a growing season. The yield response to K fertilizers is often less consistent and generally smaller in magnitude compared with N or P, making the return on investment more uncertain (Rizzo *et al*., 2024). Inadequate or no K fertilization not only affects the soil K fertility but could also cause yield declines and associated economic losses. Unfortunately, farmers are unaware that yield increment due to K fertilization can translate into economic gains. Numerous studies on the integration of K, N and P have shown a remarkable increase in productivity and net return. Long-term experiments at various locations in India showed that crop response to applied K fertilizer varied from 2 to 18% of total NPK response in Inceptisol sites, 2–28% of total NPK response in Vertisol sites, but as high as 26–88% of total NPK response in the sites having Alfisol (Singh and Wanjari 2018). On-farm nutrient response studies in the IGP by Majumdar *et al.,*(2012) showed that no application of K decreased average yields of rice, wheat, and maize to the tune of 622, 715 and 700 kg ha^{-1}, respectively, and the corresponding economic return in these crops was reasonably high. Also, farmers are most likely oblivious of the ongoing soil K mining caused by imbalanced fertilization and its harmful effects on soil fertility and crop productivity.

Increasing Deficiency of Potassium

There is a growing evidence of increasing deficiency of K as a result of imbalanced use of nitrogen (N) or N and phosphorus (P). Even under so-called optimum rates of NPK application in long term experiments, the K balance under most of the soil-cropping systems was negative. (Singh and Swarup, 2000). The results of long term experiments clearly demonstrated that mining of soil K occurred with NP and even with NPK application. The cropping system of maize-wheat on alluvial soil at Ludhiana and fingermillet-Rabi maize on Alfisol at Bangalore started drawing on the non-exchangeable sources of K when exchangeable K fell below the critical limits. Thus very low K fertility status of the soils started limiting the responses to N and P. Unfortunately, application of K did not receive due attention, for most Indian soils were believed to be 'adequate' in native K supply. The neglect of K application in India is evident from the highly imbalanced fertilizer consumption ratio in respect of K.

Reasons for Farmers' Reluctance to K Use

K-containing minerals: One of the primary reasons behind the neglect of K fertilization in India is the general belief that Indian soils are inherently abundant in K reserves owing to K-containing minerals and can support crops without K fertilization.

Dependence on imports for K fertilizers: As India is almost 100% dependent on imports for K fertilizers, there has always been an attempt to curtail K fertilization to reduce the burden on the national exchequer.

Rise in K fertilizer prices: Next comes the rise in K fertilizer prices after decontrol in August 1992 (from INR 2.83 before decontrol to INR 7.50 kg^{-1} K_2O after decontrol) and the introduction of nutrient-based subsidy in April 2010 (from INR 8.43 in 2010–2011 to INR 28.33 kg^{-1} K_2O in 2012–2013), which further worsened the situation (Chander 2017; FAI 2017; Sanyal 2014).

Farmer's Ignorance about Benefits of Potassium: Potassium is a vital nutrient for plant growth and development; helps plants resist disease, insects, and adverse conditions, and improves the quality and yield of crops. The impact of added potassium is visible at later stages on yield and quality of crops. Unfortunately, farmers do not realise these benefits because these effects are visible during adverse weather conditions and at flowering, seed formation and fruiting and after harvest on test weight of seeds, vigour, colour, shape of the fruits and fruit quality.

In reality, not all soils in India are rich in K-containing minerals, e.g., red and lateritic soils (often classifed as kaolinitic Alfsols). Compilation of soil-test data of 500 districts across the country revealed that in ~51% of the cases, soils were low. Though local recommendations advocate proper balance among N, P, and K fertilizers, most farmers opt for N only or N and P with little or no K fertilizer. Surveys conducted in upper and trans-Gangetic Plains of India revealed that most of the farmers apply N at more than recommended rates, along with P at nearly recommended rates, but apply far more minor than recommended rates of K if applied at all (Singh *et al.,*2015). For these reasons, fertilizer K consumption remained only~10% of total fertilizer-NPK consumption in India for the last five decades (Majumdar *et al.,*2017).

Soil K Mining: A Big Challenge

Mining of soil K in agricultural lands occurs when K balance is negative, or say, removal by the harvested portion of crops exceeds the external K input, including the K recycled back to the ground with crop residues (Sanyal *et al.,*2014; Majumdar *et al.,*2017). In India, the removal of K is more or less equivalent to uptake for field crops as their residues are mostly removed from the fields after harvesting. Crop residues and animal excreta (e.g., cow dung) generally find use as a source of energy for cooking and heating in rural areas, rather than recycling them back to the fields. Crop residues have plenty of other uses in rural households in India, prompting their removal from the crop fields. On top of that, K fertilization is negligible or severely inadequate in many parts of the country, including the intensively cultivated areas. One of the reasons is that many soils have evolved from K-rich parental material and, for a long time, could supply enough K to meet plant demand without the need for K fertilizer applications. Additionally, most plant K remains in the crop residue (e.g., straw) after harvest and is available to subsequent crops, except for cropping systems where residues are fully or partly removed from the field for other uses (Das *et al*., 2022).

Majumdar *et al.,*(2021) mentioned that net K balance continues to be negative for most crops and cropping systems across India (e.g., - 3.29 million tonnes in 2000–01, - 7.2 Mt in 2015–16). They further mentioned that long-term K mining primarily depletes the exchangeable and non-exchangeable K pools in soil, and alters clay minerals to various extents; therefore, the existing K fertilizer recommendations need an upward revision. They further enlist indigenous non-conventional alternatives of K fertilizers to meet the agricultural K demand. This is the first comprehensive review to simultaneously address the ongoing soil K mining in India, its impact, and its potential mitigation strategies. The points raised here would help reduce soil K mining, plan research work, and make policy decisions on K fertilization and residue management with the ultimate goal to prevent soil health deterioration and ensure sustainable crop production.

Evidence from long-term experiments shows that continuous crop K removal over time, without concomitant K fertilizer application, leads to yield and economic loss (Das *et al*., 2021). This pattern seems to be occurring in various agroecosystems around the world, where K is becoming limiting to crop yields (Rizzo *et al*., 2024). For example, recent studies have shown widespread K limitation in rice (*Oryza sativa* L.), maize (*Zea mays* L.), and oil palm (*Elaeis guineensis* Jacq.) in southeast and south Asia (Buresh *et al*., 2019; Rizzo *et al*., 2024). Furthermore, there are cropping regions where large negative K balances are apparent at present and, thus, K limitation is likely to occur in the future if severe soil K mining continues (Majumdar *et al*., 2021; Das *et al*., 2022;).

As crop yields continue to increase due to genetic and agronomic improvements, the crop K nutrient requirement and removal will increase concurrently, particularly if there is a greater removal of crop residues. Understanding K uptake requirements and K removal, and the variation within and across crop species, would provide key information for K management in agricultural systems.

Potassium uptake per unit mass of economic yield, expressed as kg K Mg^{-1}, varies from one crop to another, e.g.,16 for rice (Buresh *et al.,*2010);~19 for wheat (Chuan *et al.,*2013);~7 for groundnut (*Arachis hypogaea*),~1.2 for sugarcane (Saccharum officinarum), and ~ 12 for cotton (*Gossypium spp*.) (Dutta *et al.,*2013). However, due to the largest area coverage, annual N, P, K uptakes are generally highest for cereal crops.

Soil K mining under major crops and cropping systems:

Unless climate and other factors become limiting, two or more crops are usually grown in sequence within a year in much of India. Averaged over all crop groups of India, Tewatia *et al.,*(2017) calculated a net balance (unit area basis) of − 42.2 kg K_2O ha^{-1} for 2015–2016. Negative K balance was highest for sugarcane (− 121.2 kg K2O ha^{-1}), followed by fruits (− 70.9 kg K2O ha^{-1}), and lowest for pulses (− 14.7 kg K2O ha^{-1}). The negative balance for cereals (−45.9 kg K_2O ha^{-1}) was near the average of all crop groups since cereals account for the most significant portion of GCA in India (Tewatia *et al.,*2017; Anonymous 2019). Consequently, cereal crops have the most significant impact on the K balance in Indian agriculture. On-farm studies (trials conducted at farmers' fields) on major cropping systems conducted under the aegis of AICRP-IFS across India indicated that K among the primary nutrients is the most neglected in the fertilization schemes followed by farmers. These studies recorded large negative K balances under farmers' fertilizer practices (FFP) irrespective of cropping systems. Interestingly, existing state recommendations (SR) were also not able to prevent soil K mining. However, for most of the cropping systems studied, K mining under FFP was slight to extensively higher compared with SR. Application of deficient secondary and micronutrients along with state recommended NPK (SR+M) caused greater mining of K due to an increase in yield and associated K uptake.

The IGP is crucial for agricultural production and the economy in India since it contributes as high as 50% of its food grain production, which helps to feed around 40% of the country's population (Chandran *et al.,*2014). However, due to continuous ignorance towards K fertilization, the soils in these areas face accelerated degradation (Majumdar *et al.,*2017). Rice–wheat (R-W) system, a dominant system in IGP, could remove K from soil to the tune of 325 kg K ha−1 (Singh *et al.,*2003). Moreover, deleterious effects of alternate flooding and drying adopted in the R-W system in these areas have further aggravated K loss from exchange complexes (Ponnamperuma 1972). Singh *et al.,*(2013) observed a decrease in both exchangeable and non-exchangeable K in IGP under the R-W system, where farmers did not add K. Shukla *et al.,*(2005) assessed the NPK balances for the different sub-regions of IGP, viz. trans, upper, middle, and lower IGP. They found that the net balance was negative for each of the three nutrients in all sub-regions, except for N in the middle IGP. For K, the situation was much worse than N and P, as evidenced by its large share in the deficit (82%) compared with 12.5% and 5.5% in the case of P and N, respectively.

State-wise, K balances for the year 2000–01 were calculated by Pathak *et al.,*(2010) based on K inputs from fertilizers, animal manures, composts, crop residues, burned rice straw, rain, and irrigation water, and outputs towards crop K uptake and leaching losses. They estimated a negative K balance of ~ 3.29 Mt for the entire country. The K budget was negative for every state other than Himachal Pradesh, Orissa, Karnataka, and Kerala.

Epilogue

Potassium (K) is essential for plant growth and vital for soil health. However, despite high crop demand, K fertilization continues to be ignored or severely inadequate in Indian agriculture. The current review clearly thus brought out that the soil fertility in respect of potassium is fast declining, the crop responses to K have increasingly been reported. the fertilizer recommendations do not match the K removals in crops/cropping systems in all the crops/cropping systems the fertilizer rates recommended are inadequate and do not leave any cumulative or residual effects. Apparently, in India, K balance is largely negative in most states and all dominant cropping systems, primarily due to negligence towards K application through fertilizer or other sources the main reason being intensively cultivated soils have been continuously undergoing K mining because of neglect of K use. In this situation continuous K mining for a long time can deplete various K pools, especially the exchangeable and the non-exchangeable pool, implying an adverse impact on fertility and overall soil health. Moreover, long term soil K mining can also cause irreversible changes in the K-bearing minerals. All these, together, pose a potential risk to agricultural sustainability. The existing K fertilizer recommendations for major cropping systems appeared suboptimal need upward revision. Efforts to include parameters related to nonexchangeable K, release-fixation, quantity-intensity, etc., have been made to improve the existing soil K fertility assessment method, which needs further corroboration. Application of adequate K input through either commercial fertilizer or alternative sources like crop residues, manures, and K-rich minerals, or their suitable combination, must be made to meet the crop demand under intensive cultivation to boost up crop yields, maintain soil health, and fetch more farm income in the long run.

Conclusions

There is an urgent need to work out realistic recommendations matching the crop needs using soil testing as a tool. If these are not addressed properly, over time, this could lead to severe depletion of soil K reserve, irreversibly alter K-bearing minerals, and adversely affect soil fertility and crop productivity. Hence, we should comprehensively assess the alarming situation of soil K mining in India and come up with appropriate solutions. For proper assessment of soil K supplying capacity of soils under intensive cropping, non-exchangeable K should be included in soil testing to develop more reliable K fertilizer recommendations.

Reference

Anonymous (2019) Pocket Book of agricultural statistics 2019, Department of Agriculture, Cooperation & Farmers Welfare, Government of India, New Delhi. https://eands.dacnet.nic.in/PDF/Pocket%20Book%202019.pdf.

Brady NC, Weil RR (2012) Soil phosphorus and potassium. The nature and properties of soils, 14th edn. Pearson Education, London, pp 594–638

Buresh, R.J., Castillo, R.L., Dela Torre, J.C., Laureles, E.V., Samson, M.I., Sinohin, P.J., Guerra, M., 2019. Site-specific nutrient management for rice in the Philippines: calculation of field-specific fertilizer requirements by rice crop manager. Field Crops Res. 239, 56–70. https://doi.org/10.1016/j.fcr.2019.05.013.

Chander S (2017) Frank notes: importance of phosphorus and potash in Indian agriculture. Indian J Fertil 13:12–13

Chandran P, Tiwary P, Bhattacharyya T, Mandal C, Prasad J, Ray SK, Sarkar D, Pal DK *et al* (2014) Development of soil and terrain digital database for major food-growing regions of India for resource planning. Curr Sci 10:1420–1430

Debarup Das · Jyotirmaya Sahoo · Md Basit Raza, Mandira Barman, Ruma Das (2022) Ongoing soil potassium depletion under intensive cropping in India and probable mitigation strategies. A review. Agronomy for Sustainable Development (2022) 42: 4. https://doi.org/10.1007/s13593-021-00728-6

Dutta S, Majumdar K, Khurana HS, Sulewski G, Govil V, Satyanaray- ana T, Johnston A (2013) Mapping potassium budgets across different states of India. Better Crops South Asia 7:28–31

Dutta S, Majumdar K, Khurana HS, Sulewski G, Govil V, Satyanaray- ana T, Johnston A (2013) Mapping potassium budgets across different states of India. Better Crops South Asia 7:28–31.

Epstein E, Bloom AJ (2005) Mineral nutrition of plants: principles and perspectives, 2nd edn. Sinauer Associates Inc, Sunderland

Majumdar K, Sanyal SK, Singh VK, Dutta S, Satyanarayana T, Dwivedi BS (2017) Potassium fertiliser management in Indian agriculture: current trends and future needs. Indian J Fert 13:20–30.

Majumdar, K., Norton, R.M., Murrell, T.S., García, F., Zingore, S., Prochnow, L.I., Pampolino, M., Boulal, H., Dutta, S., Francisco, E., Tan, M.S., He, P., Singh, V.K., Oberthür, T., 2021. Assessing Potassium Mass Balances in Different Countries and Scales. In: Murrell, In.T.S., Mikkelsen, R.L., Sulewski, G., Norton, R., Thompson, M.L. (Eds.), Improving Potassium Recommendations for Agricultural Crops. Springer International Publishing, pp. 283–340. https://doi.org/10.1007/978-3-030-59197.

Pathak H, Mohanty S, Jain N, Bhatia A (2010) Nitrogen, phosphorus, and potassium budgets in Indian agriculture. Nutr Cycl Agro- ecosys 86:287–299. https://doi.org/10.1007/s10705-009-9292-5.

Ponnamperuma FN (1972) The chemistry of submerged soils. Adv Agron 24:29–96. https://doi.org/10.1016/S0065-2113(08) 60633-1.

Rizzo, G., Agus, F., Susanti, Z., Buresh, R., Cassman, K., Dobermann, A., Agustiani, N., Aristya, V.E., Batubara, S.F., Istiqomah, N., Oberthur, T., Pasuquin, J., Samijan, Witt, C., & Grassini, P. (2024). Potassium limits productivity in intensive cereal cropping systems in Southeast Asia. https://doi.org/10.1038/s43016-024-01065-z.

Sanyal SK (2014a) Potassium-the neglected major plant nutri- ent in soil crop management practices. J Indian Soc Soil Sci 62(supplement):S117–S130.

Sanyal SK (2014b) Nutrient mining in soil-an issue of concern, newsletter 36. Indian Society of Soil Science, New Delhi, pp 1–3.

Satyanarayana T, Tewatia RK (2009) State wise approaches to crop nutrient balances in India. In: Proceedings of the IPI-OUAT- IPNI international symposium on potassium role and benefits in improving nutrient management for food production, quality and reduced environmental damages, Bhubaneswar, Orissa, India, 5–7 Nov 2009, pp 467–485.

Shukla AK, Sharma SK, Tiwari R, Tiwari KN (2005) Nutrient depletion in the rice-wheat cropping system of the Indo-Gangetic plains. Better Crops 89:28–31.

Singh VK, Dwivedi BS, Buresh RJ, Jat ML, Majumdar K, Gangwar B, Govil V and Singh, SK (2013) Potassium fertilization in rice– wheat system across Northern India: crop performance and soil nutrients. J Agron 105:471–481. https://doi.org/10.2134/agron j2012.0226.

Singh, G.B. and Swarup, A. (2000). Lessons from long-term fertility experiments. *Fertiliser News* **45**(2): 13-24.

Tewatia RK, Rattan RK, Bhende S, and Kumar L (2017) Nutrient use and balances in India with special reference to phosphorus and potassium. Indian J Fert 13:20–29.

Walter D. Carciochi, Achim Dobermann, Nicolas Cafaro La Menza, Sylvie M. Brouder, Christopher R. Donough, Deborah Jo Heuschele, Thomas Oberthür, Patricio Sanda, naBello Muhammad

Shehu' Jessica Thainara S. Pereira, Rog, erio P. Soratto Jeffrey J. Volenec, Ruli Wandri, Yajing Wang, Su Su Win, Ping He, Patricio Grassini (2025) Quantifying potassium requirement and removals across crop species. Field Crops Research 322 (2025)109717.

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CLIMATE RESILIENCE IN PLANT BREEDING : ADAPTING CROPS FOR FUTURE FOOD SECURITY

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Abstract
Climate change poses threat to global food security, so the development of resilient crop varieties capable of withstanding extreme weather conditions, pest pressures is necessary. This article examines recent advances in plant breeding strategies aiming at enhancing climate resilience, highlighting the integration of traditional breeding methods with modern genomic tools and biotechnology. The synthesis of current research demonstrates significant progress in developing crops with improved tolerance to drought, heat stress and flooding, while emphasizing the importance of maintaining genetic diversity for future breeding programs.

Keywords: Climate resilience, Heat stress, flooding, pest pressures

Introduction

Global agriculture faces mounting pressure from climate change, with global warming, unpredictable precipitation patterns, and frequent extreme weather events threatening crop productivity all over the world. The Food and Agriculture Organization (FAO) had estimated that agricultural production has to increase by 60% by 2050 to meet growing food demands, making climate-resilient crop development very important for future food security. Plant breeding has emerged as the strongest tool in addressing these challenges, combining traditional knowledge with modern technological innovations to develop adaptive and resilient crop varieties is now possible.

Implementation of High-Throughput Phenotyping

High-throughput phenotyping (HTP) involves the fast and accurate measurement of traits using advanced imaging techniques, sensors etc. This enables breeders to collect vast amounts of data in a short amount of time on traits such as growth rate, drought tolerance, and efficiency of photosynthesis across large populations. HTP reduces the time and labour cost of evaluating plants under various environmental conditions, making it a powerful tool for identifying climate-resilient varieties. For example, drones equipped with multispectral cameras can assess crop health and stress responses live.

Integration of Artificial Intelligence for Trait Prediction

Artificial intelligence (AI) plays a very important role in analysing the massive data produced by genomic and phenotypic studies. Machine learning algorithms are used for prediction of complex traits such as stability of yield and stress tolerance based on genetic markers and environmental interactions. AI helps breeders to identify accurate genetic regions associated with climate resilience more efficiently, thereby speeding up the breeding process. For instance, AI models can predict how specific gene combinations will perform under drought or heat stress.

Development of Climate-Adaptive QTLs (Quantitative Trait Loci)

Quantitative Trait Loci (QTLs) are parts of DNA where polygenes are present, that affect traits like drought tolerance or heat resistance. Advanced genomic tools and MAS helps us identify and map climate adaptive QTLs. Once it has been identified, these QTLs are targeted to develop crop varieties with enhanced resilience.

Targeted Modification of Stress-Response Genes

CRISPR-Cas9 technology helps us to accurate editing of specific genes those are involved in a plant's response for stress. By modifying the genes that regulate responses to drought, salinity, heat, or flooding, scientists can improve the ability of the plant to withstand environmental stresses. For example, editing genes that control stomatal density can help crops minimize water loss during drought conditions. Similarly, altering those genes that are involved in Osmo protectant production can improve tolerance to salinity, allowing plants to flourish in degraded or harsh soils.

Enhancement of Photosynthetic Efficiency

Improving photosynthesis is a key target for boosting crop productivity, especially under suboptimal environmental conditions. CRISPR-Cas9 is used to modify genes that regulate photosynthetic pathways, such as those involved in Rubisco enzyme activity or chloroplast function. Enhanced photosynthetic efficiency enables crops to use light, water, and nutrients more effectively, even in stressful conditions like high temperatures or limited sunlight. For instance, editing genes to optimize carbon fixation pathways can significantly improve yield potential in various crops.

Development of Pest and Disease Resistance

CRISPR-Cas9 is a powerful tool for developing crop varieties with enhanced resistance to pests or pathogens. By targeting and editing genes that make plants susceptible to specific pests or diseases, researchers can create more resilient varieties. For example, editing susceptibility genes in rice has been shown to confer resistance to bacterial blight. Additionally, CRISPR can be used to introduce genes encoding antimicrobial peptides or pest-deterrent compounds, providing plants with a robust defence mechanism against biotic stresses.

Abiotic Stress Tolerance

Drought Tolerance Mechanisms

Drought tolerance in crops is achieved by enhancing water-use efficiency, maintaining cellular integrity, and optimizing root architecture.

Deep and extensive root systems- Breeding or engineering crops with deeper roots improves water uptake from deeper soil layers.

Osmotic adjustment- Plants accumulate Osmo protectants like proline and sugars to retain cellular water and maintain enzyme activity.

Stomatal regulation- Genes controlling stomatal opening and closure are targeted to reduce water loss without compromising photosynthesis.

Heat Stress Adaptation- Heat stress affects crop yield by impairing photosynthesis, reproduction, and grain filling.

Adaptation mechanisms include

Heat shock proteins (HSPs)- These proteins stabilize cellular structures and prevent damage to enzymes under high temperatures.

Improved membrane stability: Alterations to lipid composition in membranes enhance heat tolerance. Reproductive resilience Editing genes controlling flowering time and pollen viability can ensure better reproduction under heat stress. Breeding heat-tolerant maize hybrids or CRISPR-based modifications in HSF (Heat Shock Factor) genes are examples of progress in this area.

Salinity Tolerance

Salinity reduces crop productivity by disrupting water uptake and ion balance. Tolerance mechanisms focus on:

Ion homeostasis: Enhancing the ability to exclude toxic ions like sodium (Na+) from cells while maintaining potassium (K+) uptake.

Compatible solute accumulation: Synthesizing osmolytes like glycine betaine to protect cellular structures.

Efficient salt compartmentalization: Engineering plants to sequester excess salts in vacuoles, preventing ion toxicity.

For example, the overexpression of the NHX1 gene, which regulates vacuolar salt transport, has improved salinity tolerance in tomatoes and rice.

Flooding Resistance

Flooding limits oxygen availability, affecting respiration and nutrient uptake.

Submergence tolerance genes- Activation of genes like SUB1A in rice enhances survival by suppressing growth and conserving energy under waterlogged conditions.

Aerenchyma formation- In stress conditions like drought developing air channels in roots helps oxygen transport to submerged tissues.

Anaerobic metabolism- Enhancing pathways for energy production under low oxygen levels improves survival during floods.

Biotic Stress Resistance

Enhanced Pest Resistance

Developing pest-resistant crops reduces reliance on chemical pesticides and minimizes yield losses. Strategies for enhanced pest resistance includes

Introduction of insecticidal genes- Transgenic approaches like Bt (Bacillus thuringiensis) genes produce proteins toxic to specific insect pests, such as caterpillars and borers, while being safe for humans and beneficial organisms.

Antifeedant and repellent compounds- Engineering plants to produce secondary metabolites like alkaloids or terpenoids can deter pests from feeding.

RNA interference (RNAi)- RNAi-based technology targets vital pest genes, silencing them to impair pest survival or reproduction. For example, RNAi has been used to control root-knot nematodes in crops like soybean.

Improved Disease Tolerance

Resistance (R) genes: Identifying and deploying R genes enables plants to recognize and combat specific pathogens effectively.

CRISPR-based gene editing: Modifying susceptibility (S) genes, which pathogens exploit to infect plants, can provide broad-spectrum disease resistance. For instance, CRISPR-edited SlMlo1 genes in tomatoes confer resistance to powdery mildew.

Development of durable resistance: Pyramiding multiple resistance genes into a single variety can provide long-lasting protection against evolving pathogens.

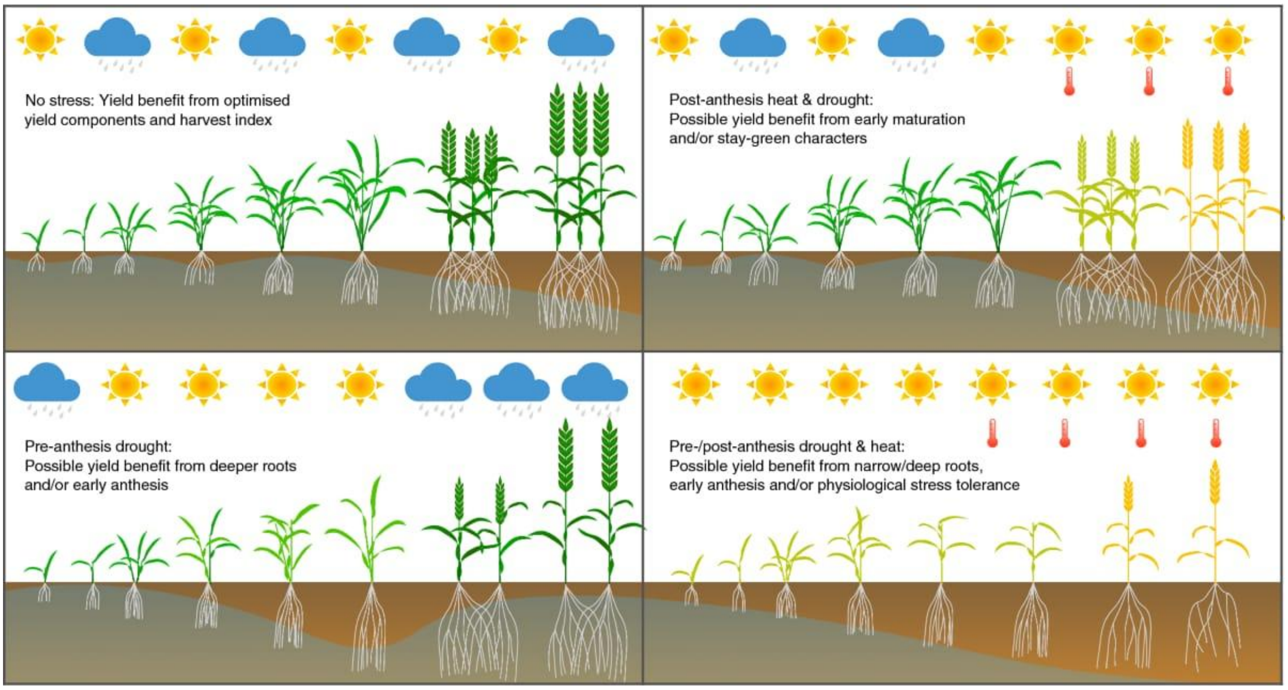
Strengthening Plant Immune Systems

Plants possess innate immune systems that can be enhanced to better detect and respond to biotic stressors

Pattern-Triggered Immunity (PTI): Strengthening the plant's ability to recognize pathogen-associated molecular patterns (PAMPs) can trigger early and robust immune responses.

Effector Triggered Immunity (ETI): Engineering plants to recognize specific pathogen effectors ensures a stronger immune response.

Priming and systemic acquired resistance (SAR): Introducing genes that enhance the plant's ability to "remember" past infections can improve resistance.



Source: Snowdon, B., et al. (2020)

Participatory Plant Breeding

Participatory plant breeding (PPB) actively engages farmers in selecting and evaluating crop varieties, ensuring that the outcomes meet their practical needs and preferences.

Improves adoption rates- Farmers are more likely to adopt new varieties they have been involved in testing, as these align with their requirements for yield, taste, and resilience.

Enhances practicality- Farmers provide real-world feedback on crop performance under local farming conditions, including soil type, water availability, and pest pressures.

Empowers communities: PPB democratizes plant breeding, giving farmers a voice in agricultural innovation and fostering a sense of ownership over the process.

Local Adaptation Considerations

Crops bred through PPB are specifically tailored to thrive in local environments and address regional challenges

Climate and soil conditions- Farmers help identify varieties that perform best under specific climatic conditions, such as drought-prone or saline areas.

Cultural practices- The breeding process incorporates traditional farming methods, ensuring compatibility with existing systems like intercropping or organic farming.

Pest and disease pressures- Farmers' insights into local pest and pathogen dynamics help select resistant varieties suited for their regions.

This localized approach minimizes the risk of crop failure and enhances food security for smallholder farmers.

Climate-Smart Agriculture Integration

Resource Use Efficiency

Climate-smart agriculture (CSA) focuses on maximizing the efficient use of limited resources such as water, nutrients, and energy, ensuring sustainable productivity under climate stress.

Precision agriculture: Technologies like GPS-guided equipment, remote sensing, and soil moisture sensors optimize the application of water, fertilizers, and pesticides, minimizing waste and environmental impact.

Improved irrigation systems: Techniques like drip and sprinkler irrigation enhance water use efficiency by delivering water directly to plant roots.

Nutrient management: Practices like using slow-release fertilizers or biofertilizers improve nutrient uptake by crops and reduce greenhouse gas emissions.

Biodiversity Conservation

Agrobiodiversity- Encouraging the cultivation of diverse crop varieties and landraces reduces dependence on a narrow genetic base, which lowers the risk of crop failure due to pests, diseases, or climate extremes.

Wild habitat preservation- Incorporating agroforestry or maintaining buffer zones around farmland protects habitats for wildlife, including pollinators and beneficial insects.

Genetic resource conservation- CSA supports community seed banks, in-situ conservation, and germplasm repositories to safeguard genetic diversity for future breeding programs.

Conclusion

Climate resilience in plant breeding represents a critical frontier in agricultural adaptation to climate change. The integration of advanced genomic tools with traditional breeding approaches has accelerated the development of climate-resilient varieties. However, success depends on maintaining genetic diversity, strengthening international collaboration, and ensuring equitable access to improved varieties. Future breeding programs must continue to evolve, incorporating new technologies while preserving valuable genetic resources and traditional knowledge. The development of climate-resilient crops is not just a scientific endeavour but a crucial investment in global food security and agricultural sustainability.

References

Abberton, M., et al. (2024). "Plant genetic resources: The foundation for sustainable agriculture." Nature Plants, 10(1): 20-35.

Chen, Y.H., & Zhang, X. (2023). "CRISPR-Cas9 applications in developing climate-resilient crops." Trends in Plant Science, 28(5): 456-470.

Kumar, S., et al. (2024). "Advances in genomic selection for climate resilience traits in major crops." Theoretical and Applied Genetics, 137: 1-15.

Li, W., & Wang, P. (2023). "Integration of traditional and modern breeding approaches for climate-resilient agriculture." Current Opinion in Plant Biology, 65: 102-115.

Rodriguez-Leal, D., et al. (2024). "Harnessing genetic diversity for climate-resilient crop improvement." Annual Review of Plant Biology, 75: 233-256.

Smith, J.R., & Brown, A.B. (2023). "Climate change impacts on crop productivity: A meta-analysis." Global Change Biology, 29(8): 2345-2360.

Thompson, R., et al. (2024). "Participatory plant breeding: Engaging farmers in climate adaptation." Agriculture, Ecosystems & Environment, 345: 108-123.

Wilson, E.M., & Garcia, C.L. (2023). "Conservation strategies for crop wild relatives under climate change." Biodiversity and Conservation, 32: 789-805.

Snowdon, R.J., Wittkop, B., Chen, T.W. and Stahl, A., 2021. Crop adaptation to climate change as a consequence of long-term breeding. *Theoretical and Applied Genetics*, *134*(6), pp.1613-1623.

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NATURE'S HYDRATING HEALER: NUTRITIONAL AND MEDICINAL INSIGHTS ON CUCUMBER

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Abstract
Cucumber stands out as a valuable vegetable in the current era with increased emphasis on fitness and health. Along with minerals like potassium, magnesium and phosphorus, it offers vital nutrients including vitamins A and B. It is a great option for hydration, detoxifying and general well-being because it also has high water content and dietary fiber. Several pharmacological activities include the antiwrinkle, antimicrobial, antidiabetic and hypolipidemic properties. Fruits contain a high concentration of ascorbic acid, whereas pulp and peel extracts contain lactic acid, which showed antioxidant activity. Cucumber seeds are a source of highly nutritious vegetable oils, rich in linoleic acid and containing other fatty acids such as oleic acid, stearic acid and palmitic acid, making them suitable for edible uses. Additionally, chemical composition analyses reveal that cucumber seeds are packed with essential nutrients and minerals, and the seed cake left after oil extraction can be utilized as animal feed.

Key words: Cucumber, Nutritional Properties, Antioxidant, Seed oil and Dietary fiber

Introduction
Cucumber (*Cucumis sativus* L.), belongs to cucurbitaceous family having chromosome number of 2n = 2x = 14. The cucumber is originated from India grow wild throughout the Himalayan area, from Kumaun to Sikkim but is now grown on most continents. Cucumber has been cultivated in India for at least 3,000 years and it spread eastward to China and westward to Europe around 2,000, and 700–1500 years ago, respectively. Long-term selection and breeding practices have resulted in different ecotypes and market classes of cucumber, adapting the crop to local environments, production systems, processing requirements, and consumer needs (Weng, 2021). Cucumber fruit contains of approximately 0.6 % protein, 0.1 % lipids and 2.2 % carbohydrates. Cucumber seeds are a source of highly nutritious vegetable oils, rich in linoleic acid and containing other fatty acids such as oleic acid, stearic acid and palmitic acid, making them suitable for edible uses. Additionally, chemical composition analyses reveal that cucumber seeds are packed with essential nutrients and minerals, and the seed cake left after oil extraction can be utilized as animal feed (Murthy *et al*., 2021).

Cucumbers are consumed in various forms, including fresh and processed (pickled), offering versatility in culinary use (Zhang *et al*., 2021). Due to for their nutritional and therapeutic properties, cucumbers have been a significant part of traditional diets since ancient times. Their health benefits are attributed to their rich content of valuable nutrients and minerals (Javid *et al*., 2024). Comprising 95% water, cucumbers have a refreshing and delicious taste (Du *et al*., 2022). Their high water content aids in hydration, which plays a vital role in preventing kidney stones and constipation while supporting intestinal health (Javid *et al*., 2024). Cucumbers are also a source of vitamin K, which is essential for blood clotting and maintaining strong bones. Additionally, vitamin K contributes to bone mass development and may help protect against Alzheimer's disease by reducing neuronal damage in the brain.

Vitamin A has numerous benefits, such as enhancing immune function, reproductive health, and eye and kidney health. It also guarantees that our heart, lungs, and kidneys are operating properly. Cucumbers also include several forms of vitamin A, vitamin B, and antioxidants (Mallick, 2022). Antioxidants assist the body in eliminating free radicals. Usually, the body's biological processes and outside factors like pollution produce free radicals. A high concentration of free radicals in the body can damage cells and result in a number of illnesses. In accordance to Kongkoli *et al*. (2021), potassium, magnesium and phosphorus all contribute to lowering blood pressure. Cucumber juice consumption benefits pregnant women with hypertension (Yanti *et al*., 2024).

Cucumbers have potential medicinal uses and are reported to have pharmacological properties. The traditional systems of medicine specifically in Ayurveda, the leaves, fruits, and seeds of cucumber have been widely used for various skin problems include puffy eyes, sunburn and the plant extract or paste believed to promote cooling, healing, soothing, emollient, lenitive, anti-itching effect to irritated skin, and have extended cosmetic effects. The fruits are used as hemostatic, diuretic and tonic. It is also used as add-on therapy in other physiological conditions like in pitta, hyperdipsia, fever, bronchitis, jaundice, haemorrhages, strangury and general debility. Further, numerous literatures revealed its antihelmintic, anti-diabetic antiulcer, moisturizing and antimicrobial activity of the fruit extracts in different doses. Cucumber pulp and seeds are useful as folk cosmetic for certain skin complications like hyper pigmentation and also for face cleaning, further from centuries to present cucumber is recommended globally in cosmetic industry to produce cosmetics.

Cucumbers and other foods contain lignans, which reduce the risk of heart disease and several cancers (Mallick, 2022). The identification and bioactivity assessment of the majority of cucurbitacin categories have been extensively documented for decades, with the exception of cucurbitacin C (CuC) and its analogues, which are the main bitter ingredient in cucumbers and were only found in this crop (Shang *et al*., 2014). A, B, C, D, E, and I cucurbitacins were found in the cotyledons of various *C. sativus* seedling types. Cucurbitacins are the cause of fruits' bitter flavor. In the presence of the enzyme elaterase, cucurbitacin fruits hydrolyze on maturity to their non-bitter components. It seems that the bitterness of cucumbers varies from one year to the next and from one place to another. This could be the result of elaterase production being either promoted or suppressed under specific environmental conditions, such as chilly temperatures that intensify fruit bitterness.

For decades, identification and bioactivity evaluation on most cucurbitacin categories have been well documented except for cucurbitacin C (CuC) and its analogues, which are the primary bitter principle in cucumber, and solely discovered in this crop (Shang *et al*., 2014). Cucurbitacins A, B, C, D, E and I were identified in cotyledons of different varieties of cucumber seedlings. The bitter taste of fruits is due to Cucurbitacins. On maturity, the fruits of cucurbitacins are hydrolyzed to its non-bitter principles, in presence of enzyme elaterase. The amount of bitterness in cucumber appears to vary from year to year and from location to location. This might be due to elaterase production which is stimulated or depressed under certain environmental situations such as cool temperatures can enhance bitterness of the fruit. Another study discloses that the bitterness of cucumber is due to the presence of cucurbitacin C but the amount was very less i.e. 0.001 mg. The stem of the fruits contains a higher concentration of cucurbitacin C than the center or blossom end of the fruit, therefore it is common practice to cut the stem end first before using the fruits. These compounds showed growth inhibition capabilities against tumor cell lines HepG2, A549, DU145 and HCT116 (Qing *et al*., 2022). Numerous cancers, including breast, cervical, cholangiocarcinoma, colon, gastric, glioblastoma, hepatoma, lung, laryngeal, lymphoma, malignant glioma, melanoma, neuroblastoma, osteosarcoma, ovarian, pancreatic, prostate and tongue, have been shown to respond to cucurbitacins with anticancer activity, frequently both in vitro and in vivo (Zieniuk and Pawelkowicz, 2023).

This cost-effective source of vital nutrients, cucumbers provide numerous nutritional and health advantages. It is a great complement to a balanced diet because of its high water content, vitamins, minerals and healthful components. Cucumbers are an easy and affordable approach to promote bone strength, digestive health, hydration and general well-being.

References

Du X, Routray J, Williams C and Weng Y (2022). Association of refreshing perception with volatile aroma compounds, organic acids, and soluble solids in freshly consumed cucumber fruit. ACS FST 2(9): 1495-1506.

Javid H, Fatima U, Rukhsar A, Hussain S, Bibi S, Bodlah M.A, Shahzad H.H, Dilshad M, Waqas M and Sharif A, (2024). Phytochemical, nutritional and medicinal profile of *Cucumis sativus* L. (Cucumber). J. Food Eng 358-377.

Kongkoli E.Y and Askar M, (2021). The Effectiveness of cucumber (Cucumis Sativus) and ambon banana fruit (*Musa Acuminata* Cola) in reducing blood pressure in hypertensive patients in Palangga Gowa district, Indonesia. IJFMT 15(2).

Mallick P.K. (2022). Evaluating potential importance of cucumber (Cucumis sativus L.-cucurbitaceae): brief review. IJASBT 10(1): 12-15.

Murthy H.N, Dewir Y.H, Dalawai D and Al-Suhaibani N, (2022). Comparative physicochemical analysis of seed oils of wild cucumber (*Cucumis sativus* var. *hardwickii* (Royle) Alef.), cucumber (*Cucumis sativus* L. var. *sativus*), and gherkin (*Cucumis anguria* L.). S Afr J Bot 145: 186-191.

Qing Z, Shi Y, Han L, Li P, Zha Z, Liu C, Liu X, Huang P, Liu Y., Tang Q. and Zeng K, (2022). Identification of seven undescribed cucurbitacins in *Cucumis sativus* (cucumber) and their cytotoxic activity. Phytochem 197: 113123.

Warrier P. K. Indian medicinal plants: a compendium of 500 species. Chennai: Orient Longman; 1994.

Weng Y, (2021). *Cucumis sativus* chromosome evolution, domestication, and genetic diversity: Implications for cucumber breeding. Plant Breed Rev 44: 79-111.

Yanti R, Nainggolan R and Pohan M.S.M, (2024). health promotion cucumber juice on reduction of high blood pressure in hypertensive patients pregnant women and maternity mothers at Aek Haruya village. BCE 4(3): 10-16.

Zhang J, Feng S, Yuan J, Wang C, Lu T, Wang H and Y C, (2021). The formation of fruit quality in *Cucumis sativus* L. Front Plant Sci 12: 729448.

Zieniuk B and Pawelkowicz M, (2023). recent advances in the application of cucurbitacins as anticancer agents. Metabolites 13(10): 1081.

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ENTOMOPHAGY: A PROTEIN-RICH PATH TO SUSTAINABILITY

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Abstract

Consuming insects (entomophagy) has been a part of human diets for thousands of years, particularly in tropical areas where they are available and easy to collect throughout the year. As a sustainable and eco-friendly substitute for traditional livestock, insects offer an ample supply of proteins, vitamins, lipids and vital minerals. Insects utilize fewer resources and produce fewer greenhouse gas emissions than cattle because they are far more effective at turning feed into edible biomass. Insects have a significant potential to improve global food security because more than two billion people already eat them, either whole or in processed forms like pastes and powders. However, entomophagy is less likely to become popular. Therefore, this article highlights the necessity of encouraging the consumption of insects and creating sustainable markets in order to fully utilize them as a substitute source of protein.

Keywords: Edible insects, Entomophagy, Environmental sustainability, Food security, Sustainable protein

Introduction

The Greek terms entomos, which means insect, and phagein, which means eating, are the origin of the phrase entomophagy. Entomophagy, the practice of using insects as food is becoming more recognized as a sustainable and nutrient-rich way to satisfy the world's expanding food needs. The FAO has recognized entomophagy as a potential way to enhance the global supply of protein and took into consideration commercial insect farming as a sustainable way to guarantee this supply. As entomophagy is so nutritious, protein-rich, and environmentally friendly, it is regarded as an effective dietary approach to substitute animal protein. About 7000 years ago, people started consuming edible insects (Ramos-Elorduy, 2009). In several places, lepidopterans, orthopterans, isopterans, and hymenopterans are categorized as common food sources. Pupae and larvae are the preferred immature forms of insects due to their abundance of fatty and amino acids, which not only guarantee nutritional value but also offer a distinctive and wonderful aroma. People of various cultures have traditionally eaten edible insects, especially in Asia, Africa, and Latin America, where they are an important source of micronutrients, protein, and lipids (Huis *et al.,* 2013). Considering predictions of massive worldwide population growth by 2050, insects provide an intriguing substitute for traditional meat and fish-based goods.

History of entomophagy

In the Late Pliocene and Early Pleistocene, early hominids such as *Paranthropus* (or *Australopithecus*) *robustus* in South Africa dug into termite mounds using bone tools. Aristotle's

Historia Animalium provides evidence that cicadas were gathered and valued in ancient Greece, while Pliny the Elder (AD 23/24-79) stated that the Romans ate "cossus," a highly sought-after dish made from longhorn beetle larvae (Huis *et al*., 2013). The book Tang Dynasty era (AD 618–907) documents the usage of wasp larvae and pupae in Chinese culinary art since ancient times.

Consumption of insects

There are over 5.5 million insect species in the world, with about one million of them having been described. About 2,100 of these species are edible (Stork, 2018). Economically significant crops like palms, bananas, and pineapple are attacked and killed by the African palm weevil, *Rhychophorus phoenicis* (L.), Asiatic rhinoceros beetles, *Oryctes rhinoceros* (L.), and African coconut beetle, *O. monoceros* (Olivier) (Hao *et al.,* 2022). However, due to their nutritional qualities, a large number of individuals in Sub-Saharan Africa consume the same insects (Anaduaka *et al.,* 2021).

Table 1. Insects order-wise consumption percentage

Sl. No.	Insect orders	Insects groups	Consumption percentage (%)
1.	Coleoptera	Beetles	31
2.	Lepidoptera	Caterpillars	18
3.	Hymenoptera	Ants, bees, and wasps	14
4.	Orthoptera	Grasshoppers, locusts, and crickets	13
5.	Hemiptera	Cicadas, leafhoppers, planthoppers, scale insects and true bugs	10
6.	Isoptera	Termites	3
7.	Odonata	Dragonflies	3
8.	Diptera	Flies	2

Nutrition in insects

Insects are an excellent source of nutrition, including high levels of protein, fat, vitamins, minerals, and fibre. In edible insects, lipids are the second most important nutrient after protein (Van-Huis *et al.,* 2021). Termites (Blattodea) have the lowest protein content, whereas crickets and grasshoppers (Orthoptera) have the highest, with a dry matter protein content ranging from 35.3% to 61.3% (Rumpold & Schluter, 2015). Beetles, termites, and fly larvae have a significantly higher lipid content (about 33.40%) than crickets, which have a lower lipid content (around 13.41%). Additionally, insects offer a significant calorie intake, with 293–762 kcal per 100g of dry matter. About 7–48g of protein per 100g is found in fresh insects. Additionally, they contain a lot of polyunsaturated fats, such as omega-3 and omega-6 fatty acids.

According to Huis *et al.* (2013), insects provide a wealth of micronutrients, including vitamins A, B1, B2, B12, and E, as well as vital minerals like iron, zinc, potassium, magnesium, copper, and selenium. Insects have high-quality protein that is easily digested and contains necessary amino acids (10–30% of total amino acids). According to Oonincx and Dierenfeld (2012), the adult yellow mealworm, *Tenebrio molitor* has a higher protein content than its larvae (237g/kg vs. 187g/kg). Yellow mealworms are also higher in vitamins (excluding B12), essential amino acids, and polyunsaturated fats, especially omega-3 fatty acids, than beef (Kourimska & Adamkova, 2016). The primary form of carbohydrates found in insects is chitin (6.71–15.98%), a polysaccharide which provides low-calorie food with health benefits, encouraging good bacteria in the human gut and helps to prevent diseases like obesity and diabetes (Burton & Zaccone, 2007).

Table 2. Some of the traditional insect-based recipes across countries

Sl. No.	Country	Recipes	Recipe image
1.	Bangkok	Fried grasshoppers	
		Fried cockroaches	
2.	Africa countries	Locust grill	
3.	Japan	Canned silkworm pupa (Kaiko)	
		Canned rice grasshopper (Hashi)	
4.	United States	Sun-dried insects (grasshoppers, stink bugs, beetles)	
		Dipping Culonas worker ants in chocolate	

Entomophagy in India

In India, entomophagy is most commonly practiced in the North-East regions, including Assam, Arunachal Pradesh, Manipur, and Nagaland. These areas are home to a rich diversity of edible insects, with approximately 245 species recorded as part of local diets (Hazarika *et al.,* 2020). The Nyishi and Galo tribes of Arunachal Pradesh consume a wide variety of insects, with preferences influenced by traditional beliefs and the availability of insect species. In Nagaland, the Sumi Nagas are known for their diverse consumption of insects, which are prepared in various ways such as frying, roasting and steaming (Chakravorty *et al.,* 2011). Insects with a high protein content, such as winged termites (sometimes called "flying termites" or Isoptera), are collected during their swarming season in some cultures. Another common insect in the area is silkworm larvae, which are consumed boiled or fried. In many rural locations, the larvae represent a significant source of nourishment due to their high protein and necessary fatty acid content.

Edible insects in Market

In the actual market insects may be found as food ingredients, for instance mealworm/cricket powders, roasted seasoned mealworms/crickets, mealworms prepared with sea salt and pepper or even toffee and crickets with honey mustard and chili lime. The choice of recipes and the way dishes are present are two other ways to avoid the disgusting factor (La-Barbera *et al.,* 2018). The insect transformation, making them unrecognizable, may facilitate its consumption (Mitsuhashi, 2010).

Challenges and Cultural Considerations

Despite its benefits, the practice of entomophagy faces challenges such as the influence of westernization and the potential loss of traditional knowledge. Additionally, there is a call for sustainable harvesting and rearing methods to protect insect biodiversity and promote their use as a food. Cultural acceptance is one of the primary obstacles to entomophagy's widespread adoption. However, as awareness grows about the nutritional and environmental benefits of edible insects, campaigns and educational programs are expected to help shift public perceptions. With the rising interest in entomophagy, more research is likely to be conducted on the nutritional benefits of edible insects. Research into food safety and potential allergens will also be crucial to ensuring the safety of insect consumption. Insect breeding techniques and the subsequent steps of killing, preparing, preserving, and packaging the product before consumption are also crucial to prevent cross-contamination or inadequate product conservation, which could put the farmer at risk of infection while performing their responsibilities.

Future Directions

As the global population continues to rise and the demand for food increases, entomophagy is expected to play an increasingly significant role in addressing food security, nutrition, and environmental sustainability. Insect farming could become an integral part of the circular economy. This waste-to-protein model can help create more sustainable food systems by turning unwanted materials into high-value food sources. Furthermore, insect farming may complement the growing movement of upcycling food waste for human consumption. National and international standards for insect farming, processing, and labelling will be essential to ensure consumer confidence and that edible insects meet health and safety requirements. Entomophagy is likely to become a global movement, with greater collaboration between governments, NGOs, researchers, and the private sector. This collaboration will focus on promoting insect consumption, improving production technologies, and overcoming cultural and logistical barriers.

Conclusion

The future of entomophagy is bright, as evidenced by the growing innovation in food products, production techniques, and sustainable practices. Edible insects are predicted to play an significant part in the global food chain as more people become aware of their nutritional and environmental advantages, helping to ensure a more resilient and sustainable future for food production.

References

Anaduaka E.G, Uchendu N.O, Osuji D.O, Ene L.N, and Amoke O.P (2021). Nutritional compositions of two edible insects: Oryctes rhinoceros larva and Zonocerus variegatus. Heliyon, 7(3).

Burton O.T and Zaccone P (2007). The potential role of chitin in allergic reactions. Trends Immunol, 28(10), 419-422.

Chakravorty J, Ghosh S and Meyer-Rochow V (2011). Practices of entomophagy and entomotherapy by members of the Nyishi and Galo tribes, two ethnic groups of the state of Arunachal Pradesh (North-East India). J Ethnobiol Ethnomed, 7, 5 - 5.

Hao M, Aidoo O.F, Qian Y, Wang D, Ding F, Ma T and Borgemeister C (2022). Global potential distribution of Oryctes rhinoceros, as predicted by boosted regression tree model. Glob Ecol Conserv, 37, e02175.

Hazarika A, Kalita U, Khanna S, Kalita T and Choudhury S (2020). Diversity of edible insects in a Natural World Heritage Site of India: entomophagy attitudes and implications for food security in the region. PeerJ, 8.

Huis A.V, Itterbeeck J.V, Klunder H, Mertens E, Halloran A, Muir G and Vantomme P (2013). Edible insects: future prospects for food and feed security.

Kouřimská L and Adámková A (2016). Nutritional and sensory quality of edible insects. NFS Journal, 4, 22-26.

La Barbera F, Verneau F, Amato M and Grunert K (2018). Understanding Westerners’ disgust for the eating of insects: The role of food neophobia and implicit associations. Food Qual Prefer, 64, 120-125.

Mitsuhashi J (2010). The future use of insects as human food. Forest insects as food: humans bite back, 115, 122.

Oonincx D.G.A.B and Dierenfeld E.S (2012). An investigation into the chemical composition of alternative invertebrate prey. Zoo Biol, 31(1), 40-54.

Ramos-Elorduy J. (2009). Anthropo-entomophagy: cultures, evolution and sustainability. Entomol Res 39 (5): 271–288.

Rumpold B.A and Schlüter O (2015). Insect-based protein sources and their potential for human consumption: Nutritional composition and processing. Anim Front, 5(2), 20-24.

Stork N.E (2018) How many species of insects and other terrestrial arthropods are there on earth? Annu Rev Entomol 63:31–45.

Van-Huis A, Rumpold B, Maya C and Roos N (2021). Nutritional qualities and enhancement of edible insects. Annu Rev Nutr, 41(1), 551-576.

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PRECISION AGRICULTURE : AN OVERVIEW

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Abstract

Precision agriculture (PA) is a cutting-edge agricultural method that maximises crop yields, reduces waste, and supports sustainable practices by utilising cutting-edge technologies. This article thoroughly analyses PA, emphasising its main features, advantages, and drawbacks. Through the application of remote sensing, GIS mapping, precision irrigation, automated crop monitoring, data analytics, and machine learning, PA improves resource allocation, boosts farm profitability, lowers water and fertiliser consumption, increases crop productivity, and fosters environmental sustainability. However, expensive upfront investment costs, low digital literacy among farmers, worries about data security and administration, and problems with infrastructure and connectivity impede PA adoption. This article aims to give readers a basic grasp of PA, its potential, and the actions required to get beyond implementation obstacles to eventually support a more productive, efficient, and sustainable agriculture industry.

Keywords: Sustainable Agriculture, Remote Sensing, GIS Mapping, Data Analytics, Automation.

Introduction

According to the World Bank's article on Climate Smart Agriculture, the world's population is expected to exceed 9 billion by 2050, meaning that approximately 70% more food will need to be produced to fulfil demand. Humanity's biggest problem today is sustainably producing food for a population that is expanding quickly. The problem has been made more difficult by declining production and earnings as well as the environmental effects of various agricultural practices. Using cutting-edge digital technologies, precision agriculture will be crucial to the third modern farming revolution. It maximises production and profitability, ensures sustainability, lessens environmental impact, and effectively minimises inputs, labour, and time sustainably. By 2030, the market for precision agriculture is projected to reach a value of $15.6 billion.

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Precision agriculture: what is it?
Precision means the quality of being clear or exact whereas agriculture is the Latin word made from agri, or "field," plus culture, "cultivation". Precision Agriculture is a notion in farm management that centres on monitoring, quantifying, and adapting to different inputs that introduce variability both within and between fields in contemporary agriculture. The phrase "precision agriculture" (PA) or "site-specific crop management" (SSCM) is commonly defined as a technology-enabled farming management technique that monitors, assesses, and evaluates the requirements of individual fields and crops. Precision farming aims to lower input costs, boost output and efficiency, and enhance environmental sustainability.

The notion of precision agriculture (PA) involves monitoring, quantifying, and adapting to crop variability both within and between fields. As-needed farming, satellite agriculture, and precision farming are among other names for PA. Information technology (IT) is used in precision agriculture to make sure that the soil and crops receive precisely what they require for maximum health and productivity. Profitability, sustainability, and environmental preservation are also guaranteed by this. When managing crops, it takes into account factors including plant development, soil type, terrain, weather, and yield data.

Real-time data is gathered from sensors in fields that monitor the soil's moisture content, temperature, and air quality. Real-time photos of individual plants can also be sent to farmers via robotic drones and satellites.

Components of a Precision Farming System?
The three primary pillars of precision farming are technology, management, and information. Agtech startups have developed specialised applications based on these fundamental ideas as technology has progressed, offering more technologically sophisticated and efficient solutions to help farmers increase yields and profitability while using fewer pesticides, herbicides, fertilisers, and other inputs. The following is a list of particular precision agricultural technologies that farmers frequently utilise.

- GPS & GIS: - Farmers can orient their equipment and data collecting in real-time for precise location and field management when they combine GPS and GIS.
- Auto-Steer Tractors and other farm equipment are guided in uniformly straight lines over agricultural fields by auto-steer, which makes use of GPS and GIS. This makes it possible for farmers to precisely till, sow, fertilise, and harvest their fields.
- Variable Rate Technology (VRT): This technique enables

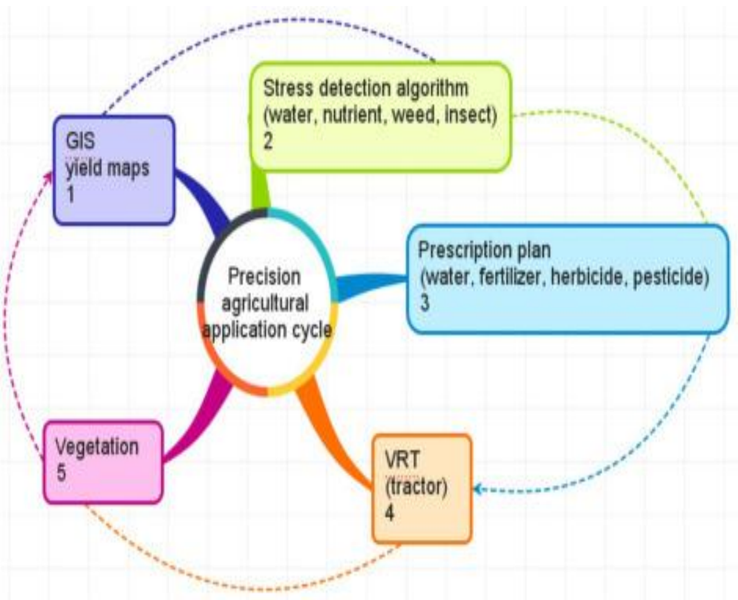

Image source: ScienceDirect

farmers to apply inputs such as fertiliser, seeds, and other materials at various rates throughout a field.

- Using remote sensing: - The process of identifying areas of crop development and stress by the use of very sensitive satellite imaging or photos captured by drones or planes, followed by the GPS geolocation of those precise places in a field.
- The application of machine learning to recognise and react to real-time input in agricultural activities is known as artificial intelligence (AI). The majority of AI research and development is focused on agricultural robotics, namely robotic harvesters and weeding equipment.
- Analytics and Data Gathering: - Gathering and evaluating data produced by every agricultural activity to provide more profound insights that inform wise farm management choices. The farm management software from AGRIVI is a data-gathering tool and analytics platform, facilitating data-driven decision-making and providing real-time insights in field data.
- Yield Monitoring: - Using GPS and GIS technology, yield monitors on combines measure the amount of harvest collected at precise spots geolocated across a field to create yield maps during harvest season. Yield maps are used in conjunction with other precision agriculture technologies, like soil and VRT maps, to help improve farm management choices.

What advantages can precision farming offer?

- Following data collection, farmers can receive recommendations regarding crop rotation, the best times to plant and harvest crops, and how to maintain the soil through the use of predictive analytics software.
- Farmers may identify fields that need to be treated and calculate the best amount of water, fertiliser, and pesticide to apply by using agricultural control centres to combine sensor and imagery data with other data.
- In addition to lowering expenses and minimising the farm's environmental effects, this aids the farmer in preventing runoff and resource waste and ensuring that the soil has the ideal number of additives.

What applications does precision agriculture have?

Precision agriculture used to be exclusive to larger businesses that could afford the IT infrastructure and other technological resources needed to properly apply the practice and reap its benefits. But today, farming cooperatives and even tiny family farms can use precision agriculture thanks to smartphone apps, smart sensors, drones, and cloud computing.

A few of the most widely used uses of precision agriculture nowadays are

- Field scouting and agricultural mapping: High-resolution maps of fields can be produced using drones that have cameras installed. This information can be used to track crops, pinpoint issue areas, and estimate prospective production.
- Soil examination and sample: Data on soil type, fertility, moisture content, and other topics can be gathered via mobile apps. Decisions on fertilisation, irrigation, and other crop management practices can be made using this information.
- Weather observation: Users can make decisions about when to plant, how much water to give crops, and when to harvest with the use of hyperlocal weather data.
- Labour administration: Mobile apps with GPS functionality allow field workers' whereabouts and activities to be monitored. Workflows can be made more efficient and

task completion guaranteed with the use of this data. management of equipment.

- Precision agriculture can assist farmers in maintaining equipment, scheduling maintenance, and budgeting for repairs because agricultural equipment is costly.

Difficulties in precision agriculture

- There are difficulties with precision farming. The largest difficulty is managing data. Making sense of the massive amount of data that precision agriculture sensors may gather can be challenging.
- Integrating the various data sources is another difficulty. Precision agriculture involves a multitude of disparate data types, and integrating them all is a challenging task.
- Finally, there is a big technological investment needed for precision agriculture. The cost of the necessary hardware and software for precision farming can be high, and mastering its use takes time.
- Precision farming is growing in popularity despite these obstacles as farmers look to maximise productivity and crop returns.

Conclusion

To wrap it up, precision agriculture (PA) has transformed the agricultural industry by utilising state-of-the-art technologies to maximise crop yields, minimise waste, and encourage sustainable practices. PA shows great promise for increasing crop productivity, lowering resource consumption, and raising farm profitability by utilising advances in remote sensing, GIS mapping, precision irrigation, automated crop monitoring, data analytics, and machine learning. PA is positioned to be a key player in addressing major global issues including food security, climate change, and environmental degradation as the agriculture industry develops further. Future developments in PA are anticipated to use cutting-edge technology like blockchain, artificial intelligence, and the Internet of Things (IoT). Drones, UAVs, and satellite images are becoming more and more common, which will improve crop monitoring and decision assistance. Furthermore, the field of PA will become more diverse than only traditional row crops as precision livestock farming and urban agriculture grow. Policymakers, researchers, and stakeholders must work together as precision agriculture develops in order to remove current obstacles, guarantee fair access, and promote a sustainable, food-secure future for future generations.

References

Lange, A. F., & Peake, J. (2020). Precision agriculture. *Position, Navigation, and Timing Technologies in the 21st Century: Integrated Satellite Navigation, Sensor Systems, and Civil Applications*, *2*, 1735-1747.

Oliver, M. A. (2013). An overview of precision agriculture. *Precision agriculture for sustainability and environmental protection*, 3-19.

Petrović, B., Bumbálek, R., Zoubek, T., Kuneš, R., Smutný, L., & Bartoš, P. (2024). Application of precision agriculture technologies in Central Europe-review. *Journal of Agriculture and Food Research*, 101048.

Saranya, T., Deisy, C., Sridevi, S., & Anbananthen, K. S. M. (2023). A comparative study of deep learning and Internet of Things for precision agriculture. *Engineering Applications of Artificial Intelligence*, *122*, 106034.

Sishodia, R. P., Ray, R. L., & Singh, S. K. (2020). Applications of remote sensing in precision agriculture: A review. *Remote sensing*, *12*(19), 3136.

Yadav, A., Yadav, K., Ahmad, R., & Abd-Elsalam, K. A. (2023). Emerging frontiers in nanotechnology for precision agriculture: advancements, hurdles and prospects. *Agrochemicals*, *2*(2), 220-256.

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INSECTS AS CRITICAL BIOINDICATORS: A KEY TO UNDERSTANDING ECOLOGICAL DYNAMICS

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Abstract
Insects are important bioindicators that provide data on pollution levels, ecological shifts, and environmental health. They can keep us focused on the quality of the soil, water, and air as well as other ecological parameters because of their sensitivity to different environmental influences. Particularly, termites, dung beetles, and certain beetles show contamination of soil quality, whereas moths and butterflies show climatic shifts and air pollution. Aquatic insects like mayflies and dragonflies are markers of water quality, whereas insects like bees and ants gather pollutants, revealing environmental degradation. Furthermore, mosquitoes and houseflies are indicators of urban hygiene. Because of their capacity to adapt to changes in their surroundings, insects are essential for evaluating the effects of pollution and habitat disruption, making them vital instruments for ecological monitoring and environmental conservation efforts.

Keywords: Bioindicators, Ecological monitoring, Environmental health, Insects, Pollution

Introduction

Biological indicators play an important role in assessing the environmental health and detect changes in the environment, either positive or negative, and their impacts on human society. The characteristics of a biosphere are basically defined by bio-organisms. It is these organisms that are termed bioindicators or biomonitors, both of which can vary greatly in their characteristics. Bioindicators can be used to determine the quality of environmental changes taking place, while biomonitors provide quantitative information on the environment's quality. An indicator species is an organism whose characteristics (e.g. presence or absence, population density, dispersion, reproductive success) are used as an index of attributes are too difficult, inconvenient, or expensive to measure for other species or environmental conditions of interest (Landres *et al.,* 1988). Invertebrates are frequently used as indicator species, including ants to measure post-mining rehabilitation, bees as a measure of pollination, butterflies and moths for ecosystem health and aquatic invertebrates for waterbody health (Burgman *et al.*, 2005).

Bioindicators:

Sl. No.	INSECT SPECIES / GROUP	BIOINDICATORS	POLLUTION
1.	Carabid beetles	Oil, sulphur, herbicides, insecticides and radioactive phosphorus	Soil pollution

Sl. No.	INSECT SPECIES / GROUP	BIOINDICATORS	POLLUTION
2.	Lepidopteran group	CO_2 concentration	Soil pollution
3.	*Coenonympha pamphilus*	Metal contamination	Soil pollution
4.	Pupa of geometrid and noctuid species	Copper, iron, nickel, cadmium and sulphuric acid	Soil pollution
5.	Ant	Soil quality	Soil pollution
6.	Fly such as *Chrysoma megacephala* and *Musca domestica*	Environmental change	Environmental pollution
7.	Sarcophagidae	Metals, asbestos fibres, and waste chemicals	Environmental pollution
8.	Odonata	Water quality	Water pollution
9.	*Halobates*	Cadmium and lead	Water pollution

Insects as bioindicators of environmental changes

Insects are critical bioindicators that provide insights into ecosystem health, pollution levels, and environmental changes. Their sensitivity to specific environmental factors makes them valuable for monitoring ecological shifts.

1. Indicators of soil and land quality

Coleopterans such as Carabidae, Staphylinidae, and Curculionidae families are often used in soil health assessments. Ground beetles (Carabidae) are particularly notable, with studies showing how exposure to toxic substances like copper affects their behaviour and increases larval mortality (Ghannem *et al*., 2018). For instance, the carabid *Parallelomorphus laevigatus* reliably indicates soil contamination with toxic substances (Conti *et al*., 2017). Termites act as "ecosystem engineers," influencing soil fertility. Their mounds improve soil physico-chemical properties, offering a sustainable alternative to chemical fertilizers (Nithyatharani and Kavitha, 2018). By breaking down animal waste, dung beetles contribute to soil nutrient enrichment, including nitrogen, phosphorus, and potassium, which promotes agricultural productivity (De Groot *et al*., 2002).

2. Indicators of air and climatic conditions

Butterflies are highly sensitive to climatic factors such as temperature, which impacts their range, oviposition sites, egg-laying rates, and larval development (Sharma and Sharma, 2017). Moths, particularly Noctuidae and Geometridae species, show changes in pupal size in response to industrial air pollution levels (Heliövaara *et al*., 1989).

Hymenopterans accumulate heavy metals and pollutants, reflecting air and soil contamination. For example, red wood ants (*Formica lugubris*) store metals like aluminum and lead in their bodies and nests (Skaldina *et al*., 2018). Honey bees act as indicators of pesticide residues and heavy metals, with contaminants being detectable in honey and bee bread.

3. Indicators of water quality

These aquatic insects (Ephemeroptera, Plecoptera, Trichoptera) are commonly used in water purity assessments. Mayflies (Ephemeroptera) are sensitive to oxygen depletion, stoneflies (Plecoptera) thrive in highly oxygenated water, and caddisflies (Trichoptera) indicate water pollution levels

(Parikh *et al.,* 2021). Chironomids (non-biting midges) are widely used in ecotoxicological tests. Antennal deformities in chironomids serve as early indicators of toxic contamination (Warwick, 1990). Other dipterans, such as Eristalis and Sphaerophoria species, accumulate heavy metals from polluted industrial areas (Markova and Alexiev, 2002). Odonates are highly responsive to habitat disturbance and heavy metal deposition in aquatic ecosystems, making them effective bioindicators of water quality in lakes and drainage areas (Shafie *et al.,* 2017).

4. Indicators of hygiene and urban conditions

The abundance of houseflies and mosquitoes signals poor sanitation and unhygienic environmental conditions. Their presence often correlates with organic waste accumulation and stagnant water, respectively, which fosters breeding grounds for these insects.

Threats

The challenges faced in utilising insects as bioindicators is that there aren't any standardised techniques, which makes cross-study comparisons difficult because of irregular protocols. Furthermore, limited understanding about how insects react to different environmental stresses such pollution, habitat loss, and climate change, which calls for more study. The lack of research on how human activities, especially land use and urbanisation, affect insect populations also limits the potential of insects as bioindicators. Furthermore, there are a lot of unanswered questions about the distribution, biodiversity, and behaviour of insects in response to environmental changes. In order to overcome these obstacles, it is necessary to create global guidelines for the use of insects as bioindicators in various ecosystems, incorporate cutting-edge technology like remote sensing and molecular tools, and concentrate more on.

Conclusion

Insects are great bioindicators because they may reflect changes in environmental quality across different ecosystems. They are essential instruments for monitoring the quality of the soil, water, and air because of their sensitivity to pollution and habitat disturbance. The demand for effective and economical monitoring techniques increases as environmental degradation becomes more apparent. Because they offer early indications of ecological changes, insects offer a workable option that is crucial for directing conservation efforts and guaranteeing sustainable environmental management. Their crucial function in evaluating the health of the environment highlights the urgent need for more research and wider use in ecological monitoring.

References

Burgman M.A, Lindenmayer D.B and Elith J (2005). Managing landscapes for conservation under uncertainty. Ecology, 86(8), 2007-2017.

Conti E, Dattilo S, Costa G and Puglisi C (2017). The ground beetle Parallelomorphus laevigatus is a potential indicator of trace metal contamination on the eastern coast of Sicily. Ecotoxicol Environ Saf, 135, 183-190.

De Groot R.S, Wilson M.A and Boumans R.M (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecol Econ, 41(3), 393-408.

Ghannem S, Touaylia S and Boumaiza M (2018). Beetles (Insecta: Coleoptera) as bioindicators of the assessment of environmental pollution. Hum Ecol Risk Assess, 24(2), 456-464.

Heliövaara K, Väisänen R and Kemppi E (1989). Change of pupal size of Panolis flammea (Lepidoptera; Noctuidae) and Bupalus piniarius (Geometridae) in response to concentration of industrial pollutants in their food plant. Oecologia, 79, 179-183.

Landres P.B, Verner J and Thomas J.W. (1988). Ecological uses of vertebrate indicator species: A critique. Conserv Biol, 2(4), 316-328.

Markova E and Alexiev A (2002). Bioaccumulation of heavy metals in syrphid flies (Syrphidae, Diptera). Environ Monit Assess, 78, 63-70.

Nithyatharani R and Kavitha U.S (2018). Termite soil as bio-indicator of soil fertility. Int J Curr Microbiol Appl Sci, 7(6), 2262-2268.

Parikh G, Rawtani D and Khatri N (2021). Insects as an indicator for environmental pollution. Environ Claims J, 33(2), 161-181.

Shafie M.S, Wong A.B, Harun S. and Fikri A.H. (2017). The use of aquatic insects as bio-indicator to monitor freshwater stream health of Liwagu River, Sabah, Malaysia. J Entomol Zool Stud, 5(4), 1662-1666.

Sharma M and Sharma N (2017). Suitability of butterflies as indicators of ecosystem condition: A comparison of butterfly diversity across four habitats in Gir Wildlife Sanctuary. Int J Adv Res Biol Sci, 4(3), 43-53.

Skaldina O, Peräniemi S and Sorvari J (2018). Ants and their nests as indicators for industrial heavy metal contamination. Environ Pollut, 240, 574-581.

Warwick W.F (1990). The use of morphological deformities in chironomid larvae for biological effects monitoring (Vol. 173). Saskatoon: Inland Waters Directorate, National Hydrology Research Institute, National Hydrology Research Centre.

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FROM CODE TO CROP

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Abstract

This is all about the inspiring stories of techies who left their job to sown and cultivate their dream for future. These farmers from Tamil Nadu are the professionals who dropped their job for their passionate interest towards the field of farming and agriculture. Through their valuable skills, innovation and technology they are creating a positive impact in the sector and motivating farmers and society that creates awareness, importance about agriculture. This journey of digital harvest from techies makes difference in Indian Agriculture.

Mr. Sudeesh K

Sudeesh K, from Krishnagiri district, who worked as a software developer in an MNC at Bangalore, quit his job due to his immense interest in farming. Together with his father, kanthasamy, he started focusing on farming in their ancestral land in Jakeri, a densely forested village in Kelamangalm, which comes under the administrative block of Krishnagiri district. They use Israeli technology to grow roses and carnations in two poly greenhouses on two acres under regulated conditions.

Srinivasan, a general manager at a multinational software company owns a neighbouring farm. Every weekend, he travels from Bangalore to tend to his high tech rose farm. He plans to eventually quit his job to become a fulltime farmer. Poly greenhouses and shade net structures are common in the four administrative blocks of Krishnagiri District: Kelamangalm, Denkanikottai, Shoolagiri, and Hosur. Young engineers, management experts, workers in information technology (IT) sector, and others are driving the high-tech horticulture boom. Being rainfed area the district led to shift towards horticulture, due to its climate. Coinciding with Bangalore's IT boom, high tech horticulture took off in the area, with phenomenal growth over the last five years driven by sons of small farmers.

Farmer named Subramani of the same village, disrupted the cycle of growing ragi and groundnut by cultivating coloured and green capsicums in two poly green houses, each spanning one acre of ground. At the farm gate, Subramani sells capsicum for Rs 50 per kilogram. The produce is picked daily by buyers from Bengaluru, who then pack and deliver it to other markets throughout the nation. 14,000 plants, including seed and labor costs, may be grown in a one-acre poly greenhouse for Rs 8.5 each. Capsicum is collected nine months of the year at a rate of 60 tons per acre.

Sudeesh with interviewer

Sudeesh and other farmers work as advisors and consultants. Other crops that farmers are pursuing include carrots, cauliflower, double beans, radish, and cabbage. Villagers are levelling dry and rocky terrain to build poly green and shade nets because the resultant wealth seems worth the risks.

Benjamin Raja

Benjamin who worked as a corporate employee quit his job and started his company in Tirunelveli after meeting his school friend John who was a farmer in Salem. He was using 1000 litres of water for irrigation instead of 100 litres which results in low productivity. John reminds unhappy with this low yield. By noticing this Benjamin decides to solve the issue by timely invention. He understands that Adequate nutrients and water is required and not in excess as well as lesser than required quantity. So, he planned to invest and develop an indigenous system where he used sensors to monitor detect and inject required inputs to maintain a good condition.

The system works as whole to prevent over irrigation and injecting proper input which result in higher yield and production. He states that this technology can cover an land area up to half an acre. He also added up that the tool introduced here cost only 2.5 lakhs where as the imported equipment cost nearly 25lakhs. He initially offered his technique in a coconut farm where the farmer Rajaratnam faced difficulty in managing the farm and about to sold it. With the help of setting this precision technique 99% of the farmer's problem was solved.

A traditional farmer named Dayalan from Pollachi said that precision farming technique has highly helped him to save resources in western ghats. Additionally, some farmers have begun cultivating barren lands. Farmers says that adapting this technique results in increasing their income which Benjamin wished and worked for.

Field with solar

Field with sensors

Mr. Shankar Venkatraman

Fathers love is always never ending towards his daughter. The real story of a techie father who was working California quit his job and started organic farming when his daughter faced ECZEMA condition (inflammation and itchy in skin due to genetic and environmental conditions). Apart from providing the best treatment to his daughter he wanted to find the root cause of her disease. All of a sudden, he noticed that the food we consume can also be toxic as the farmers use pesticides, chemicals for growing the crop. He started reading books related to that and also attend conferences regarding organic and sustainable farming. He started his own startup Hillview Organics and produces organic veggies then supplied and earned over there. His wife SUJATHA was being his biggest support. He wished to empower the farmers and for uplifting their lives he decided to move

India. He felt harder to convince the farmers not to use the chemicals and to teach them the importance of organic farming.

Coordination and team effort with the co- founder of Infosys Shibulal and Kumari Shibulal he also started working at Maple Tree. With the help from them, Shankar decided to sponsor the farmers children's education

Farmers started doing organic farming and supplied outputs to organic stores. Also earned good income under Maple tree farming. His ultimate goal was to create awareness among farmers about organic farming and along with that he planned to sow the seed of this awareness from childhood. Thus he allowed school students to take a visit over his farm under the School for Experiential Education (SEED) programme.

Farmers gained experience and helped by Shankar

Shankar's main motto is create awareness about organic farming and to save the future of children and our nature .

Mrs. Jayalakshmi

Jayalakshmi who lived in canada for 14 years returned India. Her daughter was suffered from allergies for which she look after her by giving organic veggies and food. She faced difficulty in finding organic veggies here which is easily available in Canada. Her cousin stretched out his hand to help her by providing a land where she started farming with minimum knowledge. But unfortunately it doesn't gave her as expected results and she stopped it at some conditions. Turning point in her career sparked when she met Dr Shanmuga Sundaram, an.

Jayalakshmi with her daughter

Orthodontist from "Ramakrishna Ashram Mission School" who guided her to attend the workshop about zero budget farming. With the guidance and advise she started raising back in the field. Arulpriya a housewife young women who was with her family noticed their children habit of eating fruits and decided not to dispose the waste in dustbin instead to reuse it for some other purpose. Thus she started researching about it and learnt composting , then creating awareness about this to the society by conducting workshops. Such a way Jayalakshmi and Arulpriya met and joined hands together and started NAMMA BOOMI where started selling chemical free products. Their business started growing day by day and engaging customers with natural and eco frtiendly products. She reminds as a true inspiration for women in the society.

Reference

Bouis, H. E., & Saltzman, A. (2017). Improving nutrition through biofortification: A review of evidence from Harvest Plus, 2003 through 2016. *Global Food Security*, 12, 49-58.

Shankar https://thebetterindia.com/180803/tamil-nadu-organic-farming-techie-quits-us-job-inspiring-india/

Jayalakshmihttps://krishijagran.com/success-story/fed-up-of-chemical-laden-veggies-woman-starts-organic-farming-for-her-child-in-tamil-nadu/

Benjamin Raja https://thebetterindia.com/239042/tamil-nadu-farmers-yield-double-machine-ai-startup-farm-again-benjamin-raja-inspiring-him16/#google_vignette

Sudeeshhttps://www.villagesquare.in/educated-tamil-youth-boost-growth-with-hi-tech-farming/

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APPLICATION OF GINGER (*Zingiber officinale*) IN MEDICINE AND FOOD PRESERVATION

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Summary

Ginger (Zingiber officinale) is a multifaceted plant with significant medicinal and preservative properties. Its bioactive compounds provide a wide range of health benefits, while its antimicrobial effects make it an effective natural preservative. The integration of ginger into both traditional medicine and modern food preservation techniques underscores its importance in promoting health and enhancing food safety. This review examines the various medicinal applications of ginger as well as its use as food preservative and spices.

Introduction

Ginger (Zingiber officinale) is an important and widely grown spice of over 90 species of perennial rhizomatous herbs. It is a root crop and a typical herb extensively grown across the world for its pungent aromatic under-ground stem or rhizome which makes it an important export commodity in world trade (NEPC1999; Erinle 1989; Ajibade & Dauda 2005). Ginger has been utilized for centuries in various cultures for its culinary and medicinal properties. Ginger is native to Southeast Asia and not only a popular spice but also a significant component of traditional medicine in many regions, including Africa, America, and Asia. Its diverse applications range from flavoring of food and beverages to serving as a natural remedy for various ailments. The bioactive compounds present in ginger, such as gingerols and shogaols, contribute to its health-promoting properties, which include anti-inflammatory, antioxidant, and antimicrobial effects (Mao *et al*., 2019; Unuofin *et al*., 2021; Gunathilake & Rupasinghe, 2015). The growing interest in natural remedies and functional foods and the increased consumer awareness of health and wellness has prompted extensive research into the health benefits, antimicrobial properties and demand for ginger as a functional food, highlighting its potential role in disease prevention and health maintenance (Nutakor *et al*., 2020).

Medicinal Applications of Ginger

The medicinal uses of ginger are well-documented across various cultures, particularly in Ayurvedic and traditional Chinese medicine. It has been employed to treat a range of ailments, including gastrointestinal disorders, respiratory issues, and inflammatory conditions (MohamadHesam *et al*., 2019; Bodagh *et al*., 2018). Clinical studies have demonstrated that ginger can alleviate nausea, reduce muscle pain, and improve digestion (Mao *et al*., 2019; Khan *et al*., 2021).

Antiemetic properties: Ginger has been shown to possess antiemetic properties, making it effective in alleviating motion sickness and nausea associated with chemotherapy and pregnancy (Wadikar & Premavalli, 2012; Crichton *et al*., 2022).

Blood pressure treatment: Ginger has been seen to possess potential medicinal properties in cardiovascular health through the modulation of blood lipid profiles and blood pressure. (Pinontoan, 2024; Gunathilake & Rupasinghe, 2015).

Anti-inflammatory properties: The anti-inflammatory properties of ginger are attributed to its ability to inhibit the production of pro-inflammatory cytokines and enzymes, which are implicated in various chronic diseases (Dugasani *et al*., 2010; MohamadHesam *et al*., 2019; Gunathilake & Rupasinghe, 2015).

Cancer treatment: Ginger's antioxidant capacity helps combat oxidative stress, which is linked to numerous health issues, including cancer and cardiovascular diseases (Mao *et al*., 2019; Mahat *et al*., 2019).

Digestion: Ginger can help with digestion, bloating, and gas. A study shows that consuming a ginger and artichoke preparation before eating a main meal significantly improved the symptoms of indigestion in people with functional dyspepsia, compared with taking a placebo (Giacosa *et al* 2015).

Cholesterol: Ginger helps lower low-density lipoprotein (LDL) cholesterol and triglycerides levels, and boost high-density lipoprotein (HDL) cholesterol (Arablou, 2014).

Weight control: Ginger play a role in weight loss, according to studies in humans and animals, ginger supplementation significantly reduced body weight, the waist-hip ratio, and the hip ratio in people with overweight or obesity (Dugasani *et al*., 2010). Ginger's ability to influence weight loss may be due to certain mechanisms, such as its potential to reduce inflammation (Maharlouei *et al* 2018).

Brain function: Ginger helps to prevent degenerative diseases such as Alzheimer's disease, Parkinson's disease, and multiple sclerosis. Research findings suggest that 6-shogaol and 6-gingerol compounds in ginger help to effect these functions. Oxidative stress and chronic inflammation may be key drivers of Alzheimer's disease and age-related cognitive decline. Some animal studies also suggest the antioxidants and bioactive compounds in ginger can inhibit inflammatory responses that occur in the brain. This may help prevent cognitive decline (Arcusa *et al* 2022).

Ginger as food preservative and spice

In addition to its medicinal applications, ginger serves as a natural preservative due to its antimicrobial properties. The essential oils and phenolic compounds in ginger inhibit the growth of various pathogens, making it effective in extending the shelf life of food products (Akhlaghi & Darzi, 2023; Mao *et al*., 2019).

Studies have shown that ginger extracts can be utilized in food packaging systems to prevent spoilage and maintain food quality (Akhlaghi & Darzi, 2023; Mao *et al*., 2019). This dual functionality as both a flavoring agent and a preservative highlights ginger's versatility in culinary applications.

The preservation capabilities of ginger are enhanced when combined with other natural preservatives, creating synergistic effects that further inhibit microbial growth and spoilage (Akhlaghi & Darzi, 2023; Mao *et al*., 2019).

Conclusion

Ginger has been extensively researched. Various results show the versatility and potentials of ginger in the treatment or management of several health issues. Ginger also proves to be effective in the preservation of a wide range of food product and as flavouring materialin the food and drink industry.

References

Ajibade, L.K and Dauda, Y. (2005).Ginger Plant; Ginger Extension Pamphlet. *Bennard Ginger Company*, Kafanchan, Nigeria.

Akhlaghi, N. and Darzi, G. (2023). Potential Applications of Ginger Rhizomes as a Green Biomaterial: a review. *International Journal of Engineering*, 36(2), 372-383. https://doi.org/10.5829/ije.2023.36.02b.16

Arablou, T., Aryaeian, N., Valizadeh, M., Sharifi. F., Hosseini, A. and Djalali, M.(2014) The Effect of Ginger Consumption on Glycemic Status, Lipid Profile and some Inflammatory Markers in Patients with Type 2 Diabetes Mellitus. *Int J Food Sci Nutr.* 65(4):515-20. doi: 10.3109/09637486.2014.880671.

Arcusa, R., Villaño, D., Marhuenda, J., Cano, M., Cerdà, B. and Zafrilla. P.(2022) Potential Role of Ginger (*Zingiber officinale* Roscoe) in the Prevention of Neurodegenerative Diseases. *Front Nutr.*9:809621. doi: 10.3389/fnut.2022.809621. PMID: 35369082; PMCID: PMC8971783.

Asumugha,G.N., Njoku,J.E. and Nweke,F.I. (2003) Marketing System and Spatial Price Differentiation of Ginger in Nigeria. *African Journal of Root and Tuber Crops* 5(2)

Bodagh, M., Maleki, I., and Hekmatdoost, A. (2018). Ginger in Gastrointestinal Disorders: a systematic review of clinical trials. *Food Science & Nutrition*, 7(1), 96-108. https://doi.org/10.1002/fsn3.807

Crichton, M., Davidson, A., Innerarity, C., Marx, W., Lohning, A. and Isenring, E. (2022). Orally Consumed Ginger and Human Health: an umbrella review. *American Journal of Clinical Nutrition,* 115(6), 1511-1527. https://doi.org/10.1093/ajcn/nqac035

Dugasani, S., Pichika, M., Nadarajah, V., Balijepalli, M., Tandra, S. and Korlakunta, J. (2010). Comparative Antioxidant and Anti-inflammatory Effects of [6]-gingerol, [8]-gingerol, [10]-gingerol and [6]-shogaol. *Journal of Ethnopharmacology,* 127(2), 515-520. https://doi.org/10.1016/j.jep.2009.10.004

Erinle, I.D. (1988). An Overview of Research on Ginger Productions in Northern State of Nigeria. *Proceedings of the First National Ginger Workshop*, Umudike, Nigeria, 89-93.

Ezeagu W., (2006). Ginger export. A paper presented a 3-day National Workshop on massive cassava and ginger production and processing for local industries and export; held at Fati Muazu Hall, National centre for women development, Abuja.

Giacosa, A., Guido, D., Grassi, M., Riva, A., Morazzoni, P., Bombardelli, E., Perna, S., Faliva, M.A. and Rondanelli, M.(2015) The Effect of Ginger (Zingiber officinalis) and Artichoke (Cynara cardunculus) Extract Supplementation on Functional Dyspepsia: A Randomised, Double-Blind, and Placebo-Controlled Clinical Trial. Evid Based Complement Alternat Med. 2015;2015:915087. doi: 10.1155/2015/915087.

Gunathilake and Rupasinghe(2015). Recent Perspectives on the Medicinal Potential of Ginger" Botanics Targets and Therapy. doi:10.2147/btat.s68099
Journal of Food Processing and Preservation, 36(6), 489-496. https://doi.org/10.1111/j.1745-4549.2011.00615.x

Khan, F., Nayab, M. and Ansari, A. (2021). Zanjabeel (zingiber officinale roscoe.): An Evidence-based Review of Anti-nociceptive, Anti-inflammatory, Antioxidant, and Antimicrobial Properties. *Journal of Complementary and Alternative Medical Research,* 26-35. https://doi.org/10.9734/jocamr/2021/v15i330269

Maharlouei, N., Tabrizi, R., Lankarani, K.B., Rezaianzadeh, A., Akbari, M., Kolahdooz, F., Rahimi, M., Keneshlou, F. and Asemi, Z. (2019) The Effects of Ginger Intake on Weight Loss and Metabolic Profiles among Overweight and Obese Subjects: A systematic review and meta-analysis of randomized controlled trials. *Crit Rev Food Sci Nutr.*;59(11):1753-1766. doi: 10.1080/10408398.2018.1427044.

Mahat, S., Sapkota, S., Sapkota, S., and Katuwal, K. (2019). Factors Affecting Ginger Production in Surkhet District, Nepal. *International Journal of Applied Sciences and Biotechnology,* 7(2), 269-273. https://doi.org/10.3126/ijasbt.v7i2.24650

Mao, Q., Xu, X., Cao, S., Gan, R., Corke, H., Beta, T. and Li, H.(2019). Bioactive Compounds and Bioactivities of Ginger (zingiber officinale roscoe). *Foods*, 8(6), 185. https://doi.org/10.3390/foods8060185

MohamadHesam, S., Sun, W., and Cheng, Q. (2019). Pharmacological Uses and Health Benefits of Ginger (zingiber officinale) in Traditional Asian and Ancient Chinese Medicine, and Modern Practice. *Notulae Scientia Biologicae*, 11(3), 309-319. https://doi.org/10.15835/nsb11310419

Nutakor, C., Essiedu, J., Adadi, P., and Kanwugu, O. (2020). Ginger beer: an overview of health benefits and recent developments. Fermentation,6(4), 102. https://doi.org/10.3390/fermentation6040102

Pinontoan, R. (2024). In vitro Assessment of Thrombolytic Potential of Red and White Ginger (zingiber officinale). *Functional Foods in Health and Disease,* 14(1), 62. https://doi.org/10.31989/ffhd.v14i1.1245

Unuofin, J., Masuku, N., Paimo, O., and Lebelo, S. (2021). Ginger from Farmyard to Town: nutritional and pharmacological applications. *Frontiers in Pharmacology,* 12. https://doi.org/10.3389/fphar.2021.779352

Wadikar, D. and Premavalli, K.(2012). Optimization of Ginger-based Ready-to-Drink Appetizer by Response Surface Methodology and its Shelf Stability.

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GISH AND FISH TECHNOLOGY IN BIOTECHNOLOGY

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Abstract

Genomic In Situ Hybridization (GISH) and Fluorescence In Situ Hybridization (FISH) represent groundbreaking cytogenetic techniques that have transformed our understanding of genomic architecture and chromosomal organization. This comprehensive review explores the fundamental principles, methodological approaches, and diverse applications of both techniques. GISH, primarily utilized in hybrid genome analysis and evolutionary studies, enables the visualization of parental genome contributions in hybrid species, making it an invaluable tool in plant breeding and evolutionary biology. FISH, with its capability to detect specific DNA sequences, has become essential in clinical diagnostics, gene mapping, and cancer research. The review details the technical aspects of both methods, including sample preparation, probe design, hybridization protocols, and signal detection systems. Recent technological advancements, including multi-color FISH and high-resolution imaging systems, have expanded the capabilities of these techniques. Despite challenges such as technical complexity and cost considerations, both GISH and FISH continue to evolve, offering increasingly sophisticated solutions for genetic analysis. This paper also discusses emerging applications, limitations, and future perspectives, highlighting the ongoing significance of these techniques in modern genetic research and clinical diagnostics.

Keywords: GISH; FISH; Cytogenetics; Chromosome Analysis; Gene Mapping; Hybrid Genomes; DNA Probes; Fluorescence Microscopy

Introduction

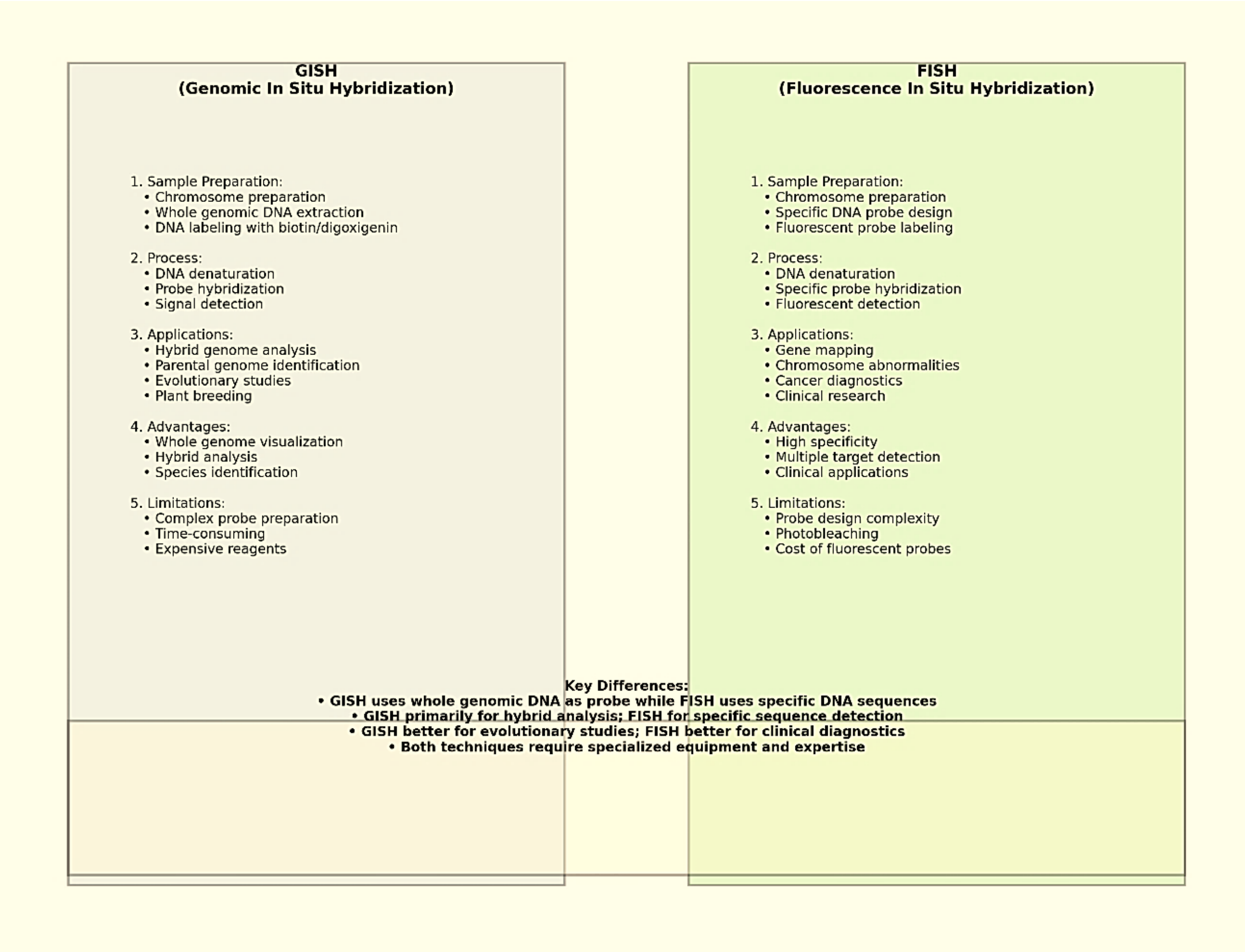
Genomic In Situ Hybridization (GISH) and Fluorescence In Situ Hybridization (FISH) are two advanced cytogenetic techniques that have revolutionized the field of biotechnology. These methods allow researchers to visualize and identify specific DNA sequences directly on chromosomes, providing critical insights into genome organization, structure, and function. GISH is particularly useful in studying hybrid genomes, such as those resulting from interspecific crosses, by distinguishing parental contributions. On the other hand, FISH is widely employed for detecting specific DNA sequences, gene mapping, and identifying chromosomal abnormalities, making it invaluable in both research and clinical diagnostics. The development of these techniques has enabled significant advancements in understanding genetic disorders, evolutionary biology, and plant and animal breeding programs.

Aims and Objectives

The primary aim of GISH and FISH technology is to enhance our understanding of genome structure, function, and evolution. These techniques are designed to address specific objectives, which include:

1) Identifying chromosomal rearrangements, such as translocations, deletions, and duplications, which are often associated with genetic disorders.

2) Mapping specific genes and DNA sequences on chromosomes to understand their location and function.
3) Studying hybrid genomes to determine the parental origin of chromosomes and their contributions to hybrid vigor or sterility.
4) Investigating genome evolution and speciation events by comparing chromosomal structures across species.
5) Assisting in the diagnosis of genetic diseases and chromosomal abnormalities in clinical settings.



Merits

GISH and FISH technologies offer numerous advantages that make them indispensable tools in genetic research and biotechnology. These include:

1) High specificity and sensitivity: These techniques can detect even small DNA sequences with high accuracy, making them ideal for detailed chromosomal analysis.
2) Versatility: GISH and FISH can be applied to a wide range of organisms, including plants, animals, and humans, for various research and diagnostic purposes.
3) Visualization of chromosomal structures: These methods provide a clear and direct visualization of chromosomal arrangements, aiding in the study of genome organization.

4) Identification of chromosomal abnormalities: FISH is particularly useful in clinical diagnostics for detecting genetic disorders such as Down syndrome and cancer-related chromosomal changes.
5) Applications in breeding programs: GISH is extensively used in plant and animal breeding to analyze hybrid genomes and improve breeding strategies.
6) Contribution to evolutionary studies: By comparing chromosomal structures across species, these techniques provide valuable insights into evolutionary relationships and speciation events.

Demerits

Despite their numerous advantages, GISH and FISH technologies have certain limitations that researchers must consider. These include:

1) Requirement for specialized equipment: The techniques require advanced microscopes and imaging systems, which may not be accessible in all laboratories.
2) Expertise needed: Successful implementation of GISH and FISH requires skilled personnel with expertise in probe preparation, hybridization, and imaging.
3) Time-consuming procedures: The processes involved, including probe labeling and hybridization, can be labor-intensive and time-consuming.
4) High cost: The reagents, probes, and equipment required for these techniques can be expensive, limiting their use in resource-constrained settings.
5) Limited resolution: While effective for many applications, these techniques may not detect very small DNA sequences or subtle chromosomal changes.
6) Potential for non-specific binding: Background noise and non-specific probe binding can sometimes interfere with the accuracy of results.

Conclusion

GISH and FISH technologies have transformed the field of cytogenetics, providing powerful tools for studying genome structure, function, and evolution. Their applications in genetic research, clinical diagnostics, and breeding programs have made them indispensable in modern biotechnology. While these techniques have certain limitations, ongoing advancements in probe design, imaging technologies, and automation are addressing these challenges, making them more accessible and efficient. As our understanding of genomes continues to grow, GISH and FISH will remain at the forefront of genetic and genomic research, driving innovations in science and medicine.

References

Smith, J.D. *et al*. (2023). Advances in FISH Technology. Nature Methods, 20(1), 23-35.

Johnson, M.K. (2022). GISH Applications in Plant Breeding. Plant Cell, 34(2), 145-160.

Williams, R.B. *et al*. (2023). Clinical Applications of FISH. Journal of Clinical Genetics, 15(3), 78-92.

Brown, A.C. (2021). Evolution of Cytogenetic Techniques. Chromosome Research, 29(4), 201-215.

Davis, P.M. *et al*. (2023). Modern Approaches in Molecular Cytogenetics. Biotechnology Advances, 41(5), 312-328.

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HERBAL STATE BEVERAGES: EXPLORING THEIR MEDICINAL BENEFITS AND EXTRACTION TECHNIQUES

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Abstract

Herbal drinks are essential to natural health practices because they are full of bioactive components derived from medicinal herbs. Their cultural, nutritional, and therapeutic importance is examined in this study, along with preparation techniques such decoctions, infusions, Maceration and percolation creative ways to improve flavour and effectiveness. Additionally, it investigates both conventional and modern extraction procedures, such as UAE and MAE, to optimize the yield and bioavailability of active components. Through the integration of scientific discoveries and traditional wisdom, this study highlights the holistic benefits of herbal beverages and encourages sustainable manufacturing methods.

Keywords: UAE (Ultrasound-Assisted Extraction), MAE (Microwave-Assisted Extraction), SMPB (State Medicinal Plants Board), MPs (Medicinal plants), Herbal beverages, infusion, decoction, maceration.

Introduction

The predominantly hilly area was divided from the state of Uttar Pradesh on November 9, 2000, creating the state of Uttarakhand in northwestern India. 13 districts make up the state, which has a total area of 53,483 square kilometres. Uttarakhand is largely covered by forests, making up over 66% of the total land area. There are eight types of forests in the state. The traditional medical system in the state uses about 700 different types of medicinal plants. There is also an abundance of traditional knowledge in the state about how to use these plants. The State Forest Department is responsible for managing around 70% of the state's forest land. Guidelines for sustainable and ecological exploitation are provided by Working Plans, which govern the management of these forests. Local people also administer certain forest areas through Van Panchayats. As revised in 2005, the Uttaranchal Panchayati Forest Rules, 2001, serve as the guidelines for the Van Panchayats' operations in Uttarakhand. Currently, Uttarakhand has 12,089 Van Panchayats in charge of 5,241 square kilo meters of forests. Approximately 8,000 medicinal plants found in India's natural forests serve as the main source of healthcare for 60–80% of the population, especially the unemployed in rural areas. The harvesting of these resources is still unsustainable, and efforts to ensure their equal usage are mainly insufficient. There are 17000–18,000 flowering plant species in India, with 15 agroclimatic zones. Of these, 6000–7000 is thought to have therapeutic uses in both traditional and established medical systems, including Ayurveda, Siddha, Unani, and homeopathy. It is estimated that 960 species of medicinal plants are traded, 178 of which are consumed at levels exceeding 100 metric tons annually. Medicinal plants serve as a vital resource for traditional medicine and the herbal industry while also supporting livelihoods and promoting health security for a significant portion of India's population. The herbal trade is worth US$ 120 billion and is predicted to grow to US$ 7 trillion by 2050 due to the global revival of traditional and alternative health care systems. India now has a very small part of global trade [1].

The medicinal plants (MPs) and their traditional applications are abundant in India. Many nations use these plants for therapeutic purposes and to make herbal beverages. Since ancient times, plants have been a major source of therapeutic chemical compounds and have been essential to preserving human health. Uttarakhand is well known for its abundant medicinal plant resources, which are enriched by the state's varied soil, topography, and climate. This diversity has led to the emergence of several medicinal herbs with significant therapeutic potential, making them both valuable and economically important. These plants are widely used to treat various disorders and are extensively employed by the pharmaceutical industry to develop drugs for the Indian System of Medicine, in addition to being used by the food sector to make herbal beverages [2].

Uttarakhand, often called "Dev Bhoomi," is a Himalayan region rich in medicinal plants, traditional medical knowledge, and stunning natural landscapes, where medicinal plants have historically been a vital source of nutrition and medicine for humanity [3,4]. Medicinal plants are widely recognized for their ability to effectively treat a variety of illnesses and are among the most significant elements of the Himalayan forests [5]. Ancient Indian scriptures, including the Rigveda, Atharvaveda, and Charaka Samhita, highlight the numerous benefits of the plants found in the Himalayan region [6]. Since there are no negative side effects, unlike with allopathic medication, most populations in rural and suburban areas of India and the rest of the world still use various plant components, such as roots, stems, leaves, etc., directly as traditional medicine or herbal drinks [7]. The World Health Organization (WHO) reports that 80% of people worldwide still use traditional medicines [8,9]. Plants are a rich natural source of alkaloids, flavonoids, phenols, chalcones, coumarins, lignans, polyketides, alkanes, alkenes, alkynes, simple aromatics, peptides, terpenes, and steroids, all of which possess significant therapeutic potential [10,11]. Phytomedicines play a vital role in healthcare systems across developing countries, including India [12,13].

Herbal beverages

Herbal beverages are made from natural plant materials, such as leaves, stems, roots, fruits, buds, and flowers [14]. Herbal beverages have long been utilized by the elderly and ancient wisdom as treatments; in many nations where, traditional medicines are widely employed, like China, India, Sri Lanka, Indonesia, Malaysia, and others, these drinks are an essential part of the cuisine and culture [15]. The physical and chemical qualities of herbal drinks can be separated into two categories. The chemical characteristics of beverages can be ascertained by their mineral content, whereas the physical characteristics, such as colour, turbidity, temperature, taste, Odor, and solid content, can be measured [16]. Herbal drinks, made from single herbs or blends, are often rich in phytochemicals, including flavonoids, phenolic compounds, carotenoids, plant sterols, glucosinolates, alkaloids, polyacetylenes, coumarins, saponins, terpenoids, and various sulfur-containing compounds. The phytochemical properties of herbal drinks vary depending on the plant parts used, such as leaves, flowers, or roots. [17]. Herbal beverages high in phytochemicals also have potential pharmacological advantages for human health. Different herbal drink varieties may have distinct pharmacological characteristics, such as antioxidant properties.
The various herbs used have a variety of effects, including antibacterial, antifungal, and

antimicrobial properties; anti-inflammatory properties; anticancer and antitumor properties; anti-diabetic effects; anti-fertility properties; phytoestrogen and anti-estrogenic deficiency diseases; cardiovascular system effects; wound healing [18,19].The traditional origins of herbal drinks, based on generational knowledge, often result in inconsistent production methods and insufficient sanitation control, which can reduce people's willingness to use them as medicine. Furthermore, the limited research on herbal beverages has contributed to a lack of public awareness and interest in their consumption.

Exploring the Significance of Herbal Drinks:

Over 90% of people in Africa and 70% of people in India turn to herbal medicines to enhance their physical health [20]. Since the development of herbal medicine, herbal drinks have been promoted as one option to promote superior Health. Herbal Drinks are popular all around the world, and their popularity varies by their place of origin. In Africa and Asia, over 80% of people still use herbal treatments as their primary form of healthcare, according to the World Health Organization (WHO). To stay healthy, some populations around the world included herbal drinks in their diet. Because the treatment is reasonable and well-balanced, people are becoming more interested in drinking herbal beverages as a habit. Herbal drinks can be consumed in a variety of preparation types, including herbal tea, herbal infusion, and herbal decoction9 [21,22]. Herbal tea is a widely enjoyed beverage in countries such as China, India, Brazil, and Turkey, known for its health benefits. In Greece and the Eastern Mediterranean region, herbal teas made from flowers are particularly valued for promoting improved circulation, providing warmth and refreshment, aiding in uterine contractions, tightening the vaginal area, supporting digestion, and preventing excessive vaginal discharge [23]. The anti-inflammatory, antioxidant, anti-aging, anti-microbial, phytoestrogenic, and anti-carcinogenic qualities of Kacip Fatimah are used as postpartum drugs and may help safeguard women's reproductive systems. Additionally, kacip fatimah decoction may help prevent increased bone-resorption activity and the decline in bone growth. Additionally, it helps the body lose fat, get rid of bad body Odor, launch milk, overcome stiffness, feeding issues, irregular menstruation, clean up blood from childbirth, and prevent eating disorders, infections, coughing, and illness. Herbs are used in herbal drinks to increase physical strength and combat illness and stress [24,25]. Herbal drinks have gained popularity in the emerging niche market, alongside other well-known beverages, due to their abundant content of natural bioactive compounds [26].

List of Herbs, Plant Components, Preparation Techniques, and Applications

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
1	*Abelmoschus esculentus (L.)*	Malvaceae	Under-Shrub	Root	Juice	Leucorrhea
2	*Abutilon indicum (L.)*	Malvaceae	Under-shrub	Leaf	Oral	Piles
3	*Acacia catechu (L.f)*	Fabaceae	Tree	Bark	Ash, water extract	Nasal sinus, diabetes
4	*Achyranthes aspera L.*	Amaranthaceae	Under-shrub	Whole plant	Juice, paste, powder, garland, pounded, oil, chewing, oral, external	Joint pain/arthritis, toothache, ear and throat diseases, jaundice, epilepsy,

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
						skin disease, menstrual disorder
5	*Achyranthes bidentata*	Amaranthaceae	Under-shrub	Root, leaf	Pounded, paste, chewing decoction, oral, external	Urinary disease, snakebite, women sterility, toothache, boil, worm infestation, umbilicus displacement
6	*Acmella paniculata*	Asteraceae	Herb	Flower root	Decoction, chewing	Fever, toothache
7	*Aconitum ferox*	Ranunculaceae	Herb	Root	Cooked	Joint pain/arthritis
8	*Aconitum heterophyllum*	Ranunculaceae	Herb	Root	Pounded, powder, chewing, decoction, water- soaked, water extract, juice, paste, oral	Stomachache, jaundice, fever, worm infestation, cancer, diabetes, dysentery, tonic, pain
9	*Acorus calamus L.*	Acoraceae	Herb	Leaf, root	Garland paste	Fever, ear and throat diseases
10	*Adiantum capillus-veneris L.*	Pteridaceae	Terrestrial fern	Whole plant	Juice	Mouth ulcer
11	*Adina cordifolia*	Rubiaceae	Tree	Leaf	Juice	Headache, sexual disorders
12	*Aegle marmelos (L.)*	Rutaceae	tree	Fruit	Juice, roasted	Diarrhea, dysentery
13	*Aesculus indica*	Sapindaceae	Tree	Fruit	Paste	Joint pain/arthritis
14	*Ageratina adenophora*	Asteraceae	Herb	Whole plant	Paste, juice	Cuts and wounds, Boil
15	*Ageratum houstonianum*	Asteraceae	Herb	Leaf	Juice paste	Cuts and wounds, scorpion sting
16	*Ajuga integrifolia*	Lamiaceae	Herb	Whole plant	Juice, ash, paste chewing powder	Skin disease, jaundice, nasal sinus, swelling, snakebite, scorpion sting, mouth ulcer, cuts and wounds, diabetes
17	*Allium cepa L.*	Amaryllidaceae	Herb	Bulb	Paste, juice	Snakebite, boil, ulcer, diarrhea, dysentery, ear and throat diseases, fever
18	*Allium sativum L.*	Amaryllidaceae	herb	Leaf, bulb	Juice, paste, oral, external, vegetable	Joint pain/arthritis, cold, piles, ear and throat diseases
19	*Allium stracheyi*	Amaryllidaceae	Herb	Bulb, root	Water extract, vegetable,	Joint pain/arthritis, stomachache,

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
					decoction, juice, pounded, oral	diarrhea, eye disease
20	*Aloe vera (L.)*	Asphodelaceae	Herb	Leaf	Leaf pulp	Joint pain/arthritis, Pain
21	*Amaranthus viridis L.*	Amaranthaceae	Herb	Seed	Powder	Bone fracture
22	*Amomum subulatum Roxb.*	Zingiberaceae	Herb	Fruit	Powder	Piles
23	*Andrographis paniculata*	Acanthaceae	Herb	Leaf	Powder	Joint pain/arthritis
24	*Angelica glauca Edgew.*	Apiaceae	Herb	Whole plant	Chewing, powder, pounded, decoction, water-soaked, juice, paste, oral	Stomachache, jaundice, cough, diarrhea, ear and throat diseases, joint pain/ arthritis, fever, tonic
25	*Apluda mutica L.*	Poaceae	Herb	Root	Juice	Jaundice
26	*Areca catechu L.*	Arecaceae	tree	nut	Powder	Leucorrhea, sexual disorders
27	*Arisaema tortuosum*	Araceae	Herb	Tuber, root	Paste, oral	Chhidral, diabetes
28	*Artemisia nilagirica*	Asteraceae	Under-shrub	Leaf	Paste	Boil, cuts and wounds
29	*Asparagus racemosus Willd.*	Asparagaceae	Climber	Root, whole plant	Juice, oral, powder, decoction, external	Headache, toothache, anemia, veterinary disease, urinary disease, sexual disorders, jaundice
30	*Aucklandia costus*	Asteraceae	Herb	Root, whole plant	Powder, decoction, paste, chewing, water extract, juice	Cough, ear and throat disease, jaundice, eye disease, fever, joint pain/ arthritis, snakebite, dysentery, diarrhea, toothache, stomachache
31	*Azadirachta indica*	Meliaceae	Tree	Leaf, stem bark	Juice, paste	Blood disorder, malaria/ dengue, skin disease, boil, eye disease, jaundice
32	*Baccharoides anthelmintica (L.)*	Asteraceae	Under-shrub	Whole plant seed	Powder, water extract	Stomachache, ear and throat diseases, diarrhea
33	*Bambusa bambos (L.)*	Poaceae	Tree	External peel	Powder	Piles

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
34	*Barleria cristata L.*	Acanthaceae	Under - shrub	Leaf, root	Powder	Hair fall/dandruff
35	*Bauhinia variegata L.*	Fabaceae	Tree	Fruit, flower	Oral	Stomachache, dysentery
36	*Berberis aristata DC.*	Berberidaceae	Shrub	Whole plant	Decoction, paste, powder, water extract	Eye diseases, malaria/ dengue, diabetes, cancer, cough
37	*Berberis asiatica*	Berberidaceae	Shrub	Root, stem, bark	Water extract, juice	Eye disease, Diabetes, Burn, Cuts and wounds, Pain
38	*Bergenia ciliata*	Saxifragaceae	Herb	Root, whole plant	Powder, paste, water, extract, pounded, decoction, juice, chewing, oral	Kidney stones, cuts, and wounds, women sterility, urinary diseases, piles, kidney stone, mouth ulcers, cough, joint pain/ arthritis, diabetes
39	*Beta vulgaris L.*	Amaranthaceae	Herb	Root	Juice	Anemia
40	*Betula utilis D.Don*	Betulaceae	Tree	Stem bark, leaf	Ashes, fomentation	Piles, stomachache
41	*Boerhavia diffusa L.*	Nyctaginaceae	Herb	Root	Juice	Jaundice
42	*Bombax ceiba L.*	Malvaceae	Tree	Stem bark	Powder	Sexual disorders
43	*Boswellia serrata Roxb.*	Burseraceae	Tree	Gum	Paste, oral	Dysentery, diarrhea, cuts, and wounds
44	*Brassica campestris*	Brassicaceae	Herb	Seed	Oil	Joint pain/arthritis, Headache, Jaundice, Boil, Ear and throat diseases, Pain
45	*Cajanus cajan (L.)*	Fabaceae	Shrub	Leaf	Juice	Ear and throat diseases
46	*Calotropis procera*	Apocynaceae	Shrub	Leaf, flower, root, latex	External juice, powder, paste, poultice	Snakebite, joint pain/ arthritis, toothache, nasal sinus, cough, jaundice, pain, boil, scorpion sting

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
47	*Camellia sinensis (L.)*	Theaceae	Small tree or shrub	Leaf	Tea	Dysentery
48	*Cannabis sativa L.*	Cannabaceae	Under-shrub	Leaf, root	Paste, juice, external, oral	Cuts and wounds, boil, headache, headache, diarrhea, dysentery, fever
49	*Capsicum annuum L.*	Solanaceae	Herb	Fruit	Paste, ash	Cuts and wounds, Snakebite
50	*Carica papaya L.*	Caricaceae	tree	Root	Water extract juice	Urinary disease, kidney stone
51	*Carum carvi L.*	Apiaceae	Herb	Seed	Decoction	Cough
52	*Catharanthus roseus (L.)*	Apocynaceae	Herb	Leaf	Juice	Diabetes
53	*Cedrus deodara Roxb.*	Pinaceae	Tree	Stem, oil	Saw dust, oil	Leucorrhea, skin disease, boil, veterinary diseases
54	*Chlorophytum borivilianum*	Asparagaceae	Herb	Root	Powder	Anemia
55	*Cinnamomum camphora (L.)*	Lauraceae	Tree	Exudate	Oral	Mouth ulcer
56	*Cissampelos pareira L.*	Menisperacea e	Climber	Whole plant, root	Paste, powder, oral	Diarrhea, dysentery, snakebite
57	*Citrus maxima (Burm.)*	Rutaceae	Tree	Young buds	Oral	Urinary disease
58	*Citrus medica L.*	Rutaceae	Shrub/s mall tree	Fruit	Juice	Blood pressure, stomachache, Piles
59	*Clitoria ternatea L.*	Fabaceae	Climber	Leaf	Paste	Skin disease
60	*Coccinia grandis (L.)*	Cucurbitaceae	Climber	Root	Paste	Skin disease
61	*Cocos nucifera L.*	Arecaceae	Tree/sm all tree	Fruit	Coconut water	Kidney stone
62	*Colchicum autumnale L.*	Colchicaceae	Herb	Leaf	Powder	Joint pain/arthritis
63	*Colocasia esculenta (L.)*	Araceae	Herb	Rhizom e	Paste	Boil
64	*Coriandrum sativum L.*	Apiaceae	Herb	Leaf, seed	Chewing	Diabetes
65	*Cucumis sativus L.*	Cucurbitaceae	Climber	Tender shoots, fruit, seed	Juice, paste	Fever, urinary disease, urinary disease
66	*Cucurbita pepo L.*	Cucurbitaceae	Climber	Peduncl e	Paste	Poisoning

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
67	*Cullen corylifolium (L.)*	Fabaceae	Under-shrub	Seed oil	Oil	Boil, skin disease
68	*Cuminum cyminum L.*	Apiaceae	Herb	Seed	Powder, tea, decoction	Piles, cough, malaria/ dengue
69	*Curcuma amada Roxb.*	Zingiberaceae	Herb	Rhizome	Powder	Leucorrhea, Bone fracture
70	*Curcuma longa L.*	Zingiberaceae	Herb	Leaf, Rhizome	Powder, paste, decoction	Joint pain/arthritis, skin disease, mouth ulcer, diarrhea, cuts and wounds, dysentery, pain, cough
71	*Curcuma zedoaria*	Zingiberaceae	Herb	Rhizome	Powder	Leucorrhea, sexual disorders
72	*Cuscuta reflexa Roxb.*	Convolvulaceae	Climber	Whole plant	Paste, external	women sterility, hair fall/ dandruff, fever
73	*Cynodon dactylon (L.)*	Poaceae	Herb	Root	Fresh	snakebite
74	*Cyperus rotundus L.*	Cyperaceae	Herb	Root	Paste, external	Urinary disease, hydrocele
75	*Dactylorhiza hatagirea*	Orchidaceae	Herb	Root, whole plant	Powder, juice, paste	Cuts and wounds, anemia, boil, tonic
76	*Dactylorhiza incarnata (L.)*	Orchidaceae	Herb	Root, whole plant	Powder, juice, paste	Headache, joint pain/ arthritis, cuts, and wounds
77	*Datura stramonium L.*	Solanaceae	Shrub	Leaf, fruit	Juice, poultice, ash, external	Headache, joint pain/ arthritis, ear and throat diseases, cough, asthma
78	*Delphinium denudatum*	Ranunculaceae	Herb	Root, whole plant	Paste, powder, water extract, chewing, external pounded	Boil, skin disease, veterinary disease, cuts and wounds, diarrhea, anemia, mouth ulcer, cancer, tonsil
79	*Desmostachya bipinnata (L.)*	Poaceae	Herb	Root	Paste	Worm infestation
80	*Dioscorea bulbifera L.*	Dioscoreaceae	Climber	Tuber, bulbil	Paste, vegetable	Boil, joint pain/arthritis
81	*Echinochloa frumentacea*	Poaceae	Herb	Seed	Bread	Diabetes
82	*Elettaria cardamomum (L.)*	Zingiberaceae	Herb	Fruit	Powder, chewing, decoction	Piles, ear and throat diseases, cough, malaria/

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S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
						dengue
83	*Eleusine coracana (L.)*	Poaceae	Herb	Seed	Flour, bread	Cold, pain, diabetes, bone fracture
84	*Ephedra gerardiana Wall.*	Ephedraceae	Under-shrub	Stem	Chewing	Asthma
85	*Equisetum diffusum D.Don*	Equisetaceae	Terrestrial fern	Whole plant	Decoction, powder	Kidney stone, urinary disorder, kidney stone
86	*Equisetum ramosissimum*	Equisetaceae	Terrestrial fern	Whole plant	Juice, powder	Joint pain/ arthritis, kidney stone
87	*Eucalyptus camaldulensis*	Myrtaceae	Tree	Leaf	Paste	Toothache
88	*Euphorbia heterophylla L.*	Euphorniaceae	Herb	Leaf	Vegetable	Stomachache
89	*Euphorbia hirta L.*	Euphorniaceae	Herb	Whole plant, root	Juice, paste	Diarrhea, snakebite, boil
90	*Falconeria insignis*	Euphorniaceae	Tree	Twig, latex	External	Skin disease, joint pain/ arthritis
91	*Ficus benghalensis L.*	Moraceae	Tree	Bark	Ash	Nasal sinus
92	*Ficus racemosa L.*	Moraceae	Tree	Leaf gall	Paste	Wart
93	*Flacourtia indica*	Salicaaceae	Tree	Stem bark	Water extract	Jaundice
94	*Foeniculum vulgare Mill.*	Apiaceae	Herb	Seed	Oral	Stomachache
95	*Fragaria nubicola*	Rosaceae	Herb	Root, leaf	Decoction, juice, chewing	Cough, fever, tonsil
96	*Fritillaria cirrhosa D.Don*	Liliaceae	Herb	Bulb	Roasted bulb	Cough and cold
97	*Galium aparine L*	Rubiaceae	Herb	Whole plant	Paste	Snakebite, cuts, and wounds
98	*Galium elegans Wall.*	Rubiaceae	Herb	Whole plant	Juice, paste, water extract	Skin disease, boil, diarrhea, snakebite, burn, veterinary diseases, cuts, and wounds
99	*Girardinia diversifolia*	Urticaceae	Under-shrub	Leafy twig	External	Joint pain/arthritis
100	*Gloriosa superba L.*	Colchiaceae	Herb	Root	Paste	Snakebite
101	*Glycine max (L.)*	Fabaceae	Herb	Seed	Water extract	Jaundice, Cough
102	*Glycosmis pentaphylla*	Rutaceae	Shrub	Bark	Juice	Jaundice
103	*Hedychium spicatum Sm.*	Zingiberaceae	Herb	Rhizome	Powder, decoction, juice, oral	Stomachache, malaria/dengue, joint pain/arthritis

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
104	*Helianthus annuus L.*	Asteraceae	Under-Shrub	Seed	Roasted	Jaundice
105	*Helicteres isora L.*	Malvaceae	Shrub	Fruit	Powder	Stomachache
106	*Helinus lanceolatus*	Rhamnaceae	Climber	Root	Chewing	Toothache, mouth ulcer, ear and throat diseases
107	*Hibiscus rosa-sinensis L.*	Malvaceae	Under-Shrub	Leaf, root	Paste	Boil, nasal sinus
108	*Hippophae salicifolia D.Don*	Elaeagnaceae	Tree	Fruit	Decoction, juice, pickles, paste, water extract, oral	Worm infestation, stomachache, vomiting, stutter, cough, diabetes, cancer, joint pain/ arthritis, headache, tonic, veterinary disease
109	*Holarrhena pubescens*	Apocynaceae	Shrub	Leaf, bark	Paste	Worm infestation
110	*Hordeum vulgare L.*	Poaceae	Herb	Seed, flour	Water extract, bread	Ear and throat diseases, diabetes
111	*Ichnocarpus frutescens (L.)*	Apocynaceae	Climber	Root	Powder	Eye disease
112	*Ipomoea carnea*	Convolvulaceae	Shrub	Leaf, flower	Oral, external	Diabetes, boil
113	*Juglans regia L.*	Juglandaceae	Tree	Stem bark	Chewing	Toothache
114	*Justicia adhatoda L.*	Acanthaceae	Shrub	Leaf, root	Decoction, poultice	Cough, joint pain/arthritis
115	*Justicia gendarussa*	Acanthaceae	Shrub	Leaf, bark	Powder, ash, paste	Cough, skin disease, asthma
116	*Kalanchoe pinnata (Lam.)*	Crassulaceae	Under-Shrub	Leaf	Juice	Kidney stone
117	*Kigelia africana (Lam.)*	Bignoniaceae	Tree	Fruit	Powder	Stomachache, kidney stone, asthma
118	*Lablab purpureus (L.)*	Fabaceae	Climber	Leaf, stem	Juice	Skin disease, blood disorder
119	*Lannea coromandelica*	Anacardiaceae	Tree	Leaf	Juice	Snakebite
120	*Lantana indica Roxb.*	Verbenaceae	Shrub	Leaf	Juice	Cuts and wounds
121	*Launaea procumbens (Roxb.)*	Asteraceae	Herb	Whole plant	External	Snakebite
122	*Leucas aspera (Willd.)*	Lamiaceae	Herb	Whole plant	Decoction	Fever
123	*Leucas cephalotes (Roth)*	Lamiaceae	Herb	Leaf	Decoction, powder	Umbilicus displacement, Skin disease

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
124	*Lindenbergia indica (L.)*	Orobanchaceae	Herb	Leaf	Paste	Skin disease
125	*Linum usitatissimum L.*	Linaceae	Under-Shrub	Seed	Roasted, powder, paste	Joint pain/ arthritis, Bone fracture,
126	*Litsea glutinosa (Lour.)*	Lauraceae	Tree	Bark	Paste, powder	Bone fracture, joint pain/ arthritis
127	*Luffa cylindrica (L.)*	Cucurbitaceae	Climber	Fruit, whole plant	Smelling, powder	Jaundice
128	*Macrotyloma biflorum*	Fabaceae	Climber	Seed	Water extract, decoction	Kidney stone, jaundice
129	*Malva neglecta Wallr.*	Malvaceae	Herb	Root	Paste	Skin disease
130	*Malva pusilla Sm.*	Malvaceae	Herb	Whole plant	Oral	Veterinary disease
131	*Marchantia polymorpha L.*	Marchantiaceae	Herb	Whole plant	External	Skin disease
132	*Martynia annua L.*	Martyniaceae	Under-Shrub	leaf	Paste	Hydrocele
133	*Matricaria chamomilla L.*	Asteraceae	Herb	Leaf	Decoction	Leucorrhea, menstrual disorder
134	*Melaleuca viminalis*	Myrtaceae	Tree	Root	Paste	Burn
135	*Melia azedarach L.*	Meliaceae	Herb	Whole plant	Decoction	Diabetes
136	*Mentha arvensis L.*	Lamiaceae		Whole plant, leaf	Juice, fresh, paste, chewing	Cuts and wounds, stomachache, diarrhea, vomiting
137	*Mentha spicata L.*	Lamiaceae	Herb	Leaf	Paste	Cuts and wounds
138	*Mesua ferrea L.*	Calophyllaceae	Tree	Flower	Oral	Piles
139	*Mimosa pudica L.*	Fabaceae	Under-Shrub	Whole plant	Powder	Bone fracture
140	*Mirabilis jalapa L.*	Nyctaginaceae	Under-Shrub	leaf	Paste	Boil, skin disease
141	*Momordica charantia L.*	Cucurbitaceae	Climber	Leaf, fruit	Decoction, juice	Fever, malaria/dengue
142	*Moringa oleifera Lam.*	Moringaceae	Tree	Fruit	Vegetable	Leucorrhoea
143	*Morus alba L.*	Moraceae	Tree	Fruit, stem	Juice, water extract	Diabetes
144	*Murraya koenigii (L.)*	Rutaceae	Shrub	Root	Paste	Boil
145	*Musa × paradisiaca L.*	Musaceae	Tree-like-Herb	Whole plant	Juice, oral, ash	Ear and throat diseases, diarrhea, tonsil, cough,

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
						asthma, sexual disorders
146	*Myrica esculenta*	Myricaceae	Tree	Bark	Powder	Bone fracture
147	*Myristica fragrans Houtt.*	Myristicaceae	Tree	Fruit	Powder	Bone fracture
148	*Nardostachys jatamansi (D.Don)*	Caprifoliaacea e	Herb	Root	Water extract, powder, ash, oil	Stomachache, toothache, joint pain/arthritis, hair fall/dandruff
149	*Nicotiana tabacum L.*	Solanaceae	Under-Shrub	Steam, leaf	Juice, paste	Ear and throat diseases, boil
150	*Ocimum tenuiflorum L.*	Lamiaceae	Under-Shrub	Leaf	Decoction, powder, tea, juice	Cough, fever, nasal sinus, ear and throat diseases
151	*Ophiocordyceps sinensis (Berk.)*	Ophiocordycip itaceae	Saprophy tic fungi	Whole plant	Powder	Sexual disorder, tonic, asthma
152	*Origanum vulgare L.*	Lamiaceae	Herb	Leaf, seed	Powder, decoction	Kidney stone, cough
153	*Oroxylum indicum (L.)*	Bignoniaceae	Tree	Seed	Powder	Stomachache
154	*Oryza sativa L.*	Poaceae	Herb	Young shoots, seed	Powder, chewing	Nasal sinus, mouth ulcer
155	*Ouret lanata (L.)*	Amaranthacea e	Under-Shrub	Root	Chewing	Toothache
156	*Oxalis corniculata L.*	Oxalidaceae	Herb	Leaf, root, whole plant	Juice, chewing	Body heat, ear and throat diseases, stomachache, sexual disorders
157	*Paederia foetida L.*	Rubiaceae	Climber	Leaf, root	Powder, paste	Stomachache, vomiting, jaundice
158	*Paeonia emodi Royle*	Paeoniaceae	Shrub	Leaf	Powder, vegetable, cake	Piles, stomachache, diarrhea
159	*Papaver somniferum L.*	Papaveraceae	Herb	Fruit, exudate	Paste	Dysentery, joint pain/ arthritis
160	*Paris polyphylla Sm.*	Melanthiacea e	Herb	Root	Decoction, paste, powder	Cuts and wounds, boil, stomachache
161	*Phanera retusa Benth.*	Fabaceae	Tree	Bark, root	Paste, chewing	Rickets, placenta, joint pain/ arthritis, veterinary disease, toothache

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
162	*Pholidota articulata Lindl.*	Orchidaceae	Herb	Whole plant	Paste	Bone fracture
163	*Phyllanthus amarus*	Phyllanthaceae	Herb	Whole plant	Decoction	Fever, malaria/dengue
164	*Phyllanthus emblica L.*	Phyllanthaceae	Tree	Fruit	Powder, fruit pulp	Piles, leucorrhea, burn, cuts and wounds, pain, cough, asthma
165	*Picrorhiza kurroa Royle*	Plantaginacaea	Herb	Root, seed	Decoction, juice, water extract, paste, chewing, powder	Malaria/dengue, cough,fever, jaundice, diabetes, urinary disease,
166	*Pinus roxburghii Sarg.*	Pinaceae	Tree	Oil, resin	Oil, resin, external	Pain, ear and throat diseases, bone fracture, cuts, and wounds
167	*Piper longum L.*	Piperaceae	Climber	Fruit, whole plant	Tea, powder paste, decoction	Cough, joint pain/ Arthritis, snakebite, Headache, Malaria/dengue
168	*Piper nigrum L.*	Piperaceae	Climber	Fruit,	Powder, tea, decoction, paste	Cough, kidney stone, ear and throat diseases, snakebite, scorpion sting, vomiting
169	*Pleurospermum angelicoides*	Apiaceae	Herb	Stem	Powder	Stomachache
170	*Plumbago zeylanica L.*	Plumbaginaceae	Under-Shrub	Stem, root bark	Paste	Joint pain/arthritis
171	*Podophyllum hexandrum*	Berberidaceae	Herb	Stem, root	Decoction, paste, juice, water extract	Cancer, fever, skin disease
172	*Pongamia pinnata (L.)*	Fabaceae	Tree	Leaf	Paste	Skin disease
173	*Potentilla indica*	Rosaceae	Herb	Whole plant	Decoction	Cough
174	*Potentilla lineata Trevir.*	Rosaceae	Herb	Root	Chewing gum	Mouth ulcer, toothache, ear and throat disease
175	*Potentilla sundaica*	Rosaceae	Herb	Leaf	Chewing	Ear and throat diseases
176	*Prinsepia utilis*	Rosaceae	Shrub	Leaf	Chewing	Snakebite, ear and throat diseases
177	*Prunus amygdalus*	Rosaceae	Tree	Seed	Powder	Joint pain/ arthritis
178	*Prunus armeniaca L.*	Rosaceae	Tree	Leaf, oil	Paste, oil	Cuts and wounds, joint

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
						pain/ arthritis
179	*Prunus cerasoides*	Rosaceae	Tree	Bark, oil	Paste, oil	Bone fracture, joint pain/ arthritis
180	*Psidium guajava L.*	Myrtaceae	Tree	Bud, leaf, fruit	Roasted	Cough, stomachache
181	*Pterocarpus santalinus L.f.*	Fabaceae	Tree	Wood	Decoction	Fever
182	*Pueraria tuberosa Roxb.*	Fabaceae	Climber	Root	Powder	Stomachache
183	*Punica granatum L.*	Lythraceae	Tree	Fruit peel, bud, seed	External, oral, decoction	Cuts and wounds, piles, cough, mouth ulcer
184	*Quercus oblongata D.Don*	Fagaceae	Tree	Rind	Paste	Scorpion sting
185	*Ranunculus distans D.Don*	Ranunculaaceae	Herb	Root	Paste	Boil
186	*Raphanus raphanistrum*	Brassicaceae	Herb	Root, whole plant	Oral	Jaundice
187	*Rauvolfia serpentina (L.)*	Apocynaceae	Herb	Root,	Powder	Fever
188	*Rheum australe D.Don*	Polygonaceae	Herb	Root, whole plant	Paste, juice, fomentation, decoction, powder	Cuts and wounds, anemia, blood clotting, fever, mouth ulcer, bone fracture, swelling, pain, joint pain/arthritis, cough, boil
189	*Rhododendron arboreum*	Ericaceae	Tree	Leaf	Decoction	Dysentery
190	*Ricinus communis L.*	Euphorbiaceae	Tree	Seed oil, leaf	Oil, poultice	Joint pain/arthritis
191	*Rosa indica L.*	Rosaceae	Shrub	Flower	Water extract, external	Eye disease, chest pain, boil
192	*Roscoea purpurea Sm.*	Zingiberaceae	Herb	Root	Chewing, external	Toothache, stomachache, skin disease
193	*Roylea cinerea (D.Don)*	Lamiacea	Shrub	Whole plant	Decoction	Fever, malaria/dengue, diabetes
193	*Rubia cordifolia L.*	Rubiaceae	Climber	Root	Paste, decoction, external	Headache, boil, hair fall/ dandruff, skin disease

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
194	*Rubia manjith Roxb.*	Rubiaceae	Climber	Leaf, root	Decoction, juice	Skin disease, ear and throat diseases, eye disease,
195	*Rubus ellipticus Sm.*	Rosaceae	Shrub	Root	oral	Stomachache
196	*Rubus paniculatus Sm.*	Rosaceae	Climber	Root	Chewing, decoction	Cough, mouth ulcer, fever, ear and throat diseases
197	*Rumex hastatus D. Don*	Polygonaceae	Under-Shrub	Root	Powder, paste, juice	Jaundice, boil, snakebite, headache
198	*Saccharum officinarum L.*	Poaceae	Under-Shrub	Seed, stem	Decoction, tea, cooked, Juice	Dysentery, cough, jaundice, sexual disorders, eye disease
199	*Santalum album L.*	Santalaceae	Tree	Wood	Powder	Nasal sinus, boil, skin disease
200	*Sapindus mukorossi*	Sapindaceae	Tree	Seed	Water extract	Ear and throat diseases
201	*Sauromatum venosum*	Araceae	Herb	Whole plant, tuber	Paste	Snakebite
202	*Saussurea obvallata (DC.)*	Asteraceae	Herb	Root, flower, leaf, seed	Decoction, water extract, fresh	Skin disease, fever, anemia, jaundice, joint pain/ arthritis, asthma
203	*Senna tora (L.) Roxb.*	Fabaceae	Herb	Seed	Powder	Snakebite
204	*Sesamum indicum L.*	Pedaliaceae	Herb	Seed	Juice, oil	Diarrhea, dysentery, joint pain/ arthritis, ear and throat diseases
205	*Shorea robusta*	Dipterocarpaceae	Tree	Bark	Paste	Boil
206	*Sida cordifolia L.*	Malvaceae	Under-Shrub	Root	Paste	Boil
207	*Sigesbeckia orientalis L.*	Asteraceae	Under-Shrub	Leaf	Paste	Honey bee sting
208	*Solanum nigrum L.*	Solanaceae	Herb	Leaf	Juice	Ear and throat diseases, headache
209	*Solanum torvum Sw.*	Solanaceae	Under-Shrub	Leaf	Juice	Sexual disorders
210	*Solanum virginianum L.*	Solanaceae	Under-Shrub	Seed, whole plant	Paste, smoking	Toothache
211	*Sonchus asper (L.)*	Asteraceae	Herb	Flower	Decoction, oral	Jaundice
212	*Stevia rebaudiana*	Asteraceae	Herb	Leaf	Chewing	Diabetes

S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
213	*Swertia chirayita (Roxb.)*	Gentianaceae	Herb	Whole plant	Decoction, powder, juice, water extract, paste	Fever, jaundice, urinary disease, headache, diabetes, stomachache, joint pain/ arthritis, cough, asthma, boil
214	*Syzygium aromaticum (L.)*	Myrtaceae	Tree	Fruit	Decoction, chewing, external	Cough, toothache, ear and throat diseases, malaria/ dengue, hydrocele
215	*Syzygium cumini (L.)*	Myrtaceae	Tree	Seed, fruit peel	Juice, powder, vinegar	Menstrual disorder, diabetes
216	*Tagetes erecta L.*	Asteraceae	Herb	Leaf, stem, flower	Juice, paste	Eye disease, ear and throat diseases, skin disease, toothache
217	*Tagetes minuta L.*	Asteraceae	Herb	Flower	Fragrance	Headache
218	*Taxus wallichiana Zucc.*	Taxaceae	Tree	Whole plant, oil	Decoction, oil, powder, tea	Asthma, cancer, blood pressure
219	*Terminalia arjuna Roxb.*	Combretaceae	Tree	Bark	Decoction	Cardiac disorders, stomachache
220	*Terminalia bellirica*	Combretaceae	Tree	Fruit, bark, root	Powder, chewing, paste, decoction	Stomachache, cough, veterinary disease, malaria/ dengue, asthma
221	*Terminalia chebula Retz.*	Combretaceae	Tree	Fruit	Powder, decoction, chewing	Stomachache, joint pain/ arthritis, cough, piles, malaria/dengue, asthma, fever, headache,
222	*Thalictrum foliolosum DC.*	Ranunculaceae	Under-Shrub	Whole plant	Juice	Snakebite
223	*Thysanolaena latifolia*	Poaceae	Herb	Root	Juice	Stomachache
224	*Tinospora cordifolia*	Menispermaceae	Climer	Stem	Juice, powder, decoction, water extract	Fever, stomachache, jaundice, malaria/dengue, diabetes, burn, cuts and wounds, pain, piles, joint pain/arthritis, urinary disease, headache, cough

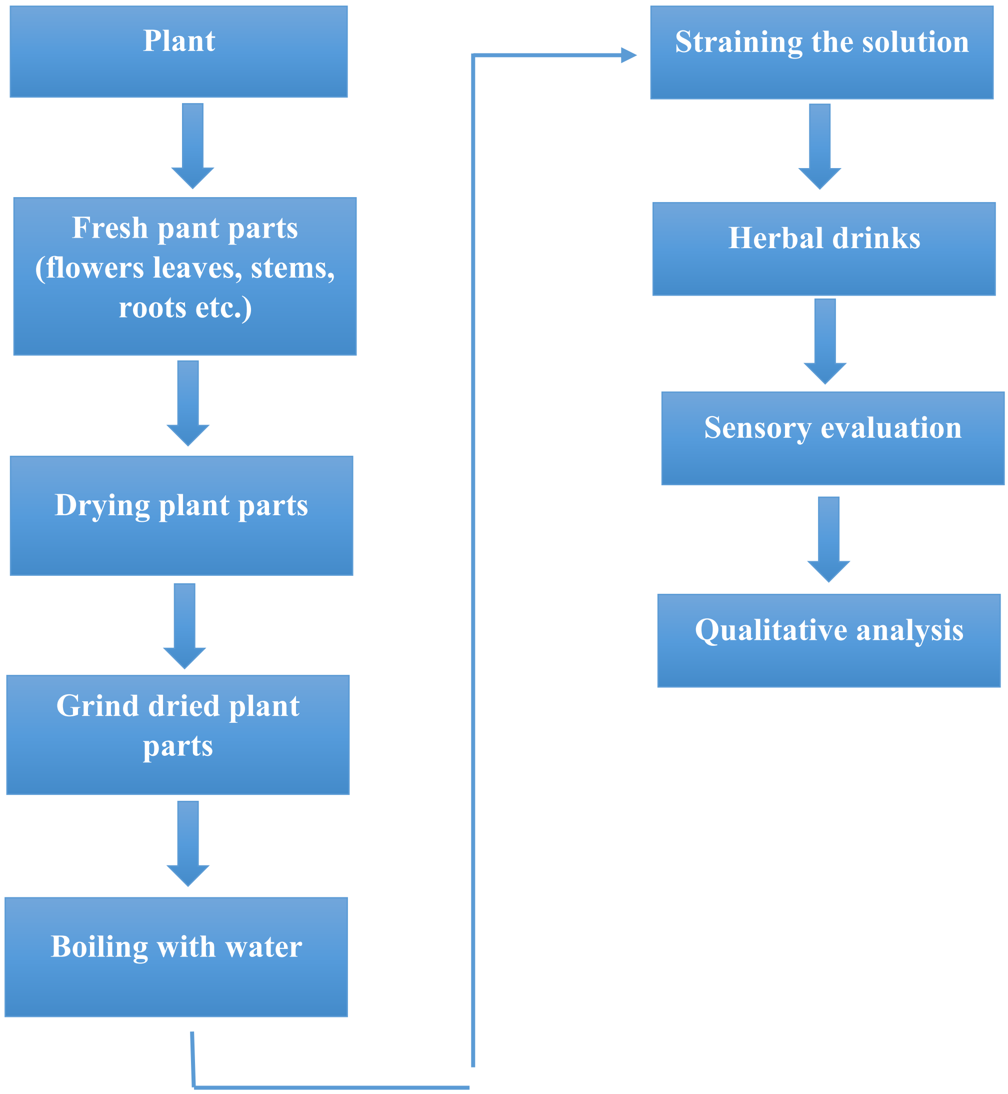
S. No	Plants Name	Family	Habit	Plant part used	Mode of Preparation/ Administration	Uses
225	*Trachyspermum ammi (L.)*	Apiaceae	Herb	Seed	Powder, decoction, water extract	Joint pain/arthritis, stomachache, cough
226	*Tribulus terrestris L.*	Zygophyllaceae	Herb	Fruit	Powder, decoction	Urinary diseases
227	*Trigonella foenum-graecum L.*	Fabaceae	Herb	Seed	Powder	Joint pain/ arthritis, stomachache, diabetes
228	*Urtica ardens*	Urticaceae	Under-Shrub	Leafy twig, root	Chewing, paste, external	Toothache, worm infestation, boil, headache, joint pain/arthritis
229	*Urtica dioica L.*	Urticaceae	Under-Shrub	Leafy twig	External	Cold, headache, paralysis, joint pain/arthritis
230	*Viola odorata L.*	Violaceae	Herb	Whole plant	Decoction, Paste, Oral	Cough, malaria/dengue, sexual disorders, boil, cuts, and wounds
231	*Vitex negundo L.*	Lamiaceae	Shrub	Leaf	Juice	Malaria/dengue
232	*Vitis vinifera L.*	Vitaceae	Climber	Fruit	Powder, oral	Joint pain/arthritis, epilepsy
233	*Withania somnifera (L.)*	Solanaceae	Shrub	Root	Powder	Joint pain/arthritis, anemia
234	*Xanthium strumarium L.*	Asteraceae	Herb	Fruit	Juice	Joint pain/arthritis
235	*Zanthoxylum armatum DC.*	Rutaceae	Shrub	Leaf, seed, fruit	Decoction, chewing	Cough, toothache, cold, asthma, stomachache
236	*Zea mays L.*	Poaceae	Under-Shrub	Cob axis, seed	Ash, flour	Cough, Diarrhea
237	*Zingiber officinale*	Zingiberaceae	Herb	Leaf, rhizome	Powder, decoction, paste, tea, juice, oral	Stomachache, cough, dysentery, eye disease, ear and throat diseases, headache

Source: Balkrishna et al. [41]

Preparation of Herbal Beverages:

Herbal beverages made from different plant parts, such as leaves, stems, roots, fruits, buds, and flowers, are known as herbal drinks [27]. The majority of herbs, such as ginseng, turmeric, ginger, Aronia, coriander, fennel seed, cinnamon, cardamom, guarana, black pepper, nutmeg, and chili, are utilized in beverages. According to recent research, herbal teas prepared from plants such as red clover, ginger root, chamomile, peppermint, Echinacea, parsley, rosehip, chrysanthemum, and others have a high nutritional content and may help treat illnesses [28]. A variety of plants or just one herb can be used in herbal beverages. Different herbal mixes in the beverage will support a number of health benefits, including energizing, relaxing, and improving appearance. The preparation of the herbal drink is based on the traditions and its intended use [29]. The flavour and health benefits of herbal beverages are derived from a blend of botanical materials, including dried leaves, seeds, grasses, nuts, barks, fruits, and flowers. Herbs can be steeped for five to fifteen minutes in hot water to create an infusion. The necessary quantity of herbs (crush or grind the entire root, bark, and seeds) is boiled with water for about 30 minutes, or until about half of the water has evaporated, to create the herbal decoction, which can be stored for two to three days. Among the herbs used in decoctions are bai hu tang (white tiger decoction) and ba zhen tang (eight treasure decoction) [30,31].

Flowchart for the Preparation of Herbal Beverages:



Exploring Conventional and Unconventional Methods of Herbal Extraction:

Herbal extracts are a vital source of bioactive compounds that play a key role in promoting human health. To effectively serve as a medicinal beverage, these extracts must be prepared with care, considering various factors. Typically, medicinal and aromatic plants are air-dried in the shade before extraction, though fresh plant material may sometimes be used. Depending on the plant part, the material is either cut into pieces, ground into powder (for harder parts like roots, stems, rhizomes, or dried fruits), or lightly crushed and used as is (for softer parts like leaves and flowers). The extraction process may be followed by additional steps such as filtration, concentration, or drying. In order to extract and identify the bioactive components of medicinal plants, as well as other things, the extraction process used is crucial. Natural components derived from plants can be found in any part of the plant, including the stem, bark, leaves, flowers, roots, rhizomes, fruits, seeds, and more. Currently, a number of techniques are used in practice to extract and separate biologically active chemicals from plant sources [32]. No single technique is currently accepted as the standard for removing bioactive chemicals from plants, despite the development and optimization of numerous innovative techniques over time in addition to the conventional and straightforward ways. The key input factors primarily determine the effectiveness of both traditional and unconventional extraction techniques [33]. Key factors that influence the extraction process include the duration of extraction, the type of solvent used, solvent pH, temperature, particle size of plant tissues, and the solvent-to-sample ratio. The effectiveness of herbal extracts can also be affected by the nature of the plant material, its origin, the level of processing, moisture content, and particle size.

- **Crushing:** The preparation of plant material and optimization of the final solution are two important technological phases in the extraction of medicinal herbs. Crushing is performed to disrupt plant organs, tissues, and cell structures so that the constituent materials can be exposed to the extraction solvent more effectively. Stated differently, the primary objective of the process is to maximize surface area, which will improve the transfer of active chemicals from plant material to the solvent.
- **Filtration:** The technological stage that follows extraction is called filtration. The resulting solution is passed through many layers of cheesecloth or specifically made filters, either with or without the use of a vacuum pump, to remove the vegetal remains (exhausted plant material).
- **Concentration:** The process of concentration is carried out under vacuum to create a thick concentrated extract, which is then dried to create a solid mass devoid of solvent. A diluted version of the concentrated solution that is produced will be utilized.

1. **Conventional Extraction Methods:**
   Most of these techniques depends on the extraction capabilities of various solvents, heat application, and/or mixing. Currently used conventional techniques, often known as solvent-based techniques, to extract bioactive chemicals from plants are considered to be:
   1.1. Infusion.
   1.2. Decoction.
   1.3. Maceration.
   1.4. Percolation.
   1.5. Soxhlet extraction.

1.1. Procedure for Preparing Herbal Infusions:

i. ***Select Plant Material:*** Choose plant parts with thin cell walls, such as flowers, leaves, young stems, or some fruits. Ensure the plant material is pre-crushed to improve extraction.

ii. ***Add Water:*** Add either boiling water or cold water to the crushed plant material, depending on the desired extraction method.
iii. ***Boil the Mixture:*** If using boiling water, heat the mixture and allow it to boil for a short time to release the soluble compounds. If using cold water, proceed to the next step without boiling.
iv. ***Cover and Steep***: Once the mixture is boiling, cover the container and let it sit at room temperature for 10-15 minutes. Shake the mixture occasionally to enhance the extraction process.
v. ***Filter the Infusion:*** After steeping, filter the mixture to remove the solid plant material, leaving behind the infused liquid.
vi. ***Storage:*** The resulting infusion is a dilute solution of the plant's soluble compounds. It should be kept cool and used within 12 hours to prevent bacterial growth.
vii. ***Usage:*** Infusions are best prepared fresh and used as needed for therapeutic or medicinal purposes.

1.2. Procedure for Preparing Herbal Decoction:

i. ***Select Plant Material:*** Choose plant parts with thicker membranes, such as roots, rhizomes, bark, stems, hard fruits, and seeds. Decoctions are also suitable for flowers, leaves, and fruits, particularly when extracting volatile oils.
ii. ***Prepare the Plant Material***: Chop the plant material into smaller pieces to facilitate extraction.
iii. ***Add Water***: Measure the correct amount of water, typically a 1:4 ratio of plant material to water (1 part plant to 4 parts water).
iv. ***Boil the Mixture***: Place the chopped plant material and water into a pot and bring it to a boil. Allow the mixture to continue boiling.
v. ***Reduce the Volume***: Boil the mixture until the volume is reduced to one-fourth of its original amount, concentrating the active compounds in the solution.
vi. ***Filter the Decoction***: Once the boiling is complete, filter the hot liquid to remove the solid plant material.
vii. ***Wash the Residue***: Rinse the plant residue with water to extract any remaining soluble compounds.
viii. ***Adjust the Volume***: Add water to the filtered liquid to bring it back to the original volume.
ix. ***Storage:*** The decoction can be used immediately or stored in the refrigerator. It should be consumed within 24 hours of preparation to ensure its effectiveness.
x. ***Usage:*** Use the decoction as needed for medicinal purposes, ensuring it remains refrigerated if not used right away.

1.3. Procedure for Preparing Herbal Extracts through Maceration:

i. ***Prepare Plant Material:*** Chop the plant material (roots, stems, leaves, flowers, or seeds) into small pieces, ensuring it is suitable for cold extraction.
ii. ***Choose the Solvent:*** Select the appropriate solvent for extraction, which could be water, a water-alcohol mixture, or other solvents like oil, wine, or vinegar, depending on the intended use. A typical ratio is 1 part plant material to 10 parts solvent (1:10 g:vol).

iii. ***Combine Plant Material and Solvent:*** Place the chopped plant material in a container and add the solvent, ensuring it fully covers the plant material.
iv. ***Allow to Macerate***: Let the mixture sit at room temperature for a specified period, which can range from several hours to a few days. Shake the container occasionally to facilitate the extraction of active compounds.
v. ***Filter the Extract***: Once the extraction time is complete, filter the mixture to separate the plant material from the liquid extract. This can be done using a regular filter or a Buckner funnel under vacuum for better efficiency.
vi. ***Store the Extract:*** The resulting extract can be stored in a clean, airtight container. If alcohol was used, the extract can be used as an alcoholic solution or for further processing.
vii. ***Optional Digestion Step***: For some extractions, gentle heat may be applied during the maceration process to create a form of maceration called digestion. This method is suitable when moderate heat is acceptable for the plant material and the compounds being extracted.
viii. ***Use the Extract***: The filtered and stored extract can now be used for its intended purpose, whether for medicinal, cosmetic, or other applications.

1.4. Procedure for Preparing Herbal Extracts by Percolation:

i. ***Prepare Plant Material:*** Select and prepare the plant material to be extracted, ensuring it is appropriately cut or ground into smaller pieces. The usual ratio of plant material to solvent is 10:1.
ii. ***Moisten Plant Material:*** Moisten the solid plant material with the appropriate amount of solvent, typically 50% or 70% ethyl alcohol, to start the maceration process. Allow the mixture to sit in a sealed container for 4–12 hours.
iii. ***Set Up Percolator:*** Prepare the percolator column, which should be about 40–50 mm in diameter. Ensure the column is clean and ready for the extraction process.
iv. ***Add the Solvent:*** After maceration, transfer the moistened plant material into the percolator column. Begin adding the solvent slowly, maintaining a flow rate of 30–50 mL per hour.
v. ***Continue Percolation:*** Allow the solvent to pass through the column, extracting the bioactive compounds from the plant material. As needed, add more solvent to ensure continuous extraction.
vi. ***Collect the Percolate:*** Collect the percolate (extracted liquid) until it reaches about three-quarters of the required volume of the final product.
vii. ***Concentrate the Percolate:*** To concentrate the extract, remove the solvent under reduced pressure, ensuring that the temperature does not exceed 50°C to preserve the bioactive compounds. This will result in a hydroalcoholic or aqueous solution.
viii. ***Complete the Extraction:*** For a more thorough extraction, use a "battery" of two to three percolator columns to fully exhaust the plant material, ensuring maximum yield of active compounds.
ix. ***Final Product:*** Once extraction is complete and the solvent has been concentrated, the final herbal extract is ready for use, typically in the form of tinctures or fluid extracts.

1.5. Procedure for Preparing Herbal Extracts by Soxhlet Extraction [34]:

i. ***Prepare Plant Material:*** Grind the plant material into a fine powder to increase the surface area and facilitate better extraction.
ii. ***Set Up the Soxhlet Extractor***: Place the ground plant material into the thimble or cartridge of the Soxhlet extractor. Attach the extractor to the condenser and solvent flask, ensuring all parts are securely connected.
iii. ***Choose the Solvent***: Select the appropriate solvent based on the desired extract. For functional and medicinal beverages, water or ethyl alcohol is typically recommended.
iv. ***Start the Extraction Process***: Fill the solvent flask with the chosen solvent and heat it. As the solvent vaporizes, it condenses in the condenser and repeatedly contacts the plant material, dissolving the active components.
v. ***Recycling of Solvent***: With each cycle, the solvent enriches itself with the extracted compounds. This continuous process of solvent evaporation and condensation allows for thorough extraction of bioactive compounds.
vi. ***Monitor Extraction Time***: Depending on the type of extract, the extraction time may vary. For aqueous extractions, the process typically lasts up to 30 minutes. For alcoholic extractions, it may take up to 10 days. For aqueous solutions, the extraction time can be extended to 6 hours in some cases.
vii. ***Stop Heating and Cool***: Once the extraction is complete, stop the heating process. Allow the plant material to cool while the water circulation in the condenser continues to maintain temperature regulation.
viii. ***Remove and Dry the Plant Material***: After cooling, remove the thimble containing the extracted plant material. Dry it and weigh it to determine the amount of extracted material.
ix. ***Prepare the Extract***: If necessary, the resulting extract can be further processed or diluted to the desired concentration for medicinal or functional use.
x. ***Storage of Aqueous Extracts***: Aqueous extracts should be prepared shortly before use due to their limited shelf life (several hours). To preserve their quality, 0.1% nipagin may be added as a preservative, as recommended by the Pharmacopeia.
xi. ***Use of Extract***: The prepared extract can now be used directly for medicinal or functional beverage production or further diluted as required.

2. Unconventional Extraction Methods:

Unconventional extraction methods developed in the last 50 years are environmentally friendly, using fewer synthetic and organic chemicals, reducing operating time, and offering higher yields and better-quality extracts. However, challenges remain in scaling these methods for industrial use, along with concerns about the risks and toxicity to operators. Therefore, a number of methods have been developed and are detailed in the literature in order to improve the overall yield and selectivity of the bioactive components recovered from the plant material: Ultrasound treatments [35], field extraction pulsed electric field [36], extrusion, microwave-assisted extraction (MAE) [37], and ohmic heating, extraction with supercritical fluids, and extraction with accelerated solvents [38]. Meanwhile, the traditional extraction techniques like Percolation, maceration, or Soxhlet extraction are still regarded as the standard techniques to evaluate the effectiveness of recently developed approaches, with numerous articles on this topic [39,40].

2.1. Procedure for Microwave-Assisted Extraction (MAE):

i. **Prepare Plant Material**: Grind the plant material into smaller pieces to increase surface area and improve the extraction efficiency.
ii. **Select Solvent**: Choose an appropriate solvent (such as water, ethanol, or another suitable solvent) depending on the compounds to be extracted and the desired result.
iii. **Setup Microwave Extraction Apparatus**: Place the prepared plant material into the microwave extraction vessel. Add the selected solvent at the appropriate ratio, typically following the specifications for the plant material.
iv. **Set Parameters**: Adjust the microwave parameters, such as power, time, and temperature, based on the type of plant material and desired extract. A typical MAE process has a short extraction time, ranging from a few minutes to around 20 minutes, depending on the specific conditions.
v. **Microwave Heating**: Apply microwave energy to heat the solvent and plant material, which helps increase the rate of mass transfer. The microwave energy facilitates the release of the active compounds from the plant matrix into the solvent.
vi. **Monitoring**: Keep track of the process, ensuring that the temperature does not exceed the recommended levels for the plant material. The use of a cooling system may be necessary to prevent overheating.
vii. **Cooling and Separation**: Once the extraction time is complete, allow the mixture to cool. After cooling, filter the extract to separate the solvent from the plant material.
viii. **Concentration (if needed)**: If required, the solvent can be evaporated or concentrated under reduced pressure to obtain a more concentrated extract.
ix. **Storage**: Store the final extract in appropriate containers, away from light and heat, to preserve the bioactive compounds.
x. **Use the Extract**: The extracted liquid is now ready to be used for further applications, such as in herbal beverages, functional foods, or medicinal products.

2.2. Procedure for Ultrasound-Assisted Extraction (UAE):

i. **Prepare Plant Material**: Grind or chop the plant material to increase the surface area for more effective extraction. This is particularly important for tough materials like roots or bark.
ii. **Select Solvent**: Choose an appropriate solvent based on the desired active compounds to be extracted. Water is commonly used for herbal extracts, especially for compounds with antimicrobial activity, though other solvents can be used depending on the target compounds.
iii. **Set Up Ultrasound Extraction Equipment**: Place the prepared plant material and solvent into an ultrasonic extraction vessel. Ensure the ultrasonic bath or probe is set up according to the required specifications.
iv. **Set Ultrasound Parameters**: Adjust the ultrasonic frequency (typically between 20–2000 kHz) and power level. Lower frequencies (below 20 kHz) can be used for tougher materials like roots and bark. Set the extraction time, which typically ranges from a few minutes to 30 minutes, depending on the material.

v. **Apply Ultrasound Energy**: Activate the ultrasound waves, which will cause cavitation (the formation and collapse of microscopic bubbles) within the solvent. This cavitation creates high shear forces that break the cell walls of the plant material, increasing permeability and facilitating the release of active compounds.

vi. **Monitor the Process**: Keep an eye on the process, ensuring the temperature does not exceed the recommended limits to avoid damaging the extract. Ultrasonic energy can generate heat, so temperature control may be necessary.

vii. **Filtration and Separation**: Once the extraction is complete, allow the mixture to cool before filtering the liquid to remove the solid plant material. The liquid extract now contains the biologically active compounds.

viii. **Concentration (if required)**: If needed, the extracted solution can be concentrated by evaporating the solvent under reduced pressure or other methods.

ix. **Storage**: Store the final extract in suitable containers, ensuring protection from light, heat, and air to preserve its bioactive properties.

x. **Use of Extract**: The extracted liquid or semisolid can now be used for medicinal or functional purposes, such as in beverages, ointments, or other health-related products.

xi. **Considerations**: While UAE is an environmentally friendly and energy-efficient method, it's important to note that excessive ultrasound energy can generate free radicals, potentially leading to undesirable changes in the active compounds. Always optimize the process to balance efficiency and compound integrity.

Conclusion

Herbal drinks are extremely valuable in natural health practices because they combine the therapeutic, nutritional, and cultural benefits of medicinal plants. By investigating both conventional and novel methods of preparation, their taste, effectiveness, and bioavailability can be greatly improved. Combining traditional and contemporary extraction techniques also guarantees the best possible use of active ingredients while encouraging environmentally friendly production methods. In order to fully grasp the potential of herbal drinks in promoting health and well-being, this study emphasizes the significance of fusing traditional knowledge with modern discoveries.

References

Bouis, H. E., & Saltzman, A. (2017). Improving nutrition through biofortification: A review of evidence from Harvest Plus, 2003 through 2016. *Global Food Security*, 12, 49-58.

Welcome to State Medicinal Plants Board, Uttarakhand...

Kumar A, Kumar R, Sharma M, et al. Uttarakhand medicinal plants database (UMPDB): A platform for exploring genomic, chemical, and traditional knowledge. Data. 2018;3(1):7.

Singh, J.S.; Singh, S.P. Forest vegetation of the Himalaya. Bot. Rev. 1987, 53, 80–192.

Gangwar, R.S.; Joshi, B.D. Some medicinal flora in the riparian zone of river Ganga at Saptrishi, Haridwar, Uttaranchal. Himal. J. Environ. Zool. 2006, 20, 237–241.

Nautiyal, S.; Rajan, K.S.; Shibasaki, R. Environmental conservation vs compensation: Explorations from the Uttaranchal Himalaya. Environ. Inform. Arch. 2004, 2, 24–35.

Sharma, J.; Gaur, R.D.; Paiuli, R.M. Conservation status and diversity of some important plant in the Shiwalik Himalaya of Uttarakhand, India. Int. J. Med. Aromat. Plants 2011, 1, 75–82.

Gangwar, K.K.; Deepali, G.R.; Gangwar, R.S. Ethnomedicinal plant diversity in Kmaun Himalaya of uttarakhand, India. Nat. Sci. 2010, 8, 66–78.

Mukhergee, T.K. Protection of Indian traditional knowledge: In Ethno Medicinal Plants; Trivedi, P.C., Sharma, N.K., Eds.; Poiner Publishers: Jaipur, India, 2004; pp. 18–33.

Naini, V.; Mamidala, E. An ethnobotanical study of plants used for the treatment of diabetes in the Warangal district, Andhra Pradesh, India. Biolife 2013, 1, 24–28.

Panchangam,S.S.; Vahedi,M.; Megha,M.J.; Kumar,A.; Raithatha,K.; Suravajhala, P.; Reddy, P. Saffron'omics': The challenges of integrating omic technologies. Avicenna J. Phytomed. 2016, 6, 604–6

20.Jee, B.; Kumar, S.; Yadav, R.; Singh, Y.; Kumar, A.; Sharma, N. Ursolic acid and carvacrol may be potential inhibitors of dormancy protein small heat shock protein16.3 of Mycobacterium tuberculosis. J. Biomol. Struct. Dyn. 2016.Mo

dak,M.; Dixit, P.; Londhe, J.; Ghaskadbi, S.; Devasagayam, T.P.A. Indian herbs and herbal drugs used for the treatment of diabetes. J. Clin. Boichem. Nutr. 2007, 40, 163–173.

Sen, S.; Chakraborty, R. Revival, modernization and integration of India traditional herbal medicine in clinical practice: Importance, challenges and future. J. Tradit. Complement. Med. 2017, 7, 234–244.

Skrajda-Brdak, M. N. (2018). Health benefits of herbal extracts and beverages. Journal of Education, Health and Sport, 8(9), 1270–1281. https://doi.org/10.5281/ zenodo.1432862

Ekor, M. (2014). The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. Frontiers in Pharmacology, 4, 177. https://doi.org/10.3389/fphar.2013.00177

Rahmanian, N., Ali, S. H. B., Homayoonfard, M., Ali, N. J., Rehan, M. M., Sadef, Y., et al. (2015). Analysis of physiochemical parameters to evaluate the drinking water quality in the state of Perak, Malaysia. Journal of Chemistry, 2015, Article 716125.

Carbonara, T., Pascale, R., Argentieri, M. P., Papadia, P., Fanizzi, F. P., Villanova, L., et al. (2012). Phytochemical analysis of A herbal tea from Artemisia annua L. Journal of Pharmaceutical and Biomedical Analysis, 62, 79–86. https://doi.org/10.1016/j. jpba.2012.01.015.

Singh, P., Khan, M., & Hailemariam, H. (2017). Nutritional and health importance of Hibiscus sabdariffa: A review and indication for research needs. Journal of Nutritional Health & Food Engineering, 6(5), 125–128.

Nguyen, Q. V., & Chuyen, H. V. (2020). Processing of herbal tea from Roselle (Hibiscus sabdariffa L.): Effects of drying temperature and brewing conditions on total soluble solid, phenolic content, antioxidant capacity and sensory quality. Beverages, 6(1), 2. https://doi.org/10.3390/beverages6010002.

Saad, J. M., & Prochaska, J. O. (2020). A philosophy of health: Life as reality, health as a universal value. Palgrave Communications, 6, 45.https://doi.org/10.1057/s41599- 020-0420-9.

Ekor, M. (2014). The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. Frontiers in Pharmacology, 4, 177. https://doi.org/10.3389/fphar.2013.00177.

Rashid, N., Gbedomon, R. C., Ahmad, M., Salako, V. K., Zafar, M., & Malik, K. (2018). Traditional knowledge on herbal drinks among indigenous communities in Azad Jammu and Kashmir, Pakistan. Journal of Ethnobiology and Ethnomedicine, 14, 16. https://doi.org/10.1186/s13002-018-0217-8.

Fitriana, W. D., Istiqomah, S. B. T., Ersam, T., & Fatmawati, S. (2018). The relationship of secondary metabolites: A study of Indonesian traditional herbal medicine (Jamu) for postpartum maternal care use. In , 2049. Proceedings of the AIP Conference Proceedings. AIP Publishing LLC, Article 020096. https://doi.org/10.1063/ 1.5082501.

Nadia, M. E., Nazrun, A. S., Norazlina, M., Isa, N. M., Norliza, M., & Ima Nirwana, S. (2012). The Anti-Inflammatory, Phytoestrogenic, and Antioxidative Role of Labisia pumila in Prevention of Postmenopausal Osteoporosis. *Advances in Pharmacological and Pharmaceutical Sciences*, *2012*(1), 706905.

Rehman, S. U., Choe, K., & Yoo, H. H. (2016). Review on a traditional herbal medicine, Eurycoma longifolia Jack (Tongkat Ali): Its traditional uses, chemistry, evidence- based pharmacology and toxicology. Molecules, 21(3), 331. https://doi.org/ 10.3390/molecules21030331.

Hajra, N. G. (2017). Organic tea: Global market and forecast sales. Journal of Tea Science, 7(11), 58–68. https://doi.org/10.5376/jtsr.2017.07.0011

Skrajda-Brdak, M. N. (2018). Health benefits of herbal extracts and beverages. Journal of Education, Health and Sport, 8(9), 1270–1281. https://doi.org/10.5281/ zenodo.1432862

Ravikumar, C. (2014). Review on herbal teas. *Journal of Pharmaceutical Sciences and Research*, *6*(5), 236.

Rashid, N., Gbedomon, R. C., Ahmad, M., Salako, V. K., Zafar, M., & Malik, K. (2018). Traditional knowledge on herbal drinks among indigenous communities in Azad Jammu and Kashmir, Pakistan. Journal of Ethnobiology and Ethnomedicine, 14, 16. https://doi.org/10.1186/s13002-018-0217-8

Abubakar, A. R., & Haque, M. (2020). Preparation of medicinal plants: Basic extraction and fractionation procedures for experimental purposes. Journal of Pharmacy and Bioallied Sciences, 12(1), 1–10. https://doi.org/10.4103/jpbs.JPBS_175_19

Nagalingam, A. (2017). Drug delivery aspects of herbal medicines. Japanese Kampo Medicines for the Treatment of Common Diseases: Focus on Inflammation, 17, 143–164. https://doi.org/10.1016/B978-0-12-809398-6.00015-9

Thangaraj, P. (2016). *Pharmacological assays of plant-based natural products* (Vol. 71, pp. 11-13). Berlin, Germany: Springer.

Azmir, J., Zaidul, I. S. M., Rahman, M. M., Sharif, K. M., Mohamed, A., Sahena, F., ... & Omar, A. K. M. (2013). Techniques for extraction of bioactive compounds from plant materials: A review. *Journal of food engineering*, *117*(4), 426-436.

Iloki-Assanga, S. B., Lewis-Luján, L. M., Lara-Espinoza, C. L., Gil-Salido, A. A., Fernandez-Angulo, D., Rubio-Pino, J. L., & Haines, D. D. (2015). Solvent effects on phytochemical constituent profiles and antioxidant activities, using four different extraction formulations for analysis of Bucida buceras L. and Phoradendron californicum. *BMC research notes*, *8*, 1-14.

Chemat, F., Rombaut, N., Sicaire, A. G., Meullemiestre, A., Fabiano-Tixier, A. S., & Abert-Vian, M. (2017). Ultrasound assisted extraction of food and natural products. Mechanisms, techniques, combinations, protocols and applications. A review. *Ultrasonics sonochemistry*, *34*, 540-560.

Xue, D., & Farid, M. M. (2015). Pulsed electric field extraction of valuable compounds from white button mushroom (Agaricus bisporus). *Innovative Food Science & Emerging Technologies*, *29*, 178-186.

Karami, M., Akhavan-Bahabadi, M. A., Delfani, S., & Raisee, M. (2015). Experimental investigation of CuO nanofluid-based direct absorption solar collector for residential applications. *Renewable and Sustainable Energy Reviews*, *52*, 793-801.

Aleksic, V., & Knezevic, P. (2014). Antimicrobial and antioxidative activity of extracts and essential oils of Myrtus communis L. *Microbiological research*, *169*(4), 240-254.

Dhanani, T., Shah, S., Gajbhiye, N. A., & Kumar, S. (2017). Effect of extraction methods on yield, phytochemical constituents and antioxidant activity of Withania somnifera. *Arabian journal of chemistry*, *10*, S1193-S1199.

Savoia, D. (2012). Plant-derived antimicrobial compounds: alternatives to antibiotics. *Future microbiology*, *7*(8), 979-990.

Balkrishna, A., Sharma, I. P., & Arya, V. (2024). Ethno-Medicinal Study of Traditional Medicinal Plants Used by Tribal Communities of Uttarakhand, India. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, *94*(2), 277-299.

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INTEGRATION OF COMPUTER VISION AND ARTIFICIAL INTELLIGENCE FOR ENHANCED FRUIT QUALITY MONITORING IN POSTHARVEST TECHNOLOGY

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Abstract

Computer vision systems (CVSs) have emerged as innovative, non-destructive technologies for the in-line grading and quality assessment of fruits. These systems utilize digital cameras, illumination setups, and computer algorithms to extract relevant visual information related to colour, texture, and defects. The benefits of CVS technology include objective and consistent food control, reduction in losses and waste, and increased consumer satisfaction. The most common CVS for the quality inspection of fresh produce is based on RGB colour cameras that reproduce human vision. CVS-CI can measure and detect many external quality traits and defects and requires careful design to integrate mechanical and optical components for producing digital images containing relevant information. Applications of CVS in fruit quality monitoring include colour assessment, internal quality evaluation, fresh-cut fruit monitoring, pH and chemical traits prediction, and smartphone-based analysis. CVS technology, combined with artificial intelligence algorithms, is expected to improve the economic performance, general performance, coordination performance, and robust performance of agricultural automation systems in the future. Large-scale datasets and computer vision intelligence technology will be widely used in every aspect of agricultural production management to solve current agricultural problems.

Keywords: Computer Vision Systems (CVSs), artificial intelligence, image analysis, fruit quality monitoring

Introduction

Postharvest losses differ significantly between different commodities, production regions, and seasons. It may develop while a product travels through the post-harvest chain for various reasons, including poor handling or biodeterioration caused by microbes, insects, rodents, or birds. However, internal and external factors are responsible for the losses. Developing automated technologies capable of inspecting the quality of every piece of fruit before sale will increase product value and producer competitiveness. Several non-destructive techniques have been reported for measuring fruit quality attributes (Blasco *et al.,* 2017). Commercial sorting lines use techniques for external attributes such as colour, size, and the absence of external defects, mostly machine vision-based technologies. However, these technologies present constraints, as different fruit skin colors, defects, and lighting conditions affect monitoring reliability. For internal quality attributes, most techniques present a slow measurement speed, and high cost and are specific for laboratory use, thus non-applicable for industrial sorting lines. The success of these techniques depends on how closely they mimic the perceptions of humans, therefore future sensors should preferably be based on biomimetic principles (Carvalho *et al.,* 2021).

Computer Vision Systems

Computer Vision (CV) is the process of applying a range of technologies and methods to provide imaging-based automatic inspection, process control, and robot guidance in industrial applications. Computer vision systems (CVSs) have emerged as innovative, contactless, and non-destructive technologies for the in-line grading of fruits. These systems utilize digital cameras, illumination setups, and computer algorithms to assess the visual quality of fruits. By extracting relevant visual information related to colour, texture, and defects, CVSs can classify, grade, and assess the quality of fruits. The benefits of CVS technology include objective and consistent food control, reduction in losses and waste, and increased consumer satisfaction. (Fan *et al*., 2020). It includes capturing, processing, and analyzing images to facilitate the objective and non-destructive assessment of visual quality characteristics in agricultural and food products. The techniques used in image analysis include image acquisition, image pre-processing and image interpretation, leading to quantification and classification of images and objects of interest within images. Images are acquired with a physical image sensor and dedicated computing hardware and software are used to analyze the images to perform a predefined visual task (Mahendran *et al.,* 2012).

The most common CVS for the quality inspection of fresh produce is a traditional system based on RGB colour cameras that reproduce the vision of human eyes using three monochromatic filters centered on red (R), green (G) and blue (B) wavelengths at 700, 546 and 435 nm, respectively. CVS based on conventional imaging (CVS-CI) mimics human vision, acquiring and analyzing images of the visible surface of food to assess its quality (Bhargava and Bansal, 2021). The CVS-CI can measure and detect many external quality traits (i.e. colour, shape, size and texture) and defects.

Workflow of image processing performed by CVS-CI

A careful design is required to integrate mechanical and optical components for producing digital images containing relevant information for the task at hand. CVS-CI typically uses high resolution charged coupled device (CCD) or complementary metal-oxide semiconductor (CMOS) digital cameras based on RGB colour for image acquisition. They involve the choice of a proper illumination system, carefully selecting spectral distribution and spatial geometry of the light sources. The position as long as the choice between front or backlighting, the type of lamps (incandescent, fluorescent, laser, LED or infrared lamps), colour quality and uniform distribution of the illumination are all important concerns when designing an efficient and accurate vision system (Zhang *et al.,* 2014). Finally, a personal computer normally collects data acquired by the sensors, performs some basic processing (colour correction, segmentation, feature extraction), accomplishes feature classification or parameter estimation by constructing suitable models using statistical methods or machine learning techniques (i.e. decision trees, regression trees, ensemble learning, random forest or convolutional neural network) (Palumbo *et al.,* 2023).

Applications of CVS in Fruit Quality Monitoring

Colour Assessment

CVS technology accurately evaluates colour properties at the pixel level, offering more objective assessments than standard colorimeters. For example, CVS has been used to assess the quality of rocket leaves and to differentiate between various cultivation methods. The technology demonstrated high accuracy in both quality assessment and discrimination of cultivation approaches through the use of advanced algorithms.

Internal Quality Evaluation

CVS is not only concerned with the external appearance of horticultural products; it can also assess their internal quality. By analyzing colour changes, CVS can estimate various properties, such as antioxidant activity, total phenol content, fruit acidity, and enzymatic activities including polyphenol oxidase and peroxidase during storage.

Fresh-Cut Fruits

CVS is essential for monitoring the quality of fresh-cut fruit, reducing food waste, and ensuring market freshness. It has been effectively applied to assess various fresh-cut products, including nectarines and apples (Fan *et al.,* 2020).

pH and Chemical Traits Prediction

CVS methods have been developed to predict the pH values of fruits, such as oranges, allowing for rapid and non-destructive assessments. Furthermore, when combined with regression models, CVS has been used to correlate image data with chemical traits, including total soluble solids and pH levels in strawberries (Sabzi *et al.,* 2020).

Smartphone-Based Analysis

Innovative applications have emerged that utilize smartphones for image analysis. For instance, the RGB (Red, Green, and Blue) values captured from smartphone photos of kiwifruits were correlated with their quality parameters. This approach offers a quick evaluation method for assessing postharvest quality (Li *et al.,* 2022).

Conclusion

Computer vision systems (CVSs) are innovative, non-destructive technologies for in-line grading and quality assessment of fruits. CVSs use digital cameras, illumination setups, and computer algorithms to extract visual information related to colour, texture, and defects. It is concluded that computer vision technology is an emerging technology, applied to agriculture. In the future, computer vision intelligence technology based on large-scale datasets will be widely used in every aspect of agricultural production management and will be more widely used to solve the current agricultural problems. Computer vision technology combined with artificial intelligence algorithms will improve the economic performance, general performance, coordination performance and robust performance of agricultural automation systems. CVS technology, combined with artificial intelligence algorithms, is expected to improve the performance of agricultural automation systems in the future, with large-scale datasets and computer vision intelligence technology being widely used in agricultural production management.

References

Bhargava, A. and Bansal, A., (2021). Fruits and vegetables quality evaluation using computer vision: a review. *JKSUCI,* 33(3):243–257

Blasco, J., Munera, S., Aleixos, N., Cubero, S. and Molto, E. (2017). “Machine Vision-Based Measurement Systems for Fruit and Vegetable Quality Control in Postharvest,” in *Measurement, Modeling and Automation in Advanced Food Processing.*, Springer, 71–91.

Carvalho, M., Pedro, R., Verónica, R. and Susana C. (2021). Smart fingertip sensor for food quality control: fruit maturity assessment with a magnetic device. *Journal of Magnetism and Magnetic Materials*, *536*, 168116.

Fan, S., Li, J., Zhang, Y., Tian, X., Wang, Q. and He, X. (2022). Online detection of defective apples using a computer vision system combined with deep learning methods. *J Food Eng,* 286

Li, H., Lv, S., Feng, L., Peng, P., Hu, L., Liu, Z. (2022). Smartphone-based image analysis for rapid evaluation of kiwifruit quality during cold storage. *Foods,* 11(14):2113.

Mahendran, R., Jayashree, G. C. and Alagusundaram, K. (2012). Application of computer vision technique on sorting and grading of fruits and vegetables. *J. Food Process. Technol*, 10:2157-7110.

Palumbo, M., Cefola, M., Pace, B., Attolico, G. and Colelli, G. (2023). Computer vision system based on conventional imaging for non-destructively evaluating quality attributes in fresh and packaged fruit and vegetables. *Postharvest Biology and Technology*, 200

Sabzi, S., Javadikia, H., Arribas, J. I. (2020). A three-variety automatic and non-intrusive computer vision system for the estimation of orange fruit value. *Measurement,* 152

Zhang, B., Huang, W., Li, J., Zhao, C., Fan, S., Wu, J. and Liu, C., (2014). Principles, developments and applications of computer vision for external quality inspection of fruits and vegetables: a review. *Food Res. Int.* 62:326–343

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THE EFFECTS OF CLIMATIC FACTORS ON THE NUTRITIONAL QUALITY OF STORED MAIZE (*Zea mays*)

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Abstracts

Maize is a common staple crop grown in many regions of the world and it plays a significant role in various component of the diet. It is nutritionally high in fiber, phytochemicals, minerals, carbohydrates, proteins and vitamins. It is consumed by man in making various dishes and plays important role in formulation of livestock feeds. However, the production of maize in Nigeria is faced with numerous challenges, such as climate changes (excessive rainfall and drought), post-harvest losses due to improper handling of harvested food crops, improper storage, growing of molds and infestation of pests. The use of good storage system for maize is very important, so as to retain it sensorial, nutritional, microbiological quality and to reduce post-harvest losses. The essence of this study is to assess how climatic factors affect the nutritional quality of stored maize.

Keywords: Temperature; Storage; Aspergillus flavus; nutrient; pest

Introduction

Maize (*Zea mays*) is an annual nutrient -rich cereal grain, which belongs to the family of *Poaceae*. The word Zea is from the ancient Greek and it means "sustaining life" while mays are from Taino language meaning "life giver" (Kumar & Jhariya, 2013). It is a staple food consumed by millions of people in Nigeria and all over the world. Among all food crops, maize is considered as the third leading crop of the world after rice and wheat (Sandhu, Singh & Malhi,2007).

The world production of maize was 967 million metric tons (MMT), while United States of America (USA) is the largest producer of maize, contributing about 35% of the total world maize production.

It is known globally as "queen of cereals" due to its highest yield potential among other cereals. The largest producer of maize is United States of America (USA) contributing about 35% of the total world maize production. (Milind & Isha, 2013). It plays an important role in food security, livestock feed and the economy of the country. Nigeria is one of the largest maize producers in Africa, thereby producing over 10 million metric tons annually. The Importance of maize cannot be over-emphasized as well as its potential to mitigate the present food insecurity and alleviate poverty in developing countries of the world. Maize is an ideal staple food for over 900 million poor consumers, 120-140 million families and about one third of malnourished children (CIMMYT and IITA, 2010)
Maize is an important source of protein, iron, carbohydrate, fiber, vitamin B, phytochemicals and minerals as shown in Figure1.

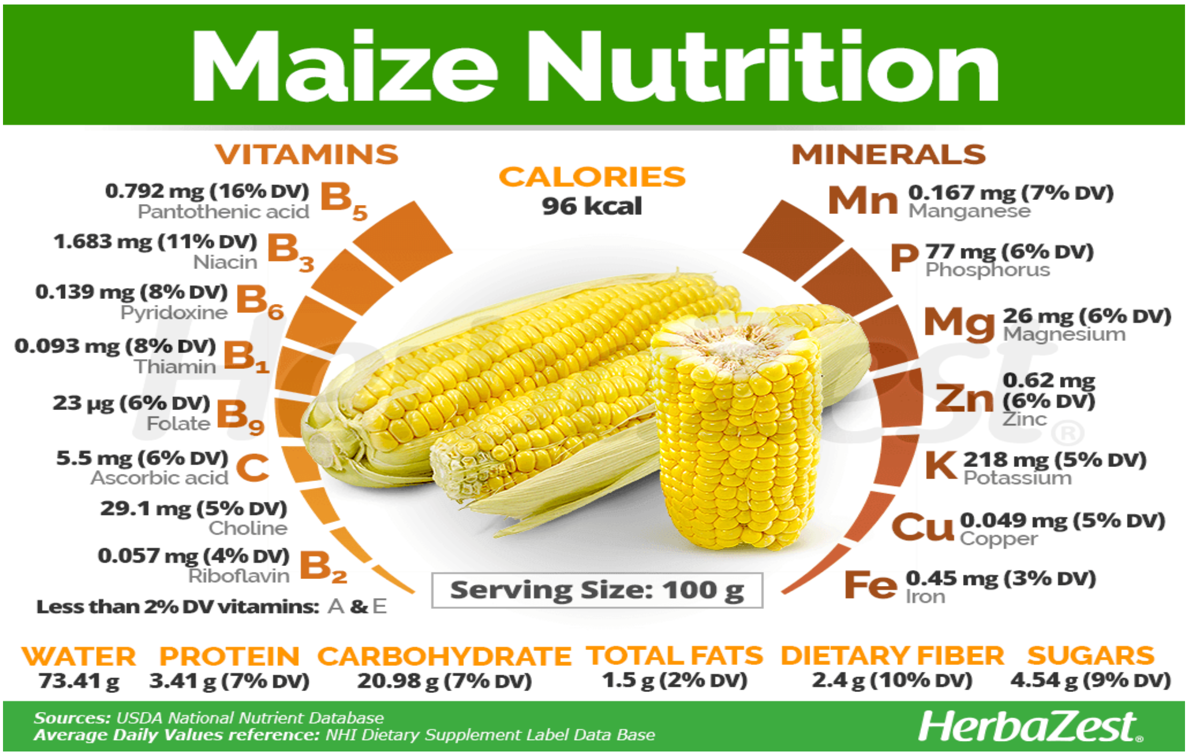

Figure 1: The Nutritional Content Present in Maize
Source: USDA National Nutrient Database 2014

It can be consumed as a whole grain either freshly green or dried, it may be used or processed into various types of products such as cornmeal, grits, starch, flour, tortillas, snacks, and breakfast cereals such as ogi, akple, tuwo, donkunnu, maasa, gwate, nakia, egbo, abari, donkwa, ajepasi, aadun, kokoro, elekute etc. (Abdulrahaman and Kolawole, 2006).). The flour is also used to make flat bread and chapatis which are consumed in a few Northern states of India (Mehta & Dias,1999).

The major challenges faced with maize production and other food crops in Nigeria ranges from environmental challenges (this comprises, climate change, soil degradation and drought), biotechnical challenges (pests, diseases and weeds) and technological challenges (limited access to improved varieties, inadequate irrigation systems and limited adoption of technology). Preservation of maize and other food crops from spoilage are also dependent on moisture content, relative humidity and temperature.

Proper storage of maize is very important to maintain its quality, to prevent spoilage from growth of fungi (Lehmane *et al*.,2022) and insect infestation, such as weevils (*Sitophilus zeamais*) (Basyal *et al*., 2022) which can cause substantial grain damage and weight loss. (Kumar & Kalita 2017). This usually involves cleaning them after harvestation, drying (using parabolic dryers), sorting and proper packaging in rodent-proof storage and air tight containers to prevent moisture and insect infestations) (Stathas *et al.,* 2023).

Maize is stored via traditional (cribs, silos and sacks) and modern method (hermetic bags and metal silos). The methodology used for storage also affect the effectiveness in retaining the quality of the stored maize as well as factors such as moisture content, relative humidity and temperature playing a significant role (Weinberg *et al*.,2008). The nutritional value and safety of maize for consumption is determined by the physical and chemical properties of the stored grains.

Climatic factors that affect the nutritional quality of stored maize

- **Temperature:** The quality of stored maize can be affected either at high temperature or at a very low temperature. Elevated temperature can accelerate the rate of biochemical reactions in maize thereby resulting to the degradation of dry matter, proteins, essential nutrients and vitamins; it also enhances the growth of mycotoxins and molds, which can also affect their nutritional quality (Hossain *et al*., 2019). While low temperatures may preserve the nutritional quality of maize. But most importantly, ideal storage temperature is 15°C and below is for long term storage of 6months and above.
- **Moisture content**- it can be described as the amount of water present in a grain. High moisture content promotes the growth of molds and mycotoxins which pose health risk to human and also destroy nutritional content of maize. The optimal moisture content for the storage of maize is at 13-14%.
- **Relative humidity**- a conducive relative humidity within 50%-70% should be maintained in stored maize. At high relative humidity, the moisture content also increases which invariably also enhances spoilage of stored agricultural products.
- **Air quality**- air which are highly rich in oxygen can promote oxidative reactions that degrade vitamins and fats in maize. When the quality of air is poor, it can also introduce pathogens and pollutants which will affect the nutritional value of stored maize.
- **Light**- it tends to affect stored crops due to some reactions that occur in the presence of light, known as photo-oxidation which results to the degradation of various nutrients in maize such as lipid oxidation which can cause rancidity, off-flavour and harmful compounds.
- **Pest infestation**- the climatic conditions that will enhance the infestation of stored food crops such as warm and humid environments should be prevented, as they can results to grain damage and loss of nutrients.

Strategies for Maintaining Nutritional Quality of Stored Maize

- **Proper cleaning-** maize should be properly cleaned to remove contaminants after harvesting, before storage.
- **Drying -**it should be dried properly so as to reduce the moisture content, to prevent the growth of molds and degradation.
- **Sorting-** The crops should be sorted, by removing damaged kernels of grains, so as to prevent infestation of pests.
- **Use of opaque packaging material-** this will prevent oxidative reactions that occur in the presence of light, that denature the nutritional value of maize**.**
- **Standard Storage conditions-**standard storage conditions should be maintained at appropriate temperature, moisture content and relative humidity.
- **Regular monitoring-**this should be done from time to time, so as to check for signs of spoilage or pest infestation.

Conclusion

The effect of climatic factors on the nutritional value of stored maize cannot be over-emphasized. The study revealed that storage of maize during harvest season to reduce post-harvest loss is as important as the maintenance of the nutritional quality of such crops. Climatic factors that affect storage of maize are temperature, moisture content, relative humidity and light which also have impact on the nutritional quality of stored maize. Therefore, it is very important to store maize under controlled climatic conditions to maintain its nutritional quality. The use of proper storage conditions should also be adopted and regular monitoring during storage period. Further studies should be carried out on smart storage systems using modern technologies and applications such as nano-technology and Artificial Intelligence and Machine Learning to analyse data on nutritional quality and maize storage conditions.

References

Abdulrahaman A.A. and Kolawole O.M. (2006) Traditional preparation and uses of maize in Nigeria. Ethnobot. leaflets 10:219-227.

Basyal, K.; Sapkota, R.; Bajryacharya, A.and Bhattarai, S. (2022). Use of Botanicals for Management of Weevil (*Sitophilus zeamais* motschulky) in Maize Storage. *J. Agric. Environ.*, *23*, 166–176. [**Google Scholar**] [**CrossRef**]

CIMMYT and IITA (2010). Maize-Global alliance for improving food security and the livelihoods of the resource-poor in the developing world. Draft proposal submitted by CIMMYT and IITA to the CGIAR Comortium Board. El Batan, Mexico, 91pp.

Hossain, F.; Sarika, K.; Muthusamy, V.; Zunjare, R.U. and Gupta, H.S. (2019). Quality Protein Maize for Nutritional Security. In *Quality Breeding in Field Crops*; Qureshi, A., Dar, Z., Wani, S., Eds.; Springer: Cham, Switzerland; pp. 217–237. [**Google Scholar**]

Kumar, D., and Jhariya, N. A. (2013). Nutritional, medicinal and economical importance of corn: A mini review. Research Journal of Pharmaceutical Sciences, 2, 7–8.

Kumar, D. and Kalita P. (2017). Reducing Postharvest Losses during Storage of Grain Crops to Strengthen Food Security in Developing Countries. *Foods* **2017**, *6*, 8. [**Google Scholar**] [**CrossRef**] [**Green Version**]

Lehmane, H.; Ba, R.; Dah-Nouvlessounon, D.; Sina, H.; Roko, G.; Bade, F.; Socohou, A.; Adjanohoun, A. and Baba-Moussa, L. (2022). Status of Techniques Used to Control Moulds in Maize Storage in Africa. *Agric. Sci.* **2022**, *13*, 49–64. [**Google Scholar**] [**CrossRef**]

Mehta, D. C., and Dias, F. F. (1999). Maize: Perspectives and applications in India. Starch - Stärke, 51, 52–57. http://dx.doi.org/10.1002/(ISSN)1521-379X

Milind, P., and Isha, D. (2013). Zea maize: A modern craze. International Research Journal of Pharmacy, 4, 39–43.

Sandhu, K. S., Singh, N., and Malhi, N. S. (2007). Some properties of corn grains and their flours I: Physicochemical, functional and chapati-making properties of flours. Food Chemistry, 101, 938–946. http://dx.doi.org/10.1016/j.foodchem.2006.02.040

Stathers, T.E.; Arnold, S.E.J. and Rumney, C.J.(2020). Measuring the nutritional cost of insect infestation of stored maize and cowpea. *Food Sec.* **2020**, *12*, 285–308. [**Google Scholar**] [**CrossRef**] [**Green Version**]

Stathas, I.G.; Sakellaridis, A.C.; Papadelli, M.; Kapolos, J.; Papadimitriou, K. and Stathas, G.J. (2023). The Effects of Insect Infestation on Stored Agricultural Products and the Quality of Food. *Foods*, *12*, 2046. [**Google Scholar**] [**CrossRef**] [**PubMed**]

US Department of Agriculture, Agriculture Research Service, Nutrient Data Laboratory (2010). National Nutrient Database for Standard Reference Release 23. Version current 2010.

Internet: http://www.ars.usda.gov/Services/docs.htm?docid=22115 (accessed 30 June 2014).

Verheye W. (2010). Soils, plant growth and crop production Vol. II. Growth and production of maize: Traditional low input cultivation. UNESCO-EOLSS.

Weinberg, Z.G.; Yan, Y.; Chen, Y.; Finkelman, S.; Ashbell, G. and Navarro, S. (2008). The effect of moisture level on high-moisture maize (*Zea mays* L.) under hermetic storage conditions—In vitro studies. *J. Stored Prod. Res.*, *44*, 136–144. [**Google Scholar**] [**CrossRef**]

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OUAT KALINGA RICE 8 (SURYASHREE): A NEW HEAT TOLERANT CULTIVAR FOR ODISHA

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Abstract

A heat tolerant rice cultivar OUAT Kalinga Rice 8 (Suryashree) was released in Odisha for cultivation in *Rabi* in irrigated medium land situations by the State Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops, Government of Odisha, Bhubaneswar in its meeting held on 12.04.2023 and approved for notification by Government of India, Ministry of Agriculture and Framers Welfare on its meeting held on 02.05.2023 and notified on 25.09.2023 in the Gazette of India. It can tolerate heat stress above 38^{o}C, matures in 125 days, yields 4276 kg seed per hectare under *rabi* condition (*Dalua* situation) and has resistance to gall midge. It has yield advantage of 18.98 per cent, 18.54 per cent and 12.12 per cent over national check 'Gontra bidhan-3', zonal check 'Mandakini' and local check 'Lalat', respectively.

Keywords : Heat-tolerance, rice, Suryashree, variety release.

Introduction

Among the staple crops rice plays a vital role in feeding a significant portion of world's population. However, rice crop is susceptible to various biotic and abiotic stresses. Among them heat stress is important in *rabi* season (*Dalua* crop) which is a severe threat to the food security (1,2). So this is the peak time for the researchers and scientists to develop heat tolerant rice varieties that can withstand high temperatures and maintain productivity in changing climatic conditions (3). Rice being a C3 plant is particularly sensitive to heat stress, making it highly susceptible to rising global temperatures. Heat stress reduces photosynthetic efficiency, impairs grain development, and causes yield losses. As global temperatures continue to rise, heat waves during critical growth stages, such as flowering and grain filing, resulting in an increased number of chaffy grains, significantly affecting rice production (4).

In India rice is cultivated in an area of 4.45 million hectares, which can be classified into seven different ecosystems: irrigated *kharif* (27.4%), rainfed upland (19.1%), medium land (12.4%), shallow lowland (22.5%), semi-deep (7.9%), deep (3.4%), and irrigated *rabi* (7.4%) (1). The immense diversity in growth conditions makes classification and characterization of the rice environments a challenging task. The total cultivated land of the state is 61.01 lakh ha out of which 30.94 lakh ha (47%) is high land, 18.43 lakh ha (28%) medium land and 16.45 lakh ha (25%) low land and about 46% of cultivated land in *kharif* season is irrigated. Total 78.6, irrigated Odisha's share in the country's rice production is 11%. Rice in Odisha is now grown on an area of 4.4 million hectares, which accounts for 91% of the area under cereals and contributes about 94% of total cereal production in the state (4). With the objective of high yield, heat tolerance and resistance to gall midge for *rabi* season (*Dalua* crop), a breeding programme was initiated.

Materials and methods

The present breeding programme was initiated in the All India Coordinated Research Project on Rice, RRTTS, Chiplima, Sambalpur, Odisha located at 20°-9'N latitude and 82°-39' and 85°-15'E longitude. The heat tolerant lines were received from INGER, IRRI, Philippines under CISA project. It was tested in different AICRP testing centres. Preliminary Yield Trial (PYT) was carried for three consecutive years, i.e., from 2014 to 2017 and it was tested under AICRP on Rice with culture name IR-12C-147 and IET No 27737 over 20 locations all over India during *kharif* 2018-2019 (IVT) and 2019-2020 (AVT1). It has performed well in many centres especially in Haryana; the yield potential was 8 t/ha. The state level Multi-location Trial (MLT) was conducted in different agro-climatic zones of Odisha, *viz.*, Chiplima, Kirei, Jeypore and Ranital for three consecutive years during 2018-19, 2019-20 and 2020-21. The crop was inspected regularly at a 20 days interval to record the phonological events which was recorded during reproductive stage of the crop.

Growing Degree Days (GDD):

Compiling all the growing degree days by daily mean temperature above the base temperature express the degree day. 10^0 C is taken as the base temperature (Lucas *et al.*, 2016). This is determined by using the formula as per Nuttonson, 1955.

GDD (^{0} C) = $\frac{(T + T\ min)}{2} - Tbase$

Where

T max = Daily Maximum temperature (^{0} C)
T min = Daily Minimum temperature (^{0} C)
T base = Minimum base temperature (^{0} C)

Grain Yield Use Efficiency (GYHUE):

Grain yield use efficiency is indicated as amount of yield produced per unit of growing degree days. This computed using the formula:

GYHUE = $\frac{Total\ Yield\ (kglha)}{\sum GDD}$

Dry Matter Use Efficiency (DMUE):

Dry matter use efficiency is indicated as amount of dry matter produced per unit of growing degree days. This is computed using the formula:

GYHUE = $\frac{Total\ dry\ matter\ (g\ hill{-}1)}{\sum GDD}$

SPAD:

A SPAD or Chlorophyll meter is used to measure the chlorophyll content of leaves. This device provides a quick and non-destructive method to assess the health and nutritional status of plants by quantifying the chlorophyll levels, which are indicative of the plant's photosynthetic capacity and overall vigor.

Results and discussion

The pooled data (2018 to 2021) of the Station Preliminary Yield Trials (Table 1) revealed the yield advantage of 'IR12C-147' (4273 kg/ha) by 76% over the national check 'Gontra bidhan 3' (4267 kg/ha), Zonal check Manadini and local check of Lalat. It performed well in Haryana Zone II, expressed 8.3q/ha and having percentage increase over weighed means >22.44% over National Check, >32.85 % over Zonal check and >39.34 % over Local check.

The reaction of IR12C147 to major diseases and insect pests was moderately resistant to gall midge (5).The multi-location trials (MLTs) conducted in different agro-climatic zones of Odisha during 2018-19 corroborated the results of All India Coordinated Trials and Station PYTs tested over years (**Table 1 (a),(b)**).

The agronomical characteristics of Suryashree are detailed in Table 2. It outperformed the local check (Lalat) in 50 percent flowering and plant height, and the zonal check (Mandakini) in plant height. Suryashree is suitable for cultivation in lowland irrigated medium lands during the rabi season, with a duration of 125 days and a seeding to flowering range of 65-87 days. Based on the performance of IR12C147, it was released as Suryashree by the State Sub-Committee on Crop Standards, Notification, and Release of Varieties for Agricultural Crops, Government of Odisha, Bhubaneswar, in April 2022. Promoting Suryashree among farmers will significantly boost the production and productivity of heat-tolerant rice varieties in Odisha.

Conclusion

The development of heat tolerant rice varieties is of utmost important to secure the global food supplies in the face of climatic change. Through an integrated approach that combines genetic research, biotechnology, physiological studies and agronomic strategies, researchers aim to equip rice plants with the ability to thrive under rising temperatures, ensuring food security for the future generations. The ultimate goal of this any research work is to create a sustainable agricultural system that can with stand the challenge posed by an increasingly warming world. So in coming days farmers may be benefited with the new cultivar OUAT Kalinga Rice 8 (Suryashree) going to have a great impact on the farmers community.

Acknowledgement

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References

1. Anonymous. 2018. Annual Report (2018-19), All India Coordinated Research Project on Rice, Indian Institute of Rice Research, Hyderabad
2. Anonymous. 2019. Annual Report (2019-20), All India Coordinated Research Project on Rice, Indian Institute of Rice Research, Hyderabad
3. FAOSTAT. (2014). http://faostat3.fao.org
4. ICAR-Indian Institute of Rice Research. (2019). the reaction of IR12C147 to major diseases and insect pests was moderately resistant to gall midge. In *Annual Progress Report Vol. 1 – Varietal Improvement* (2018 & 2019). Hyderabad, India: ICAR-IIRR
5. Mishra, A. (2023). Rice cultivation with special reference to Odisha. *International Journal of Research Publication and Reviews*, 4(12), 4450-4453. Avaliable at www.ijrpr.com.

Fig:1

Fig:2

Fig:1 Depicting grain variation for IR12C-147 (OUAT Kalinga Rice 8 Suryashree)
Fig 2: Multilocational trail of heat tolerant genotypes

Table 1(a). State wise summary of mean grain yield (Kg/ha) in Co-ordinated (MS) trials during 2018-19. OUAT Kalinga Rice-8 (Suryashree)

Year	Name of the trials	No. of test entries (No. of location)	Yield (Kg/ha)			
			OUAT Kalinga Rice-8 (Suryashree) IET 27737	N.C. (Gontra Bidhan-3)	ZC (Mandakini)	LC (Lalat)
2018	IVT-MS	64 (24)	4733	5561	5056	5351
2019	AVT-1-MS	19 (30)	5109	4750	3482	4456
Weighted Mean			5425	5033	3873	4768
% increase over Weighted Mean				(+)7.22	(+)28.6	(+)12.11

Source: IIRR Annual Progress Report Vol. 1 – Varietal Improvement (2018 & 2019)

Table 1(b). Zone wise summary of mean grain yield (Kg/ha) in coordinated trials (MS trials) during 2018-19.OUAT Kalinga Rice-8 (Suryashree)

Zone (States)	Year of testing	No. of locations tested	Name of the trial	OUAT Kalinga Rice-8 (Suryashree) IET 27737	NC 1 (Gontra Bidhan-3)	ZC (Mandakini)	LC (Lalat)
Zone – III	2018	24	IVT-MS	4387	4937	5760	5995
Zone-II	2019(3)	5	AVT-1-MS	6002	6597	6096	6164
Weighted Mean				4980	4412	4078	5002
% increase over	2018				(-) 12.53	(-) 31.29	(-) 36.65
	2019				(-) 9.91	(-) 1.56	(-) 2.69

Zone (States)	Year of testing	No. of locations tested	Name of the trial	OUAT Kalinga Rice-8 (Suryashree) IET 27737	NC 1 (Gontra Bidhan-3)	ZC (Mandakini)	LC (Lalat)
% increase over Weighted Mean					(+) 22.44	(+)32.85	(+) 39.34
Zone – V	2018	24	IVT-MS	4041	4737	4570	4637
	2019	5	AVT-1-MS	5109	4750	3482	4456
Weighted Mean				5447	4697	3564	4291
% increase over	2018				(-) 17.22	(-) 13.09	(-) 14.74
	2019				(+) 7.02	(+) 31.84	(+) 12.78
% increase over Weighted Mean					(-) 10.2	(+) 18.75	(-)1.96
Zone – VI	2018	24	IVT-MS	4104	5567	5057	6417
	2019	5	AVT-1-MS	5393	5310	4121	5638
Weighted Mean				5413	4958	4569	5227
% increase over	2018				(-) 35.64	(-) 23.22	(-) 56.35
	2019				(+)1.53	(+)23.58	(-)4.54
% increase over Weighted Mean					(-)34.11	(+)0.36	(+)60.89

Table 2: Yield data of Multi Location Trials in state for Three years (2018-19, 2019-20, 2020-21)

S. No	Name of the variety	Jeypore			Ranital			Kirei		
		2018-19 (kg/ha)	2019-20 (kg/ha)	2020-21 (kg/ha)	2018-19 (kg/ha)	2019-20 (kg/ha)	2020-21 (kg/ha)	2018-19 (kg/ha)	2019-20 (kg/ha)	2020-21 (kg/ha)
1	IR-12C-147 Proposed variety	2740.00	2391.25	3956.00	4838.00	4721.67	4959.00	4527.33	4798.00	4634.33
2	Lalat (LC)	2876.25	2062.75	2816.00	1966.00	1656.00	2990.00	2418.33	1681.67	2939.00
3	MTU-1010 (LC)	-	2062.25	2337.33	2720.00	2341.00	2881.33	2676.67	2405.33	2820.33
Yield advantage over check variety MTU 1010		At par	(+) 16%	(+) 69%	(+) 78%	(+) 102%	(+) 72%	(+) 69%	(+) 99%	(+) 64%
Yield advantage over check variety Lalat		At par	(+) 12%	(+) 40%	(+) 146%	(+) 185%	(+) 65%	(+) 87%	(+) 185%	(+) 57%

MLT of OUAT Kalinga Rice 8 (Suryashree) performed well in all three locations having high yield advantage over check varieties

Table 3: Comparative performance of IR 12C-147 with other varieties at different date of sowing for growth, yield attributes and SPAD values during *rabi* 2018-19 at RRTTS, Chiplima (Data pooled over 2 years)

Treatment	Days to maturity	Plant height (cm)	Tillers m^{-2}	Panicle length (cm)	Test weight (g)	Grains $panicle^{-1}$	Sterile grains $panicle^{-1}$	SPAD value at 80DAT
Sowing dates								
Dec.10	130	87.6	438	23.2	21.2	118	25	30.7
Dec.20	127	90.8	387	23.2	21.3	125	24	33.9
Dec.30	119	99.4	367	23.9	21.3	139	26	36.4
Jan.10	112	97.5	364	23.6	22.2	119	30	27.3
CD (P=0.05)	1.0	6.1	41	NS	NS	11.7	2	0.02
Varieties								
MTU-1156	124	96	387	24.3	21.5	131	25	32.2
IR12C-147	127	100	395	25.2	22.9	134	20	40.7
CD (P=0.05)	0.1	3.5	NS	0.7	NS	10.1	1.5	0.01

OUAT Kalinga Rice 8 (Suryashree) performed well in comparison to the check variety in term of Days to maturity, Plant height, Tillers (m^2), Panicle length, Test weight and Grains panicle sterile grains per panicle and SPAD values.

Table 4: Comparative yield , grain heat use efficiency (GYHUE) and dry matter heat use efficiency (DMHUE) of IR-C-147 with other varieties and dates of sowing during *rabi* at RRTTS, Chiplima

Treatment	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})			GYHUE			DMHUE		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Sowing dates												
Dec.10	3.9	3.6	3.8	4.9	3.6	4.3	3.0	2.3	2.7	6.3	4.8	5.6
Dec.20	4.3	4.4	4.4	4.9	5.9	5.4	3.0	2.9	2.9	6.1	6.4	6.3
Dec.30	4.5	4.8	4.7	5.5	5.6	5.6	3.2	3.1	3.2	6.8	6.5	6.6
Jan.10	3.6	3.0	3.3	4.3	4.0	4.2	2.8	2.6	2.7	5.9	5.4	5.7
CD (P=0.05)	0.7	1.1	0.9	0.8	1.2	1.0	0.4	0.5	0.2	0.6	1.2	0.5
Varieties												
MTU-1156	4.2	3.7	4.0	5.2	4.6	4.9	3.0	2.6	2.8	6.4	5.6	6.0
IR12C-147	4.5	5.1	4.8	5.6	6.0	5.8	3.0	3.1	3.1	6.6	6.5	6.5
CD (P=0.05)	0.7	1.1	0.9	0.8	1.2	1.0	0.3	0.6	0.2	0.6	1.2	0.4

OUAT Kalinga Rice 8(Suryashree) expressed high 4.8 Grain yield (t ha^{-1}) when compared to check variety MTU1156 4.0 Grain yield (t ha^{-1}) and high Grain yield Use efficiency recorded 3.1 when compared with check variety was 2.6 and high Dry matter use efficiency in case of OUAT Kalinga Rice 8 (Suryashree) 6.5 while check variety recorded 6.

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STRATEGIES TO MINIMIZE POST-HARVEST LOSSES IN MUSHROOM

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Introduction

Mushrooms are the fleshy, spore-bearing fruiting bodies of some members of a lower group of plants known as fungi grown above-ground on its food sources. The fungi are characterized by the absence of chlorophyll and undifferentiated bodies except the spore bearing structures. The exotic flavour, taste and fleshiness of mushroom have made it an important delicacy in human diet. Mushroom is considered to be a complete, healthy food and suitable for all age groups also benefited with the medicinal value (Bobek, et. al, 1997**)**. Mushroom contains 20-35% protein, which is also considered as a good source of protein for vegetarian (Pathak, et. Al, 1997). Similarly, it contains appreciable amounts of vitamin C and B complex, potassium, phosphorus and sodium with zero cholesterol and is almost fat free. More than 2000 mushroom species exist in nature, but only four types, viz., white button mushroom (*Agaricus bisporus*), oyster mushroom (*Pleurotus spp.*), paddy straw mushroom (*Volvariella volvacea*) and milky mushroom (*Calocybe indica*) are grown commercially in India.

The production and consumption of mushrooms is increasing very fast in India, owing to its taste and nutritive value. Also because of the fact that, the production of mushroom can be done throughout the year in environmentally controlled units, but the seasonal growers come into play during the winters season and the supply to the local market also exceeds causing less profit due to fall in price and spoilage due to market surplus. The rate of postharvest losses is very high in case of mushroom, as it is highly perishable and get spoiled due to browning, wilting, liquefaction, loss of texture, aroma, flavour, etc, making it unsaleable. Most of the mushrooms, being high in moisture and delicate in texture, it cannot be stored for more than 24 hours at the ambient conditions prevailing in the tropics. The primary cause of the spoilage of the mushroom is may be the enzymatic reactions and also with the combination of microbial action on the tissue. Therefore, many postharvest practices and value addition of mushroom have since been developed to minimize postharvest losses.

Methods to minimize postharvest losses in mushroom

Fresh mushrooms need to be stored properly to retard postharvest deterioration till it reaches to the consumer.

Cooling and refrigeration

For consumption of fresh mushroom and also for long distance marketing cold-preservation of mushrooms is one the most important aspect of the storage and can be classified in two categories: refrigeration and freezing. Household and commercial refrigerators usually run at 4–7^{0}C, where the mushroom can be stored for 2 to 3 days. Whereas, cold or chilling storage may have a slightly lower temperature (–1 to –40C), depending upon the freshness of the mushrooms to be refrigerated and this storage is mainly preferred for long distance transportation. In case of freezing, it is done at a temperature of below -180C which will preserve mushrooms for days or weeks and frozen storage (deep freezing) will preserve for months or even years and is particularly done for bottom mushroom.

Vacuum cooling

Vacuum-cooling is a uniform and faster process, where mushrooms are subjected to very low pressure and water evaporates giving off the latent heat of vaporization (Rai and Arumuganathan, 2008). In vacuum-cooling, the water in cell walls and moisture from inside and outside surface of the mushroom get evaporated under low pressure, and the evaporative cooling lowers the temperature from the ambient to 2^0C in 15 to 20 min. The vacuum cooled mushrooms have superior colour than conventional-cooled mushrooms. The major drawback of the system is the high capital cost and loss of fresh weight of the produce during the process of cooling.

Irradiation

Irradiation is a process of using low dosses of ionizing radiation which helps to reduce the microbial contamination and extend the shelf-life of mushrooms. Irradiation should be given immediately after harvest for optimum benefits (botton mushroom, Lescane, 1994; oyster mushroom, Roy *et al*., 2000).

Modified Atmospheric packaging

Modified atmosphere packaging (MAP) has been extensively employed for preserving fresh mushrooms. In this packaging modified atmosphere (low oxygen and high carbon dioxide level) is created in a sealed package of a fresh mushroom by respiratory gas exchange, namely oxygen (O_2) intake and carbon dioxide (CO_2) evolution. When the rate of gas permeation through the packaging material equals respiratory gas exchange, equilibrium concentrations of O_2 and CO_2 are consequently established (Wakchaure, 2011). It provides an affordable packaging system that partly avoids enzymatic browning, fermentation and other biochemical processes by maintaining a controlled gas atmosphere.

Modified humidify packaging

Modified humidify packaging for mushroom is a packaging system that uses moisture absorbers to control the relative humidity inside the package. Combination of both Modified Atmospheric Packaging and Modified Humidified Pack helps improved the shelf-life of fresh mushrooms. Most of the polymeric films used in conventional method of packing have lower water vapour transmission rates relative to transpiration rates of fresh produce. Which may lead to nearly saturated conditions within packages. The high in-package-relative-humidity (IPRH) can cause condensation of water vapour within a package and allow microbial growth. This may either increase or decrease the spoilage depending on the product, depending on their transpiration coefficients and water potentials.

To obtain the desired IPRH, there are two possible approaches: perforation of the package, which precludes the possibility of achieving modified atmosphere conditions within the package, and use of in-package water absorbing compounds like calcium chloride, which can maintain the required relative humidity. An IPRH of 87-90% is desirable for best colour in mushrooms during storage.

Controlled atmospheric packaging

In this method, the oxygen and carbon dioxide concentrations are altered inside the package and respiration rate gets altered. It is similar to Modified atmospheric packaging but in controlled atmospheric packaging atmosphere inside the package in stable.

Value added product

Now a days, value added mushroom products is getting mass-market appeal. It will not only cater to the protein and micronutrient requirement of masses but at the same time will also solve the problem of short shelf-life and postharvest losses of mushrooms. Drying and canning is one of the most important preservation methods. Drying is a removal of moisture from the mushroom as it content 90% of the water. Mushroom may be sun dried which helps to increase Vitamin D or it may be dried in cabinet dryer at the temperature of 55-60^{0}C. After drying final product will be light in weight due to moisture loss and dried mushrrom can be consumed after cooking or it can be further renewed into soup powder or may be into different bakery products, nuggets, pappad, etc. Steeping in brine solution is one the best method of canning, mostly preferred for button mushroom.

Under rural area, it may not be possible to do preservation of mushrooms. A local individuals choose an alternative to make processed product rather than canning and drying. Preparation of mushroom pickle, ketchup, preserve, candy and chips is also getting popularised in market. Value addition of mushroom not only helps to enhance the storage life and taste of mushroom but also keeps its nutritional value intact and make it convenient for marketing.

Conclusion

Though mushrooms have huge health and nutritional benefits and can solve many problems of under-nutrition and malnutrition but despite of knowing this fact mushroom cultivation and its utilization is not catching up fast because of its high perishability and storage challenges. So, to minimize the postharvest losses we have short-term, long-term storage methods and also the growers can easily prepare processed product without imparting its keeping quality.

References

G C Wakchaure, 2011. Postharvest Handling of Fresh Mushrooms. Book : Mushrooms: Cultivation, Marketing and Consumption.

Rai, R.D. and Arumuganathan, T. 2008. Post Harvest Technology of Mushrooms, Technical *Bulletin*-2008, NRCM, ICAR, Chambaghat, Solan-1731213, (H.P.)

Bobek, P., Ozdín, L. & Kuniak, L. (1997). Effect of oyster mushroom and isolated [beta]-glucan on lipid peroxidation and on the activities of antioxidative enzymes in rats fed the cholesterol.

Pathak, V. N., Yadav, N. and Gaur,M. (1997). Mushroom production and processing. Agrobios (India), Jodhpur, New Delhi 342, New Delhi.

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MYCORRHIZAE & THEIR BENEFITS IN AGRICULTURE

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The term "mycorrhiza" implies the association of fungi with roots; relationships called mycorrhizal associations, which are involved in the absorption of nutrients from soil, are found between hyphal fungi and the underground organs of the gametophytes of many bryophytes and pteridophytes, as well as the roots of seed plants and the sporophytes of most pteridophytes. The two main types of mycorrhizas are ectomycorrhizas and endomycorrhizas (sometimes Ectendomycorrhizas are also a type), which differ in their structure and physiological relationships with host plants.

1. **Ectomycorrhiza** - Ectomycorrhiza form symbiotic relationships between woody plants and fungi, involving a diverse group of species (over 6,000) including basidiomycetes, ascomycetes, and zygomycetes. About 10% of plant families have ectomycorrhizal associations. In these relationships, fungi create a mantle (or sheath) around the plant rootlet, with hyphae extending outwards into the surrounding soil. The hyphae also penetrate the root cells, forming an intercellular network known as the Hartig net.
2. **Endomycorrhiza** – Endomycorrhizas, also known as Arbuscular Mycorrhizas (AM), involve fungi forming structures inside plant roots, such as arbuscules or coils, which facilitate the exchange of materials between the plant and fungus. These modified fungal hyphae offer a large surface area for resource exchange. Arbuscular mycorrhizae are the most common type of mycorrhiza, with a wide diversity of plant species—across herbaceous plants, shrubs, and trees in temperate and tropical regions—forming these associations. Fungal partners in AM relationships are highly abundant, making up 5 to 50 percent of the microbial biomass in agricultural soils.
3. **Ectendomycorrhizas** - Ectendomycorrhizas refer to mycorrhizal roots that display characteristics of both ectomycorrhizas and endomycorrhizas, without implying any specific function. These associations are primarily found in plant families like Pinus (pine), Picea (spruce), and, to a lesser extent, Larix (larch). In Ectendomycorrhizas, the fungal sheath may be reduced or absent, but the Hartig net is typically well developed, and fungal hyphae penetrate into plant root cells.

Difference between Ectomycorrhiza & Endomycorrhiza:

	Ectomycorrhiza	**Endomycorrhiza**
Definition	A form of mycorrhizal connection in which fungal hyphae do not penetrate	A form of mycorrhizae that allow fungal hyphae to enter

	Ectomycorrhiza	Endomycorrhiza
	deeply into the plant, i.e., the cortical cells	deep inside plants, such as cortical cells
Hyphal Mantle	Present	Absent
Prevalence	less prevalent (4%)	More prevalent (80%)
Hartig Net	Present	Absent
Arbuscules & Vesicles	Absent	Present
Fungi Involved	Basidiomycota, Ascomycota, & Zygomycota	Glomeromycotan
Plants	Primarily with Conifers and Hardwoods and are essential for woody plants and trees.	Almost 85% of vascular plants, such as orchids, shrubs, and foliage plants

Benefits of Mycorrhiza in Agriculture:

1. **Enhanced Nutrient Uptake:** Mycorrhizal fungi often extend much beyond root surfaces and multiply in soil pores too small for root hairs to penetrate, stimulating plants to decrease root biomass while increasing nutrient uptake capability. Vesicular arbuscular fungi are known to help plants take minerals from the soil, especially those that are not readily available, like phosphorus. AM improves plant growth and P absorption in low-phosphorus environments.

2. **Reduce need for fertilisers, thus saving cost:** Mycorrhizae aid in the absorption of nutrients by plants and improve the availability of nutrients such as phosphorus, nitrogen, zinc, and copper, which is a major nutrient for plants, and thus reduce need for fertilisers, which can lead to significant savings in fertiliser costs. The fungi help plants increase P absorption through their extended network of hyphae and by exploiting a larger volume of soil.
3. **Reduction of irrigation requirements and enhanced water uptake:** Through a variety of mechanisms, such as increased hyphae water uptake from the soil, altered hormone levels, changes in stomatal conductance, increased turgor due to lowered leaf osmotic potential, improved host nutrition, and enhanced plant recovery following drought by preserving the soil-root continuum, the arbuscular mycorrhizal symbiosis may mitigate plant responses to moderate moisture deficit.
4. **Alleviation of heavy metal stress:** According to the majority of reports, mycorrhizal inoculation promotes plant development in soils contaminated with metals. The ability of the comparatively large fungal biomass connected to host plant roots to adsorb or bind metals may be the cause of this protective advantage, since it may physically reduce or prevent metal access into host plants. Depending on the host plant and the source of the fungal isolate, arbuscular mycorrhizal fungi's protective reactions to metal toxicity in arbuscular mycorrhizal plants have varied but are typically present.
5. **Increased pathogen resistance:** By colonising plant roots, mycorrhizal fungi create a physical barrier that shields the plant from infection, thereby lowering pathogenic microorganism damage and enhancing host plant tolerance to disease.
6. **Improves plant health & stress resistance:** Arbuscular mycorrhizal fungi physiologically

modify above-ground tissue to improve tolerance to water stress and salinity by raising fluorescence, antioxidant activity, and chlorophyll levels. Consequently, crops grown under salt and drought have better nutritional value and grain biomass than areas without Arbuscular mycorrhizal fungi.

7. **Increased drought resistance:** Both high and low moisture levels can have an impact on the production and function of host plants when arbuscular mycorrhizal fungi are present. Compared to non-mycorrhizal plants, drought-stressed maize infected with Glomus exhibited greater levels of glucose, fructose, and total amino acids in its leaves and roots in greenhouse experiments. Arbuscular mycorrhizal colonisation enhanced wheat grain production, total plant and root biomass, number of tillers, and leaf area following the application of drought stress periods of varied duration and intensity.
1. **Improving soil structure**: In order to create stable aggregates that stop soil erosion, AM fungi create networks of hyphae that are more than 100 meters long. Even when they die, the hyphae keep soil aggregates together until they break down, increasing the amount of carbon in the soil. In order to unite these soil aggregates into macroaggregates, the hyphae also synthesise glomalin, a protein that is insoluble in water and functions as a glue. In addition to ensuring better water infiltration and drainage, decreased surface runoff and soil erosion, decreased losses of organic matter and nutrients, higher soil aeration, and greater retention of water and minerals—particularly phosphates—these soil macro-aggregations also help to further stabilise the soil structure.
2. **Promoting microbial diversity in the soil:** Secretions from arbuscular mycorrhizal fungi alter the rhizosphere's physio-chemical environment by producing more root exudates, which affect the makeup of the microbial population and how they function to increase soil fertility.
10. **Enhancing flowering & fruiting:** According to a number of findings, mycorrhizal symbiosis enhanced fruit biomass and nutrient accumulation. Early fruit blossoming, higher seed weight and number, and improved seed germination percentage were all facilitated by the mycorrhizal symbiosis.
11. **Increase yield and crop quality:** By boosting nutrient availability and translocation, AMF guarantees healthy plant growth. Crop plants are healthier as a result of the biocontrol of soil pathogens and improved stress tolerance. Plant productivity rises as a result. Additionally. Additionally, there is proof that AMF can increase dry matter accumulation and biomass, which will immediately increase food production and quality.

Overall, in agriculture, these benefits of mycorrhiza can increase crop productivity, improve sustainability, and promote healthier.

References

Begum, N., Qin, C., Ahanger, M. A., Raza, S., Khan, M. I., Ashraf, M. and Zhang, L. (2019). Role of arbuscular mycorrhizal fungi in plant growth regulation: implications in abiotic stress tolerance. *Frontiers in plant science*, *10*, 1068.

Lei Wang, Xin Chen, Sai Wang, Yeqin Du, Di Zhang and Zhanhui Tang. (2022). Effects of arbuscular mycorrhizal symbiosis on the growth and reproduction of cherry tomato can be persistent to the next generation, *European Journal of Soil Biology,* 112,103429.

Mohammadi, K., Khalesro, S., Sohrabi, Y. and Heidari, G. (2011). A review: beneficial effects of the mycorrhizal fungi for plant growth. *Journal of Applied Environmental and Biological Sciences*, ***1***(9), 310-319.

Schenck, N.C and G.S. Smith (1982). Responses of six species of vesicular-arbuscular mycorrhizal fungi and their effects on soybean at four soil temperatures. *New Phytol.,* 92: 193-201.

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PLANT PATHOGEN INTERACTIONS: INSIGHTS INTO PTI AND ETI MECHANISMS

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Abstract

Plants have evolved sophisticated immune systems to defend against a wide range of pathogens. Central to this defense are two primary immune responses: Pattern Triggered Immunity (PTI) and Effector Triggered Immunity (ETI). PTI is activated when plants recognize pathogen-associated molecular patterns (PAMPs) through pattern recognition receptors (PRRs) on the surface of plant cells, triggering a broad, basal immune response. In contrast, ETI is a more specific and often stronger defense mechanism, initiated when plants detect pathogen-secreted effectors via intracellular immune receptors, known as NLRs (nucleotide-binding leucine-rich repeat receptors). Although both PTI and ETI involve the activation of complex signaling networks, ETI typically leads to a more rapid and localized hypersensitive response, sometimes culminating in programmed cell death to limit pathogen spread. However, pathogens have evolved countermeasures to evade or suppress these immune responses, leading to an ongoing "arms race" between plant defenses and pathogen virulence strategies. Understanding the molecular mechanisms underlying PTI and ETI is crucial for improving plant resistance to diseases and enhancing crop protection strategies. This article explores the key components and interactions of PTI and ETI, their roles in plant-pathogen interactions, and their potential applications in sustainable agriculture.

Introduction

Plants employ two distinct layers of immunity to encounter pathogen invasion (Jones and Dangl, 2006). The first, evolutionarily ancient, layer involves the perception of evolutionarily conserved pathogen structures termed pathogen-associated molecular patterns (PAMPs) at the plasma membrane through conserved and ubiquitous receptors generally defined as pattern recognition receptors (PRRs). Binding to these receptors initiates an active defence response, so-called PAMP-triggered immunity (PTI), in both host and nonhost plants. In a second round of host-pathogen warfare, several microbial pathogens develop the ability to secrete effector proteins into the cytoplasm using type III secretion systems (T3SS) in bacteria. These effectors suppress PTI and result in the effector-triggered susceptibility.In response to pathogen effectors, plants have acquired additional receptors that specifically recognise the effectors, establishing a second layer of immunity known as the effector-triggered immunity (ETI). ETI is often associated with a hypersensitive response (HR), a plant-specific form of programmed cell death (PCD) at the infection sites, in many cases followed by systemic acquired resistance (SAR). The dynamic and continuous co-evolution between the two opponents stimulates on side of the pathogen the formation of novel effectors to suppress the ETI response .On the side of the host, new plant resistance (R) proteins are developed to recognise the obvious effectors to reconsolidate the ETI (Jones and Dangl, 2006). The understanding of PTI and ETI mechanisms is crucial for advancing plant immunity research and developing disease-resistant crops. In recent years, there has been significant progress in uncovering the molecular components involved in these immune responses, as well as how they interact to shape overall plant defense strategies. By elucidating the intricate molecular pathways underlying PTI and ETI, researchers can identify novel targets for improving disease resistance in crops, ensuring food security, and reducing reliance on chemical pesticides.

PAMP-triggered immunity

Activation of PTI depends on the perception of potential pathogenic structures by which plants can sense self or nonself (Akira *et al.*, 2006). These potential pathogenic structures, formerly known as “general elicitors” (Boller, 1995), but now called PAMPs, are conserved for a wide range of pathogens and are essential for microbial fitness and survival. Fungal chitin, elongation factor-Tu (EF-Tu), peptidoglycans, oomycete glucans, and eubacterial flagellin are classical examples.Recently, pathologists discovered that recognition of molecular structures can also occur in a class of microbes regardless of pathogenicity. These kinds of molecules are defined as microbe-associated molecular patterns (MAMPs), such as elicitins, ergosterol, and lipooligosaccharides. Additionally, some protein fragments from plant structures modified by pathogens are defined as damage-associated molecular patterns (DAMPs), such as cell wall fragment oligogalacturonides, cutin and systemin.

Perception of PAMPs is associated with a range of highly conserved structures on the plasma membrane, so-called pattern recognition receptors (PRRs). This class of proteins often consists of a domain containing an extracellular leucine-rich repeat (LRR) region and a cytoplasmic receptor-like kinase (RLK) domain, termed as LRR-RLK proteins (Fritz-Laylin *et al.*, 2005). Expression of LRR-RLK genes is triggered by bacterial infection as well as upon treatment with bacterial flagellin, lipopolysaccharides and fungal chitin.

When PAMPs are detected, early defence responses are usually triggered quickly. These responses include plasma membrane depolarisation, ion channel opening, mitogen-activated protein kinase (MAPK) cascades, WRKY transcription factor activation, reactive oxygen species (ROS) production, cell wall reinforcement, defense-related gene transcription, and phytoalexin accumulation. This is considered as a fundamental process common in all multicellular organisms, and are also important for nonhost immunity to microbial infection of whole plant species and for basal immunity in susceptible host plant species.

Role of PTI In Plant Disease Resistance:

PAMP-induced defenses in plants have been widely documented in early literature but the importance of PTI in plant disease resistance was largely overlooked because of a lack of genetic evidence. It has just become evident in the past ten years how important PTI is for plant disease resistance. PTI defence responses and general pathogen resistance are frequently compromised by mutations in PRRs. For example, Arabidopsis plants lacking FLS2 are completely defective in flg22-induced ROS accumulation, MAPK activation, and defense gene expression (Go´ mez-Go´ mez *et al.*, 1999). When fls2 plants are spray-inoculated, they show increased vulnerability to a virulent strain of P. syringae (Zipfel *et al*., 2004). The primary reason for the FLS2-mediated resistance to this strain is the restriction of bacterial access to the leaf tissue caused by PAMP-induced guard cell closure (Melotto *et al*., 2006). Agrobacterium tumefaciens is more likely to infect efr mutants, which are completely eradicated in all elf18 responses. An additional factor in explaining Arabidopsis's non-host resistance to a strain of P. syringae pv. tabaci, a disease that is unsuitable for Arabidopsis, is the flagellin gene fliC-induced defences (Li *et al*., 2005). Lastly, the identification of a new pair of PRR–PAMP interactions defined by XA21–Ax21 suggests that adaptable pathogens can be effectively restrained by activating PTI defences. In solanaceous plants, the heterologous expression of EFR excellently illustrates the potential use of PTI in improving crop plant disease resistance. It appears that EFR is unique to the Brassicaceae family. Broad-spectrum resistance to several bacterial diseases, such as P. syringae and Ralstonia solanecearum, is conferred by overexpression of Arabidopsis EFR in Nicotiana benthamiana and tomatoes (Lacombe *et al*., 2010).

Effector triggered immunity:

Current structural and functional analyses of several R proteins show that two common features—the nucleotide-binding (NB) and leucine-rich repeat (LRR) domains, or NLRs—are present. The presence or absence of a coiled coil (CC) or a Toll-interleukin 1-like receptor (TIR) at the N terminus determines the shape of other NLR domains. During pathogen invasion, a wide variety of NLRs are used by host plants to quickly identify effectors.NLRs selectively recognize the effectors, either directly or indirectly, and such recognition often leads to a hypersensitive response, a form of rapid localized programmed cell death.The immune responses elicited by PRRs and NLRs are similar, although the duration and amplitude of ETI responses are often vastly larger than those of PTI responses (Peng *et al*., 2018). However, it was reported that there is a hefty overlap in the transcriptional regulation during PTI and ETI. Surprisingly, the most recent studies reported that there is even a substantial linkage between NLR-mediated ETI and PRR-mediated PTI (Ngou *et al*., 2021; Yuan *et al*., 2021).

Pathogen effector recognition inside cells:

Direct NLR-Effector Interactions: One molecular interpretation of the gene-for-gene model, in terms of NLR-effector recognition, is that specific interaction between the receptor and its recognized (cognate) effector protein triggers resistance. The direct NLR-effector connection as the underlying mechanism of resistance specificity is in fact supported by yeast two-hybrid and in vitro interaction experiments of various NLR-effector combinations. The changeable LRR domain is a crucial factor in determining the recognition of particular effectors, as demonstrated by NLR mutational and domain swap experiments. According to the general NLR activation model, the recognition specificity between the flax L5 and L6 TNL allelic forms and the interacting flax rust (Melampsora lini) effector variant, AvrL567, relies on the receptor N-terminal TIR domains and involves multiple contact points within the receptor LRRs.

Indirect NLR Surveillance of Effector Activities: In order to keep up with the rapid development of pathogens, NLR indirect sensing of the actions of various pathogen effectors convergent on a few number of host proteins linked to the resistance signalling network may potentially expand the NLR recognition space. According to one indirect recognition paradigm, a pathogen effector that modifies a host factor that is attached to and watched over (or protected) by the NLR activates the receptor. The identification of the "modified self" is supported molecularly by the analysis of two

Arabidopsis plasma membrane CNL receptors, RPM1 (resistance to Pseudomonas syringae pv. maculicola 1) and RPS2 (resistance to Pseudomonas syringae 2).These receptors constitutively protect a host protein, RIN4 (RPM1-interacting protein 4), from various forms of interference by the P. syringae effectors AvrB, AvrRpm1, and AvrRpt2 (Axtell *et al*., 2003; Mackey *et al*., 2003). Immune signalling is triggered by RPM1 sensing AvrB-induced phosphorylation and cis/trans isomerisation along with conformational alterations of RIN4. RIN4 functions as a negative regulator of basal resistance when RPM1 and RPS2 are absent (Liu *et al*., 2009), and it seems that several bacterial effectors target it for modulation in that capacity (Wilton *et al*., 2010).

Building Receptor Signaling Complexes:

NLR Homo- and Heteromeric Associations: Genetic and molecular analyses have shown that two truncated forms, the Arabidopsis cytoplasmic TIR-NB protein CHS1 (chilling sensitive 1) and the related TIR-NB protein CHL1 (CHS1-like 1), are important for restricting TNL immunity to maintain plant growth and fitness over a range of environmental conditions (Wang *et al*., 2013). LRs might form their own N-terminal signaling platforms through homo or heteromeric NLR associations.

Signaling NLRs: NRC1 also signals in resistance and cell death responses triggered by other membrane receptors and some intracellular NLRs, suggesting that NRC1 represents a downstream convergence point in ETI initiated at various cell locations. Members of a conserved class of noncanonical CNLs also function in ETI downstream of NLR effector recognition and have been designated as helper NLRs (Bonardi *et al*.,2011; Collier *et al*.,2011). In Arabidopsis, three such CNLs—ADR1 (activated disease resistance 1), ADR1-L1, and ADR1-L2—transduce signals in ETI that lead to SA accumulation and resistance (Bonardi *et al*.,2011). The Arabidopsis ADR1 proteins also contribute to PTI and basal resistance against virulent bacteria, and an autoactive mutant form of ADR1-L2 causes a massive boost in SA, suggesting that ADR1-L2 is part of a resistance amplification loop involving SA accumulation (Roberts *et al*., 2013).

The Effector-Triggered Immunity Signaling Network:

Direct transcriptional control by activated NLRs: As previously stated, nuclear accumulation is necessary for the function of numerous nucleocytoplasmic NLRs in ETI. The WRKY transcription factor OsWRKY45, which is also necessary for Pb1-mediated rice blast fungal resistance, interacts with the rice CNL receptor Pb1 via its CC domain to regulate ETI (Inoue *et al*., 2013).In nonactivated rice cells, OsWRKY45 is degraded by the 26S proteasome. The presence of nuclear Pb1 protects OsWRKY45 from proteasome degradation, thereby enhancing OsWRKY45 accumulation and, presumably, its defense transcriptional activity (Inoue *et al*.,2013; Matsushita *et al*., 2012).

Indirect NLR Transcriptional Reprogramming: For example, the Arabidopsis CNLs RPM1, RPS2, and RPS5 associate with the plasma membrane, where they intercept effector activities, and activated RPM1 remains at the plasma membrane . Numerous studies have linked MAPK-regulated signalling circuits to plant immunity. In eukaryotes, MAPK cascades phosphorylate substrates like transcription factors to connect inputs to downstream outputs (Meng *et al*., 2013).The functionally redundant Arabidopsis MAPKs MPK3 and MPK6 interact with and phosphorylate the WRKY transcription factor WRKY33 to regulate transcription (Li G *et al*.,2012; Mao G *et al*.,2011). Transcriptional reprogramming is triggered by the MPK3 and MPK6 phosphorylation relay, which is triggered by the activated plasma membrane CNLs RPS2 and RPM1. Nuclear RPS4-induced Arabidopsis ETI has much reduced MAPK activation.

Regulation of PTI by ETI:
PTI and ETI seem to have a reciprocal affect. Recent research has demonstrated that one significant aspect of ETI is the overexpression of PTI components.Activation of multiple NLRs (i.e. RPM1, RPS2, RPS5, RPS4 and RPP4) triggers transcript and protein accumulation of multiple PRR signalling components, including BAK1, SOBIR1, BIK1/PBLs, RBOHD and MPK3 in a PTIindependent manner (Yuan *et al*.,2021; Ngou *et al*.,2021). In a similar manner, WIPK, an ortholog of Arabidopsis MPK3, is synthesised from scratch when the N protein, a TNL that gives Nicotiana tabacum resistance to tobacco mosaic virus, is activated. In addition, the ETI activation by RRS1/RPS4, which mediates resistance against the fungal pathogen Colletotrichum higginsianum in Arabidopsis potentiates ROS production and cell death triggered by the fungal PAMP chitin (Ngou *et al*.,2021). These imply that the PTI response elicited by several PAMPs can be amplified by ETI activated by distinct effecting agents.

Overlapping immune responses in PTI and ETI:
ROS production: Both PTI and ETI induce ROS, which are essential defence and signalling molecules. In contrast to PTI, which causes a quick and fleeting ROS burst, ETI causes a biphasic burst, with the second peak typically being stronger and longer-lasting than the first. The processes by which ROS are produced in PTI have been thoroughly investigated. Multiple PTI-associated protein kinases, including BIK1/PBLs, CPKs, SIK1 and CRK2, directly phosphorylate RBOHD to trigger extracellular ROS production in Arabidopsis (Zhang *et al*.,2018; Li L *et al*., 2014). Phosphorylation of RBOHD at Ser343 and Ser347 residues is crucial for ROS formation in both PTI and ETI, and RBOHD also mediates the creation of ROS during RPS2-initiated and RPM1-initiated ETI (Torres *et al*., 2002).

Ca2+ influx: Activation of PRR signalling leads to a fast and transient Ca2+ influx into the plant cell and Ca2+ influx is important for many subsequent immune responses, including ROS production and stomatal immunity (Thor *et al*.,2020). NLR signalling, on the other hand, induces a slower but longerlasting Ca2+ influx.

MAPK activation: One of PRR signaling's well-known characteristics is the rapid activation of the MAPK cascade, whereas NLR signalling causes a slower but more persistent MAPK activation.While the RLCK-family kinases directly phosphorylate MAPKKKs following PAMP perception during PTI (Yamada *et al*.,2016), how NLR signalling activates MAPK cascade remains to be elucidated.

Conclusion
In conclusion, Pattern Triggered Immunity (PTI) and Effector Triggered Immunity (ETI) are two key defense mechanisms that help plants protect themselves from pathogens. PTI provides an early, broad defense by recognizing general features of pathogens, while ETI offers a stronger, more specific response to particular pathogens when they try to interfere with plant cells. Together, these systems help plants fight off infections and reduce damage.However, pathogens constantly evolve to overcome plant defenses, creating an ongoing battle between plant immunity and pathogen attacks. Understanding how PTI and ETI work is essential for developing crops that are more resistant to diseases. This knowledge could lead to the creation of plants that need fewer chemicals and can grow better in challenging conditions.By continuing to study these immune systems, we can improve agricultural practices, make crops more resilient, and ensure food security, all while reducing the environmental impact of farming. Ultimately, a deeper understanding of PTI and ETI will help us develop more sustainable solutions for growing healthy, disease-resistant crops.

Reference

Akira S, Uematsu S and Takeuchi O (2006). Pathogen recognition and innate immunity. Cell 124: 783-801.

Axtell M.J and Staskawicz B.J (2003). Initiation of RPS2-specified disease resistance in Arabidopsis is coupled to the AvrRpt2-directed elimination of RIN4. Cell 112:369–77.

Boller T (1995). Chemoperception of microbial signals in plant cells. Annual Review of Plant Physiology and Plant Molecular Biology 46:189-214.

Bonardi V, Tang S, Stallmann A, Roberts M, Cherkis K, Dangl J.L (2011). Expanded functions for a family of plant intracellular immune receptors beyond specific recognition of pathogen effectors. PNAS 108:16463–68

Collier S.M, Hamel L.P, Moffett P (2011). Cell death mediated by the N-terminal domains of a unique and highly conserved class of NB-LRR protein. Mol. Plant-Microbe Interact. 24:918–31

Fritz-Laylin L.K, Krishnamurthy N, Tor M, Sjolander K.V, Jones JDG (2005). Phylogenomic analysis of the receptor-like proteins of rice and Arabidopsis. Plant Physiology 138: 611-623.

Go´ mez-Go´ mez, L, Felix, G and Boller T (1999). A single locus determines sensitivity to bacterial flagellin in Arabidopsis thaliana. Plant J. 18, 277–284.

H, Hayashi N, Matsushita A, Xinqiong L, Nakayama A, *et al*. (2013). Blast resistance of CC-NB-LRR protein Pb1 is mediated by WRKY45 through protein-protein interaction. PNAS 110:957

Jones J.D, Dangl J.L (2006). The plant immune system. Nature 444:323-329.

Lacombe, S., *et al*. (2010). Interfamily transfer of a plant patternrecognition receptor confers broad-spectrum bacterial resistance. Nat. Biotechnol. 28,365–369.

Li G, Meng X, Wang R, Mao G, Han L, *et al*. (2012). Dual-level regulation of ACC synthase activity by MPK3/MPK6 cascade and its downstream WRKY transcription factor during ethylene induction in Arabidopsis. PLOS Genet. 8: e1002767

Li L, Li M, Yu L, Zhou Z, Liang X, Liu Z, Cai G, Gao L, Zhang X, Wang Y *et al*. (2014). The FLS2-associated kinase BIK1 directly phosphorylates the NADPH oxidase RbohD to control plant immunity. Cell Host Microbe 15:329-338.

Li, J. (2005). Brassinosteroid signaling: from receptor kinases to transcription factors. Curr. Opin. Plant Biol. 8, 526–531.

Liu J, Elmore JM, Fuglsang AT, Palmgren MG, Staskawicz BJ, Coaker G. (2009). RIN4 functions with plasma membrane H+-ATPases to regulate stomatal apertures during pathogen attack. PLOS Biol. 7: e1000139.

Mackey D, Belkhadir Y, Alonso JM, Ecker JR, Dangl JL. (2003). Arabidopsis RIN4 is a target of the type III virulence effector AvrRpt2 and modulates RPS2-mediated resistance. Cell 112:379–89.

Mao G, Meng X, Liu Y, Zheng Z, Chen Z, Zhang S. (2011). Phosphorylation of a WRKY transcription factor by two pathogen-responsive MAPKs drives phytoalexin biosynthesis in Arabidopsis. Plant Cell 23:1639–53.

Matsushita A, Inoue H, Goto S, Nakayama A, Sugano S, *et al*. (2012). The nuclear ubiquitin proteasome degradation affects WRKY45 function in the rice defense program. Plant J. 73:302–13.

Melotto, M., Underwood, W., Koczan, J., Nomura, K., and He, S.Y. (2006). Plant stomata function in innate immunity against bacterial invasion. Cell. 126, 969–980.

Meng X, Zhang S (2013). MAPK cascades in plant disease resistance signaling. Annu. Rev. Phytopathol. 51:245–66.

Ngou B.P.M, Ahn H.K, Ding, P, Jones, J.D.G (2021). Mutual potentiation of plant immunity by cell-surface and intracellular receptors. Nature. 592(7852):110-115.

Peng Y, van Wersch R, Zhang Y (2018). Convergent and Divergent Signaling in PAMP-Triggered Immunity and Effector-Triggered Immunity. Mol. Plant Microbe Interact 31, 403–409.

Roberts M, Tang S, Stallmann A, Dangl J.L, Bonardi V (2013). Genetic requirements for signaling from an autoactive plant NB-LRR intracellular innate immune receptor. PLOS Genet. 9: e1003465

Thor K, Jiang S, Michard E, George J, Scherzer S, Huang S, Dindas J, Derbyshire P, Leitao N, DeFalco TA et.al., (2020). The calciumpermeable channel OSCA1.3 regulates plant stomatal immunity. Nature 585:569-573.

Torres M.A, Dangl J.L, Jones J.D (2002). Arabidopsis gp91phox homologues AtrbohD and AtrbohF are required for accumulation of reactive oxygen intermediates in the plant defense response. Proc Natl Acad Sci USA 99:517-522.

Wang Y, Zhang Y, Wang Z, Zhang X, Yang S (2013). A missense mutation in CHS1, a TIR-NB protein, induces chilling sensitivity in Arabidopsis. Plant J. 75:553–65

Wilton M, Subramaniam R, Elmore J, Felsensteiner C, Coaker G, Desveaux D (2010). The type III effector HopF2 Pto targets Arabidopsis RIN4 protein to promote Pseudomonas syringae virulence. PNAS 107:2349–54

Yamada K, Yamaguchi K, Shirakawa T, Nakagami H, Mine A, Ishikawa K, Fujiwara M, Narusaka M, Narusaka Y, Ichimura K *et al*., (2016). The Arabidopsis CERK1-associated kinase PBL27 connects chitin perception to MAPK activation. EMBO J, 35:2468- 2483.

Yuan M, Jiang Z, Bi G, Nomura K, Liu M, Wang Y, Cai B, Zhou J.M, He S.Y, Xin X.F (2021). Pattern-recognition receptors are required for NLR-mediated plant immunity. Nature 592(7852):105-109.

Zhang M, Chiang Y.H, Toruno T.Y, Lee D, Ma M, Liang X, Lal N.K, Lemos M, Lu Y.J, Ma S *et al*., (2018). The MAP4 kinase SIK1 ensures robust extracellular ROS burst and antibacterial immunity in plants. Cell Host Microbe 24:379-391.e5.

Zipfel C, Robatzek S, Navarro L, Oakeley E.J, Jones J.D, Felix G, and Boller T (2004). Bacterial disease resistance in Arabidopsis through flagellin perception. Nature. 428, 764–767.

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POST-HARVEST TECHNOLOGY FOR ORGANIC PRODUCE: CHALLENGES AND OPPORTUNITIES

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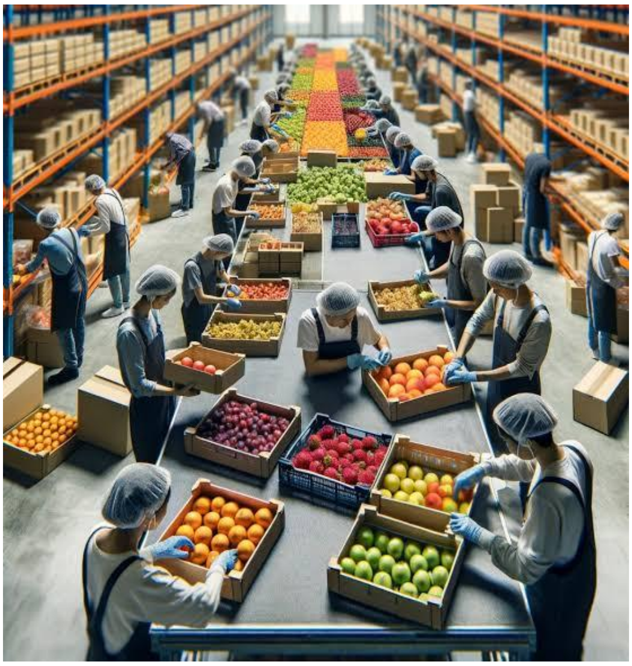
Introduction

Organic farming emphasizes natural cultivation methods that exclude synthetic chemicals, making it a sustainable and health-conscious choice. However, these benefits come with significant challenges in post-harvest management, as organic produce is highly perishable and sensitive to environmental factors. Effective post-harvest technologies tailored for organic produce can minimize losses, maintain quality, and meet the growing consumer demand. This article provides a detailed exploration of the challenges and opportunities in managing organic produce post-harvest.



Challenges in Post-Harvest Management for Organic Produce

1. Short Shelf Life

Organic produce lacks synthetic preservatives, making it more prone to rapid spoilage. For instance, fruits like berries and tomatoes are highly perishable and require immediate processing or distribution.The absence of wax coatings or chemical dips reduces resistance to water loss and microbial attack, leading to faster deterioration.

2. Pest and Microbial Infestations

Without post-harvest chemical treatments, organic produce is more vulnerable to pests such as fruit flies, storage pests, and fungal diseases. Microbial spoilage, including mold and bacteria, is a persistent issue, particularly in humid storage conditions.

3. Temperature and Humidity Sensitivity

Organic produce requires precise storage conditions, often with narrow temperature and humidity ranges, to prevent decay. Inadequate access to affordable cold chain infrastructure in many developing regions exacerbates spoilage risks.

4. High Transportation Costs

Organic produce often needs to travel long distances to reach niche or premium markets, which increases the risk of spoilage during transit. Cold chain logistics, while effective, are often energy-intensive and expensive.

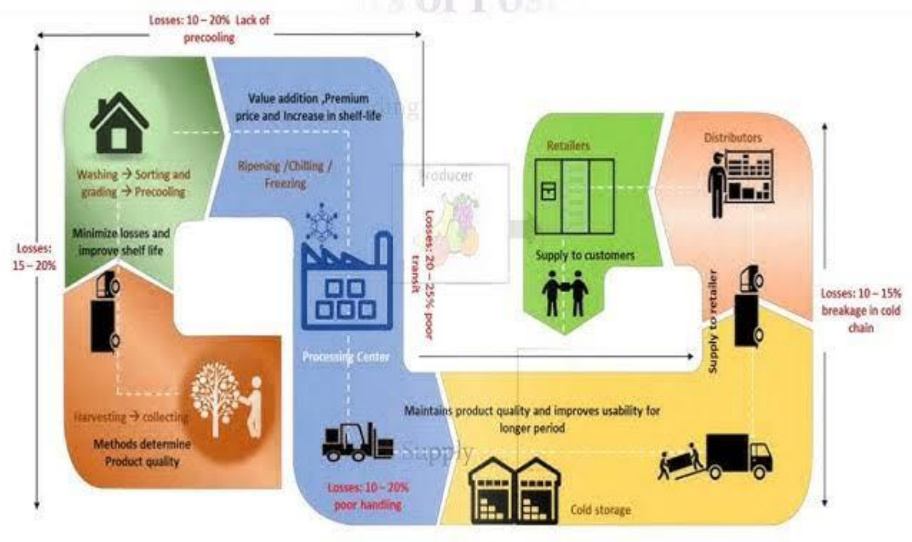
5. Compliance with Organic Standards

Maintaining organic certification throughout the post-harvest process is challenging, requiring strict adherence to standards that restrict certain preservatives and handling methods. Any deviation from these standards can compromise the organic label and lead to market rejections.

6. Lack of Access to Technology

Smallholder organic farmers, particularly in developing countries, lack access to affordable post-harvest technologies. This often results in higher losses and reduced profitability.

Different stages of product value chain and losses incurred at each stage



Opportunities in Post-Harvest Technology for Organic Produce

1. Eco-Friendly Preservation Techniques

- *Edible Coatings*: Natural coatings made from aloe vera, beeswax, or essential oils can extend shelf life by forming a protective barrier against moisture loss and microbial growth.
- *Natural Antimicrobials*: Plant-based extracts and probiotics can be used to inhibit the growth of pathogens, ensuring longer freshness without synthetic chemicals.

2. Advanced Packaging Solutions

- *Modified Atmosphere Packaging (MAP):* Adjusting gas composition in packaging can slow down respiration and ripening processes, effectively extending shelf life.
- *Biodegradable Packaging*: Materials made from cornstarch, cellulose, or bagasse align with the organic ethos and appeal to eco-conscious consumers.

3. Renewable Energy-Powered Cold Chains

Solar-powered refrigeration units and cold storage facilities provide sustainable solutions for preserving organic produce in regions with limited energy infrastructure. Portable cooling units are being developed for small-scale farmers to transport produce to markets without spoilage.

4. Non-Thermal Processing Technologies

- *Ozone Treatment*: Ozone gas can be used to control microbial spoilage in organic produce, such as bananas and grapes, without leaving chemical residues.
- *Pulsed Electric Fields (PEF):* This technology disrupts microbial cells, prolonging freshness while preserving the nutritional quality of the produce.

5. Digital Tools for Quality Monitoring

- *Blockchain Technology*: Ensures traceability throughout the supply chain, enhancing consumer confidence in the organic label.
- *IoT Sensors*: Real-time monitoring of temperature, humidity, and gas levels in storage and transit ensures optimal conditions for organic produce.

6. Collaborative Models for Shared Resources

Farmer cooperatives can pool resources to access post-harvest infrastructure, such as shared cold storage, drying facilities, and packaging units. Partnerships with private companies or government programs can help smallholder farmers adopt advanced post-harvest technologies at reduced costs.

Case Studies and Real-World Applications

- *Solar Drying for Organic Produce*: In India, farmers use solar dryers to process organic spices and herbs, such as turmeric and mint. This low-cost, energy-efficient method reduces spoilage and enhances product value.
- *Ozone Treatment in Banana Ripening*: Organic banana growers in Latin America utilize ozone technology in ripening chambers to control fungal growth, extending shelf life without synthetic treatments.
- *Blockchain for Organic Certification*: Coffee cooperatives in Ethiopia use blockchain platforms to trace organic coffee from farm to cup, ensuring compliance with organic standards and enhancing market value.
- *Controlled Atmosphere Storage for Apples*: Organic apple growers in Europe employ controlled atmosphere storage systems to regulate oxygen and carbon dioxide levels, preserving the fruit for up to six months without synthetic preservatives.

Economic and Environmental Benefits

- *Economic Gains*: Reducing post-harvest losses increases farmer incomes and improves profitability in the organic produce supply chain. Value-added products, such as dried organic fruits and herbal teas, create additional revenue streams for farmers.
- *Environmental Impact*: Eco-friendly packaging and renewable energy solutions align with the sustainability goals of organic farming. Reduced food waste minimizes greenhouse gas emissions associated with spoilage and decomposition.
- *Consumer Trust and Market Growth*: Technologies that ensure quality, traceability, and sustainability enhance consumer confidence in organic products, driving market growth.

Conclusion

Post-harvest management of organic produce presents both challenges and opportunities. While issues like perishability, pest infestations, and logistical costs persist, innovations in preservation techniques, packaging, renewable energy, and digital technology offer transformative solutions. By investing in sustainable and accessible post-harvest technologies, the organic agriculture sector can meet growing consumer demand, reduce losses, and ensure long-term viability. Governments, private sectors, and farmers must collaborate to create inclusive and efficient systems that support the organic movement and contribute to global food security. By observing the above content, we can understand the critical need for targeted post-harvest interventions to sustain and grow the organic produce industry in an increasingly competitive and sustainability-focused world.

References

Kader, A.A., 2002. *Postharvest Technology of Horticultural Crops*. 3rd ed. Oakland: University of California, Agriculture and Natural Resources.

Ray, R.C. and Ramachandran, S., 2018. *Microbial Biotechnology in Horticulture: Volume 3.* Boca Raton: CRC Press.

Kitinoja, L. and Kader, A.A., 2015. *Small-Scale Postharvest Handling Practices: A Manual for Horticultural Crops*. 5th ed. Davis: University of California.

Wills, R., McGlasson, B., Graham, D. and Joyce, D., 2007. *Postharvest: An Introduction to the Physiology and Handling of Fruit, Vegetables, and Ornamentals*. 5th ed. Wallingford: CABI.

Singh, M., Pal, R.K. and Sachdev, Y., 2013. *Postharvest Management and Processing of Fruits and Vegetables*. New Delhi: New India Publishing Agency.

Prasad, K., 2020. *Sustainable Postharvest Handling of Fruits and Vegetables*. Boca Raton: CRC Press.

Nunes, M.C.N., 2008. *Color Atlas of Postharvest Quality of Fruits and Vegetables*. 1st ed. Hoboken: Wiley-Blackwell.

FAO, 2011. *Global Food Losses and Food Waste: Extent, Causes and Prevention* . Rome: Food and Agriculture Organization of the United Nations.

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POTASSIUM DEFICIENCY IN VEGETABLES AND FRUITS

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Abstract

Potassium (K) deficiency is a problem in Indian soils due to inadequate K fertilization and imbalanced use of fertilizers. This can lead to smaller crop yields and soil fertility issues. The use of NPK fertilizers is often imbalanced, which can lead to K deficiency. The current fertilizer recommendations are outdated and need to be revised. This paper aims at creating awareness about potassium deficiency symptoms in vegetables and fruits to diagnose the deficiency and suggest corrective measures.

Introduction

In India, the removal of K is more or less equivalent to its uptake for field crops as their residues are mostly removed from the fields after harvesting. Crop residues and animal excreta (dung) generally find use as a source of energy for cooking and heating in rural areas, rather than recycling them back to the fields. Crop residues have plenty of other uses in rural households in India, prompting their removal from the crop fields or burning. On top of that, K fertilization is either nil or severely inadequate in many parts of the country, including the intensively cultivated areas.

Though local recommendations advocate proper balance among N, P, and K fertilizers, most farmers opt for N only or N and P with little or no K fertilizer. Surveys conducted in upper and trans-Gangetic Plains of India revealed that most of the farmers apply N at more than recommended rates, along with P at nearly recommended rates, but apply far more minor than recommended rates of K if applied at all. One of the primary reasons behind the neglect of K fertilization in India is the general belief that Indian soils are inherently abundant in K reserves owing to K-containing minerals and can support crops without K fertilization. Secondly, as India is almost 100% dependent on imports for K fertilizers, there has always been an attempt to curtail K fertilization to reduce the burden on the national exchequer. Next comes the rise in K fertilizer prices after decontrol in August 1992 after decontrol and the introduction of nutrient-based subsidy in April 2010 which further worsened the situation. These approaches of providing nutrients to the crops is responsible for mining of soils nutrient capital which created the problem of potassium deficiency in soils. Potassium deficiency is made worse by acidic soils (low pH), sandy or light soils (leaching), drought conditions, high rainfall (leaching) or heavy irrigation, heavy clay (illite) soils, soils with low K reserves, and magnesium rich soils. The purpose of this paper is to create awareness about potassium deficiency symptoms in fruits and vegetables to diagnose the deficiency and suggest corrective measures.

Deficiency Symptoms

Sugar beets: The first sign of K deficiency appears as tanning and leathering of the edges of recently matured leaves.When the soil solution is very low in Na, a severe interveinal leaf scorch and crinkling proceeds to the midrib (Photo 1).Under high Na conditions, tanning and leaf scorch lead toa smooth leaf surface.

Photo 1. Potassium-deficiency symptoms in Sugar beets leaves (Left) and ground part (Right)

Potatoes: Upper leaves usuallysmaller, crinkled and darker greenthan normal with small necrotic patches, middle to lower leaves show marginal scorch and yellowing.Early indicator: dark green, crinkled leaves, though varieties differ in normal leaf colour and texture. Tuber size is much reduced and crop yield is low. The leaves of the plant appear dull and are often blue-green in colour with interveinal chlorosis. Leaves will also develop small, dark brown spots on the undersides and a bronzed appearance on the upper surfaces (Photo2).

Cucumber: Growth is stunted, internodes remain short and leaves small. Older leaves are bronzed and discolored yellowish green at the margins; the main veins are sunken. At a later stage interveinal chlorosis becomes more pronounced and extends towards the center of the leaf; it is followed by necrosis. Leaf margins desiccate but the veins remain green for some time. Symptoms spread from the base towards the top of the plant, the oldest leaves being worst affected (Photo 3).

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Photo 2. Early Potassium Deficiency symptoms (Left), Late Potassium deficiency symptoms in potato (Right) ana close view of the deficiency at early growth stage (Bottom)

Photo 3. Potassium-deficiency symptoms in Cucumber

Tomato: In tomatoes, the stems are woody and growth is slow. Leaves are blue-green in colour, and the interveinal area often fades to a pale grey colour. Leaves may also have a bronzed appearance and yellow and orange patches may develop on some of the leaflets. Fruits often ripen unevenly and sometimes have green patches near the stalks (Photo 4).

Photo 4. Early (Left) and Late (Middle) potassium-deficiency symptoms on leaves and on fruit (Right) of tomato

Brinjal: Potassium deficiency in brinjal, or eggplant, can cause leaves to turn yellow and brown, and the tips to curl. The deficiency usually affects older leaves first. Plants grow slowly and have poorly developed root systems. Stalks are weak and lodging is common. Fruit quality and yield are poor.

Photo 5. Potassium-deficiency symptoms in Brinjal

Grape: Intercostal chlorosis starts on the leaf margins and spreads to the internal area of mature leaves. At the margins, necrotic zones develop. The veins remain green for a certain time **(Photo 6)**. Potassium deficiency results in different symptoms, dependent on the date of appearance and the weather conditions.

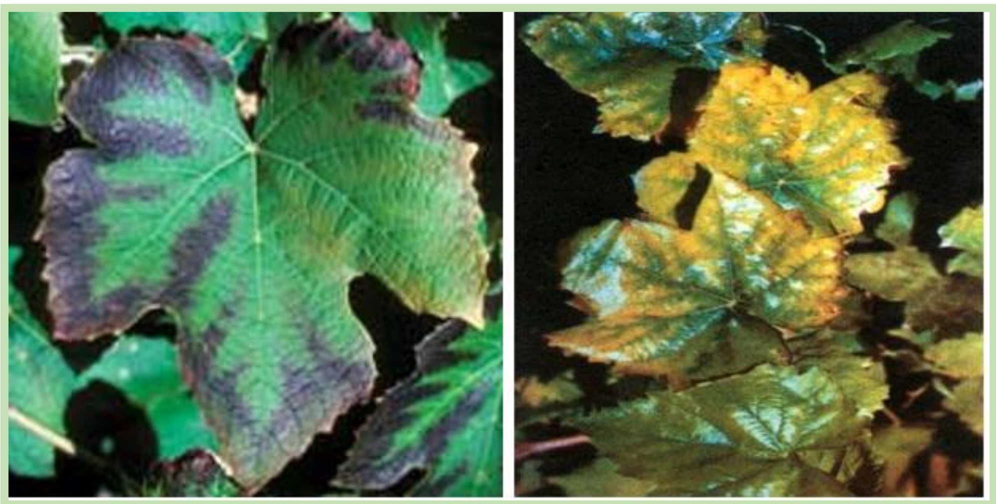

Photo 6. Early (Left) and Late (Right) deficiency symptoms of potassium in grapes

Apples: Potassium deficiency is characterized by a scorching of leaf margins often called "leaf scorch". The scorch and leaf rolling appears first on basal or spur leaves and progresses upward toward the younger leaves. Margins may first appear light green and later turn necrotic. Necrosis starts at the margin and progresses inward toward the midrib **(Photo 7)**. Leaves may appear tattered as necrotic areas fall off. Symptoms may also be accompanied by leaf abscission. Scorching is typically most severe on older basal leaves and becomes less apparent on the most apical leaves. Symptoms usually develop late in the season on slightly deficient trees or earlier if the shortage is acute. K deficiency may also reduce colour of fruit. Potassium deficient fruit will have a lower pressure test and poorer flavour. K deficient trees will be more prone to winter injury. Fruits often have a slightly acidic or woody taste, poor storage, shipping and canning qualities in fruit.

Photo 7. Potassium-deficiency symptoms in Apple

Potassium deficiency and plant disease

For many species, potassium-deficient plants are more susceptible to frost damage and certain diseases than plants with adequate potassium levels. Increased disease resistance associated with adequate potassium levels indicates that potassium has roles in providing disease resistance, and increasing the potassium levels of deficient plants have been shown to decrease the intensity of many diseases *(Defra 2010)*. However, increasing potassium concentration above the optimal level does not provide greater disease resistance (Datnoff et al. 2007). In agriculture, some cultivars are more efficient at K uptake due to genetic variations, and often these plants have increased disease resistance (Datnoff et al. 2007). The mechanisms involved with increased host resistance and potassium include a decreased cell permeability and decreased susceptibility to tissue penetration. Silica, which is accumulated in greater quantities when adequate potassium is present, is incorporated into cell walls, strengthening the epidermal layer which functions as a physical barrier to pathogens. Potassium has also been implicated to have a role in the proper thickening of cell walls (Datnoff et al.2007). To aid in potassium deficiency, farmers and many monoculture crop producers use vermiculite as a form of nutrition, soil aeration assistance as well as water retention to aid in nutrient poor environments (Wang et al. 2013).

Corrective Measures

Sources of potassium: There are a limited number of fertilizer materials that can supply K when needed. Potassium chloride (muriate of potash) has the highest K_2O equivalent at 60%. Other options include potassium sulphate (50%), potassium nitrate (44%), mono potassium phosphate (0:52:34), potassium magnesium sulphate (sul-po-mag) (22% K, 11% Mg) and poly-halite (Poly 4) dihydrated potassium, calcium, and magnesium sulphate ($K_2Ca_2Mg(SO_4)_4 \cdot 2H_2O$). Poly-halite has 19.2% S, 14% K_2O (11.6% K), 6% MgO (3.6% Mg) and 17% CaO (12.2% Ca), all in available form for plant uptake. Recently, a new fertilizer wherein the potash is derived from the molasses, a by-product of sugar mills named as Natural potash (14% K_2O) is also available in the market. Besides, a few fully water soluble NPK grades (18:18:18, 19:19:19) are available for foliar spray and fertigation. Wood ash also has high potassium content but must be used cautiously due its effect on pH level. Adequate moisture is necessary for effective K uptake; low soil water reduces K uptake by plant roots. Liming acidic soils can increase K retention in some soils by reducing leaching.

Rate of Potassium Application: Potassium deficiency in standing crops can be corrected quickly by foliar spray of 1% solution of high K containing fully water-soluble potassium sulphate (0:0:50). potassium nitrate (44%) or mono potassium phosphate (0:52:34) @ 10 gm/litre water to correct severe K deficiency. NPK grades (18:18:18, 19:19:19) can be used for foliar spray @ 10 gm/litre water to correct mild K deficiency. Soil application of muriate of potash, Poly halite (Poly 4), K– Mag etc. @ 40-60 kg K_2O/ha can help correcting K deficiency. There are several ways to naturally add K to the soil including composting, using green manure and wood ash to correct K deficiency in plants.

References

Datnoff, L.E. et al. (2007) Mineral Nutrition and Plant Disease. The American Phyto pathological Society, ISBN 0-89054-346-1.

Wang, Min; Zheng, Qingsong; Shen, Qirong; Guo, Shiwei (2013). The critical Role of Potassium in Plant Stress Response. *International Journal of Molecular Sciences*. **14** (4): 7370–7390.

Defra (2010). Fertiliser manual (RB209) (8th ed.). Norwich: TSO. ISBN 9780112432869

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THE VITAL ROLE OF SPIDERS IN AGRICULTURAL PEST MANAGEMENT

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Abstract

The management of arthropod pests in agriculture is a hot topic, the role of spiders as excellent biological control agents remains very often disregarded. Its generalistic predatory habits also serve essential services in controlling arthropods while minimizing the usage of insecticides. The main aim of this article is to analyse the environmental importance of spiders in agriculture, physical characterization of the species, their function in pest control and effects of pesticides. In addition, we consider ways to improve the provision of spider friendly structures in farming systems with specific emphasis given to their role in promoting sustainable agriculture.

Introduction

Spiders have always been less considered in the role that they play when it comes to pest management in agricultural fields mainly being viewed as fearsome creatures. However, these arachnids are perfect and very effective predators with great impacts in the regulation of pests. As more imbibed safety measures with chemical pesticides were causing demise of many species and polluting environment, demand for more integrating knockdown agents such as spiders have also risen, (Hodge M.A. 1999). According to the spider data expected in the year 2024, there are about 51,914 spider species in the world and 1,981 species are endemic to India. Based on many researchers' spiders are very important in conservation agriculture especially in greenhouse and organic farming since they reduce harm full insects. They also act as biomarkers or surrogates in the environment meaning they represent overall environmental conditions. The change of direction towards IPM has emphasized the role of non-chemical approaches, where spiders could really help out. Studies show that spiders are capable of pest suppression including planthoppers and leafhoppers in different agricultural ecosystems. However, understanding of the ecological functions of spiders still lacks much attention and thus, there should be increased incorporation of spiders into pest control systems to improve agricultural production, (Marc, *et al*., 1999).

Physical Characteristics of Spiders

Spiders, which belongs to the class Arachnida, a part of phylum Arthropoda. They are characterized by 8 legs, a distinct body structure divided into 2 segments, as the cephalothorax and the abdomen, and an exoskeleton that offers protection against external threats. This hard-outer layer helps prevent injury and water loss, enabling spiders to thrive in diverse environments, from tropical jungles to arid deserts. Although spiders present in almost every region on Earth, they are notably absent from Antarctica due to extreme cold conditions. Unlike insects, spiders predominantly occupy terrestrial habitats.

Spiders as Natural Predators

There are over 40,000 species of spiders, who can inhabit absolutely different territories and perform different methods of predatory behaviour, that let them capture any insects. This is particularly important with regard to pest populations as these can be different in different areas of agriculture. Reports have estimated that they can help control pest insects in crops such as rice that targets other potentially damaging insects such as planthoppers and leafhoppers. In the past, scientific studies have found generic value of spiders as natural control agents in specified areas of pest prevalence especially in temperate zone where it was found that spiders could effectively balance with pests. Despite an understanding that they are potential biocontrol agents, their relevance in decreasing pest populations density and abundance has been over looked, although documented, (Greenstone M.H. 1999).

The Role of Spiders in Agriculture

Contribution to Pest Management:

It is a fact that spiders are carnivores whose diet is mainly insects that they capture and take at least 10 to 15 insects per day depending on the size. It is very important for pest control, especially in farm areas to maintain balance of the numbers of such pests. Spiders employ various predation strategies: Some venom is used to paralyse its prey whilst, others secrete chemicals that liquefy the insides of their prey making it easier for them to swallow. Its aggressive nature makes it appropriate for the protection of crop vegetation, due to its capacity to go after a number of pests in agricultural industries, such as aphids, caterpillars and beetles. Spiders help to minimize the use of chemical pesticides which are not only bad for the environment, but bad for human beings as well, (M Darlene *et al*., 2003).

Crop-Specific Contributions: Spiders play a critical role in protecting various crops from harmful insects:

Paddy Crops: The brown planthopper is one of the most destructive pests which attack rice crops. One helpful spider pointed out to include within the farm are the Lycosidae family, particularly *Pardosa pseudonulata*, because they feed on this pest, thus reduces crop loss, (Khan, *et al*., 2003).

Cotton Crops: Pests affecting yields in the cotton fields are mainly whiteflies and thrips. Predator species belongs to the Oxyopidae family, including *Peucetia viridana* and *Oxypus salticus*, are responsible for the presumption decrease of these pests.

Cabbage Crops: In Pauni Chak of Jammu it has been proved that *Pardosa altitudis* maintains aphids in the cabbage thus contributing to effective growth of crops. The examples discussed above gives an idea, how spiders support agricultural pests control hence high yields and low chemical pesticide use.

Spiders as Predators in Agricultural Ecosystems:

Birds feeding on plant matters are common in farms, hence herbivores have to be controlled through predation. If the predators such as spiders are reduced, then this implies that herbivores too are likely to increase hence leading to more crop damage. The problems mentioned above can be solved by creating strong perspectives of spiders. There is an excess of 3,500 reported spider types in North America, numerous of which prey on destructive nuisance bugs. For instance, the two families of orb web building families of spiders Araneidae and Tetragnathidae feeds on different pest species such as Diptera and Homoptera. Other members like Lycosidae and Oxyopidae are predatory and predatory spiders with an extensive and diverse range of insects that makes spiders efficient bio control agents, (Saurabh, *et al*., 2013).

Reducing and Stabilizing Pest Densities:

For effective predation to occur, predators must not only suppress pest levels beneath economic levels, but they must also balance such populations in the long-run. In achieving this primary role, spiders employ several tactics comprising of wasteful killing, functional and numerical responses and prey specializations. They help enhance their capability to introduce top - down influence on pests, which in any case would compromise crop yield. It appears that spiders can control herbivore numbers by both direct consumption of the pests as well as modifying their behavior. For instance, it has been evidenced that phytosocial spiders can reduce feeding by spotted cucumber beetles on squash plant even when the spiders and the beetles are in two different zones. Similarly, within the context of IPM, spiders have been known to help lessen loss due to Lepidoptera larvae within apple plantations by making the larvae prematurely leave the plants they feed on, (Kritika Rao and Amita Kanaujia, 2023). Notably, spiders are considered to engage in wasteful killing practices as most of the occasions they kill much more than they can consume. Various researches show that probably some spiders can block up to 50 times more prey than they possibly eat. This overexploitation can also help insect populations in that it will create a horizontal of over-predation, (Sumita Sharma, 2014).

Importance of Spiders in Organic Farming

Recently, there has been a shift toward sustainable agricultural practices, with farmers increasingly adopting organic methods that minimize pesticide use. Spiders offer a natural alternative to chemical pest control, helping maintain insect populations within acceptable limits and promoting ecological balance.

Species Diversity and Effectiveness:

The spider predation substantially with the help of species diversity in the spider population. It has been established that the use of a mixture of various spider species is more efficient in the management of pest compared to a solitary establishment. For instance, in agricultural plots, a greater number of spider species has been identified to negatively correlate with insect density than in plots with fewer species of spiders. Thus, populations of different spiders can occupy different niche and feed at different periods of their life, which makes them very universal predators. The factor of existence of different species is essential for expanding the options for the capture of prey necessary for the preservation of pest control in various environmental conditions.

Specialization and Feeding Behaviour:

Despite the fact that spiders are mainly generalized predators, that is, universal arthropod predators, some of them are predominately specialized. Different species of spider differ mainly on the approach and area that it selects for trapping of the pest. For instance, the recognized web building spiders larger prey specialists or smaller very small, soft-bodied insects such as aphids. Variation of the foraging activities throughout the year also affects the spiders in regard to their role as biological control agents. The activity of some spiders is body during the day, and others are night active, depending on the time of day their prey is active. In addition, species selectivity is also in generating a specific size of the prey as compared with the spiders as a ground of their feeding habits. This specialization also assures them they have the capacity in controlling the pest within those niches.

Importance in Agricultural Ecology

Arthropods are among the dominant biological control agents in agricultural biological production systems. They are known predators; for instance, in China, farmers release spiders into the paddy field to eradicate insects. Likewise, in Israel, spiders are used to control pests in apple production areas to give the best yields. This practice is gradually gaining acceptance across the globe with numerous areas across North and South America being served by spiders in aspects touching on crop hygiene.

The Ecological Impact of Spiders

Spiders have a very specific and strong direct effect on the populations of the main pests, the herbivores, in agricultural ecosystems. Competition may not check the population of herbivores in the same way that predation by spiders keeps the numbers of these animals in check. Many occasions the growth of herbivores proves to be a menace with crops receiving severe danger and producing spiders in those surroundings is therefore felt to be vital.

It was found that some spider groups like orb-web spiders and funnel-web spiders comprise specific pest-control species like aphids, grasshopper and weevil. That predatory behaviour helps them kill and remove more prey than consumed in order to effectively and positively impact pest population extinction.

Ecological Significance

Spiders serve as natural buffers, limiting the rapid growth of pest populations through their predatory activities. Diverse spider species enhance the ecological stability of agroecosystems, allowing for better pest management without chemical interventions. Studies have shown that vegetation diversity within agroecosystems can enhance plant protection by supporting a rich assemblage of natural predators, including spiders.

Importance of Spider Conservation

Thus, the results of this work emphasise the need to preserve spiders in agri-environments. Measures that support webs-spinning arthropods including the spiders-liked preservation of the plants cover and avoidance of toxins such as pesticides-considerably improve their populations and the efficiency of the concepts based on them as BHAs. Efforts should be targeted on making conditions favourable for sheltering and feeding these spiders and thus support the role of spiders in controlling pests.

Conclusion

Despite the limited knowledge on their effects in the environment, spiders are important biological control agents that help in non-chemical pest control in agriculture. They all have different ways of predation which help them control pests for integrated pest management, practices that are environmentally friendly for agriculture. Because they function as integrated members of agroecosystems, beneficial spiders contribute significantly to crops yields besides acting as informants to the conditions of the environment. Increased preservation of web-building beneficial spiders entails use of policies that preserve plants and discourage pesticide application a critical step in enhancing utilization of spiders in controlling pests. Appreciation and incorporation of spiders into the processes of pest management would go a long way in improving the sustainability and diversities within agricultural practices hence the need to support the Appreciation of such valuable predators.

References

Greenstone M.H (1999). Spider predation: now and why we study it. *J. Arachnol*. 27: 333-342.

Hodge M.A (1999). The implications of intraguild predation for the role of spiders in biological control. J. Arachnol. 27: 351-362.

Khan A.A., Mishra, D.S (2003). Studies on qualitative and quantitative composition of spider fauna in rice ecosystem of eastern Uttar Pradesh. Plant Protect. Bulletin 55(1+2): 35-41.

Kritika Rao, Amita Kanaujia (2023). Spiders' Impact on Controlling Insect Pests in the Agricultural Ecosystem. *International Journal of Research Publication and Reviews*, Vol 4, no 7, pp 2389-2392.

Maloney Darlene, Drummond Francis A., Alford Randy (2003). Spider Predation in Agroecosystems: Can Spiders Effectively Control Pest Populations? Technical Bulletin 190, Maine Agricultural and Forest Experiment Station, The University of Maine, pp: 1-32.

Marc P., Canard, A., Ysnel, F (1999). Spiders (Araneae) useful for pest limitation and bioindication. *Agric. Ecosyst. Environ*. 74: 229-273.

Saurabh Sarma, D. Pujari, Zeenat Rahman (2013). Role of Spiders in Regulating Insect Pests in The Agricultural Ecosystem - An Overview. *JIARM*, Volume 1 Issue 5, ISSN: 2320 - 5083.

Sumita Sharma (2014). A Study on Spiders as Predators in The Agro Ecosystems. *Mun. Ent. Zool*, Vol. 9, No. 1.

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STATUS OF NON-DESCRIPT MULKI CATTLE POPULATION IN NARMADAPURAM DIVISION OF MADHYA PRADESH

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Introduction

Livestock is an essential part of many agro-ecosystems. This is particularly true in dry and semi-arid areas, where extensive grazing is frequently the only way to produce (high-value) agricultural products under the unique eco-climatic conditions. There are many indigenous cattle breeds in India that can adapt to a range of agro-ecological conditions. Furthermore, most smallholder rural farmers in India rely on indigenous livestock breeds, for which these genetic resources are crucial for better nutrition, revenue, and investment assets. Therefore, the native animals of India and other tropical regions are crucial to the development of appropriate and sustainable agricultural systems. Native cattle breeds are suited to the diverse conditions of the tropical climate due to a variety of species-specific traits and adaptive mechanisms. In general, these traits and adaptation processes can be categorized as morphological/anatomical, physiological, behavioral, neuro-endocrine, haematological, molecular, and cellular characteristics. In the meantime, it has been noted that native cow populations are dwindling globally at an accelerated rate (BAHS, 2024). This is primarily due to the fact that native cattle are sometimes bred with foreign or temperate high-producing livestock to boost milk yield. There may be a substantial, highly evolved gene pool in Indian cow breeds, which contains several genes with economic significance. Many of these are well-known for their ability to adapt to the agroclimatic conditions of the area, their resistance to tropical diseases and harsh weather, and their ability to thrive on low-input production and inadequate nutrition (Sarang *et al*., 2024). When estimating the actual economic value of native cattle, it is important to consider their whole utility and contribution. This includes lifetime productivity, the market value of native animal products, ecosystem preservation, the productivity and sustainability of low-input production systems, value of animal waste, social and cultural evaluation, and climate-resilient traits. Many methods for assessing the economic and environmental value of indigenous species are already available in the literature. These methods can be broadly classified into three categories: assessing the breed's or population's true economic value, setting priorities for breeding programs, and estimating the cost of conservation measures (Sserunjogi and Kaur, 2016).

Native tract of non-descript Mulki cattle population

The Narmadapuram Division is located in central India, with a diverse geography shaped by the Narmada River flowing through it. This area is marked by rolling hills, dense forests and fertile plains. Its capital is in Hoshangabad, officially Narmadapuram. It comprises Narmadapuram, Harda, and Betul districts. Narmadapuram district is located in the Vindhya mountain range with a large forest cover and known for its lush greenery and the river valley. Harda district is located in the southwestern part of Madhya Pradesh. It is predominantly a tribal area where the Korku and the Gond tribal groups form two-thirds of the total population. Harda district is mostly an agricultural region because of its vast plains and fertile soils. It is part of the entire Narmada Valley. Betul district is a part of the Satpura Range, is forested and hilly and is recognized for its tribal population as well as its scenic surroundings. In Narmadapuram division, livestock sector plays a significant role in the local economy, providing employment and contributing to the agricultural output of the region. The government has implemented several programs to support livestock farmers and improve productivity. Betul, Harda and Narmadapuram districts locations in terms of longitude and latitude are shown below in the table 01 and additional districts location of the breeding tract of Mulki also shown in the figure 1.

Table 01: Different districts locations in terms of longitude and latitude

Particulars	Districts		
	Betul	Harda	Narmadapuram
Latitude (N)	21° 54′	22° 20′	22° 75′
Longitude (E)	77° 54′	77° 5′	77° 72′
Height from sea level (meter)	653	302	331
Area (sq. Km.)	10078	3334	5408.23
Average rain fall (mm)	1129	1261	1340

(Source: https://www.mapsofindia.com/maps/madhyapradesh/)

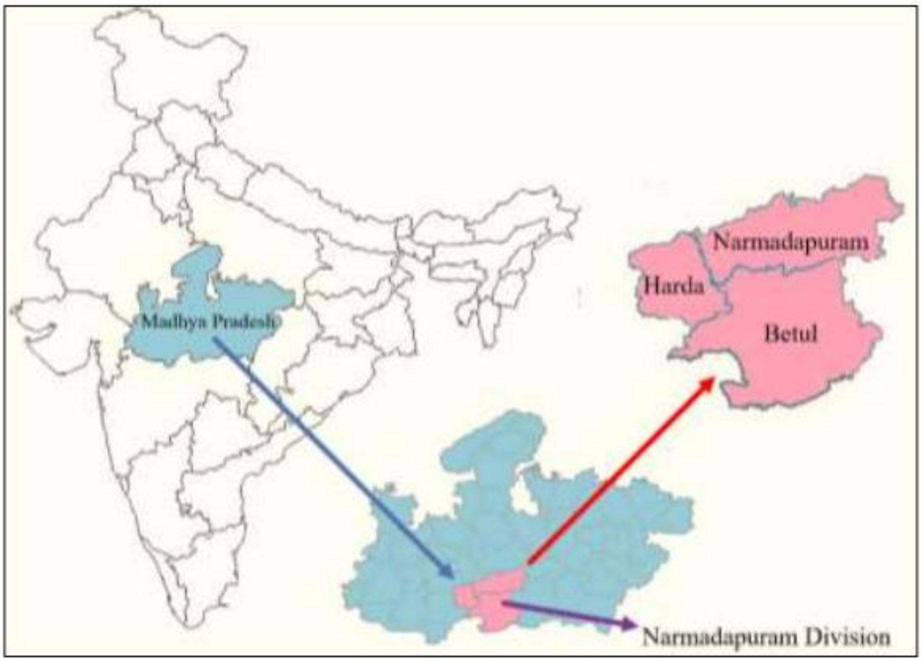

Fig. 01: Geographical location of Narmadapuram division of M.P.

Cattle population and approximate area of distribution of Mulki cattle

The population (as per 20th Livestock Census) and distribution of cattle population in Narmadapuram division of the MP state is shown in the table 02. Mulki cattle is mainly concentrated in the Athner, Betul, Bhainsdehi, Chicholi, Multai and Shahpur tehsil of Betul district and adjoining areas of Timurni tehsil of Harda and Seoni Malwa tehsil of Narmadapuram districts of Madhya Pradesh. More than 85% cattle population is residing in the rural area of the Narmadapuram division of Madhya Pradesh.

Table 02: Distribution of Cattle population (20th Livestock Census)

District	Cattle population			Total livestock population	Milk Production (000 MT, 2020-21)
	Indigenous	Crossbred	Total		
Betul	502420	70785	573205	986725	361.47
Harda	148851	10636	159487	320344	142.04
Narmadapuram	291157	39195	330352	532058	310.12
Madhya Pradesh	17055850	1696163	18752013	40638079	17999.30

Topography of Narmadapuram division of Madhya Pradesh

The topography, types of soil, climate and major crops of different districts of Narmadapuram division of Madhya Pradesh are given in table 03.

Table 03: Topography of Narmadapuram division of Madhya Pradesh

Particulars	Betul	Harda	Narmadapuram
Topography	Located in the Satpura mountain ranges, average height of 653 meters above sea level. The mountains are higher in the east and slope down towards the west	Located in the southwestern part of M.P. state. Narmada forms its northern boundary & land rises towards the Satpura Range to the south	Located in the central Narmada Valley and on the northern fringe of the Satpura Plateau
Geographical location	Latitude: 21.22'N to 22.24'N & Longitude: 77.10'E to 78.33'E	Latitude: 76.47'N to 77.20'N & Longitude: 21.53'E to 22.36'E	Latitude: 21.54'N to 22.59'N & Longitude: 76.46'E to 78.42'E
Soil types	It includes coarse shallow soils, medium black soils, and deep black soils. The district has the suitable soil and climate for growing maize	Black soils ferruginous red lateritic soils, sandy clay loam, sandy loam and clay loam. Major soil type is black humid	Black soils and ferruginous red lateritic soils, Sandy clay loam, sandy loam and clay loam (area lying west of Ganjal river)
Climate	It characterized by hot summers and general dryness. The district has a moderate climate	The climate of Harda district is normal i.e. temperate climate	Climate of the district is neither more hot nor more cool except the winter season of the Pachmarhi
Crops	Main crops include maize, paddy, and wheat	Soybean, Arhar, Rice, Wheat, Gram and Sugarcane	Wheat, Soybean, Gram Paddy, and Tuar
Average rain fall (mm)			
Annual rain fall	1129.6	1261	1340
Kharif (Jun.- Oct.)	1058.9	1206.2	1286.6
Rabi (Nov.- Mar.)	57.9	45.9	43.7
Summer (Apr.-May)	12.8	8.9	9.7

Status of cattle Population in Narmadapuram division of Madhya Pradesh

Total population of cattle in Madhya Pradesh state is 18.75 million (20th Livestock census) and all three surveyed districts is 1.063 million (~7 % of total cattle population). Population of cattle under studied blocks within district is shown in the table 04. As shown in table 04, the distribution of cattle population is highest in Betul district as compared to other districts of Narmadapuram division of Madhya Pradesh.

Table 04: Distribution of cattle population under studied district of M.P.

District	Blocks/Tahsils	Total Cattle population	% share
Betul	Betul	137824	13.97
	Bhainsdehi	199534	20.22
	Athner	63160	6.40
	Chicholi	70534	7.15
	Shahpur	97932	9.92
	Multai	195837	19.85
	Ghoda Dongri	101388	10.28
	Amla	120518	12.21
	Total	**986727**	100.00
Harda	Timarni	41985	13.11
	Sirali	45291	14.14
	Khirkiya	55979	17.48
	Handiya	50880	15.88
	Harda	53116	16.58
	Rehatgaon	73082	22.81
	Total	**320333**	100.00
Narmadapuram	Seoni-Malwa	104286	19.60
	Pipariya	95614	17.97
	Babai	69428	13.05
	Bankhedi	54831	10.31
	Dolariya	30764	5.78
	Hoshangabad	30117	5.66
	Itarsi	79143	14.87
	Sohagpur	67875	12.76
	Total	**532058**	100.00

(Sources: http://ahd.mp.gov.in)

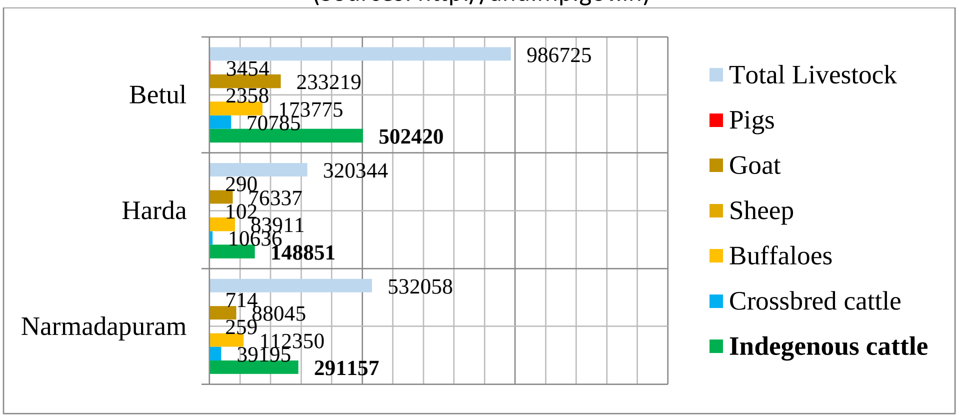

Fig. 2: District wise total cattle population of Narmadapuram division of M.P. (Sources: http://ahd.mp.gov.in)

The estimated Mulki cattle population in Narmadapuram division of Madhya Pradesh has been presented in table 05. As per the survey conducted under the research project entitled "Survey, documentation of ITK and Phenotypic Characterization of Non-Descript Breed of Cattle in Narmadapuram Division of Madhya Pradesh" funded by Madhya Pradesh Biodiversity Board, Bhopal. The estimated total superimposed population of Mulki cattle was 2.75 lakhs in Narmadapuram division of the Madhya Pradesh (Table 05).

Table 05: Estimated Mulki cattle population in Narmadapuram division of M.P.

S. No.	Particulars	Total
1	Number of villages surveyed in three districts	215
2	Total cattle population surveyed in three districts	30530
3	Cattle population/village	142
4	Total no of village in three districts	2935
6	Total Mulki population surveyed	18396
7	Mulki population/village	86
9	Mulki population (% of total cattle population)	37.43
10	Population of all cattle in Narmadapuram division*	18.39 Lakhs
11	Estimated population of Mulki cattle in Narmadapuram division of Madhya Pradesh	2.75 Lakhs
12	Total cattle Population in Madhya Pradesh*	187.52 Lakhs

(Sources: http://ahd.mp.gov.in)

The details of cattle and non-descript population in three districts (viz. Betul, Harda, Narmadapuram) of Narmadapuram division and of Madhya Pradesh has been presented in table 06.

Table 06: District wise details of Cattle population as per 20th Livestock Census

Particulars	Total Population in Narmadapuram division			
	Betul	Harda	Narmadapuram	Madhya Pradesh
Cattle	526053	141709	340002	19602366
Non-Descript Cattle	**484331**	**132238**	**314829**	**16323199**
ND Cattle (%)	**92.07**	**93.32**	**92.60**	**83.27**
Gaolao	50	0	0	77768
Gaolao Graded	351	0	231	99136
Sahiwal	0	1204	124	30866
Sahiwal Graded	513	810	2129	113538
Tharparkar	0	0	0	5618
Tharparkar Graded	2	0	19	11455
Malvi	310	98	675	682522
Malvi Graded	2939	1431	130	357686

Particulars	Total Population in Narmadapuram division			
	Betul	Harda	Narmadapuram	Madhya Pradesh
Nimari	76	0	6	341828
Nimari Graded	618	0	14	111805
Gir	7	1724	105	112161
Gir Graded	1191	1735	892	177585
Hariana	506	0	191	33660
Hariana Graded	12129	0	288	187702
Kenkatha	0	0	0	61819
Kenkatha Graded	2	0	0	33041
H.F.	14	97	494	4770
Jersey	258	369	1042	31424
Crossed H.F.	3449	755	3320	131644
Crossed Jersey	19177	1248	15513	673139

Most households in Madhya Pradesh rear animals such as cows, buffalos, goats, pigs, and poultry irrespective of how much land they own or are landless. The socio-economic and cultural character of the farming community is directly linked to livestock rearing under mixed farming systems. Various communities are rearing Mulki cattle for milk and agricultural purposes. The surveyed households have an average of 4 cattle, which ranges from 1 to 20 irrespective of gender. The general trend is that farmers build kutcha houses for cattle and other livestock species. Most of the households were not found to have separate pens for calves or bullock sheds. During the survey it was observed that most of the farmers keep their cattle tied/in the house only at night and send them for grazing during the day. This type of housing management is more or less a common practice prevalent in all the surveyed areas of Narmadapuram division. The animals mainly depend on grazing in the pasture. The few farmers feed concentrated mixture to the cows at the time of milking. However, organised commercial dairy farms in urban and semi-urban areas keep buffaloes, indigenous milch breeds and crossbred cows under stall fed system. They provide their animals with adequate feed, fodder, good management and health care for maximum production. But Mulki cattle are not kept in organised herds. This may be the reason for low milk production of cows. Sources of drinking water such as rivers, streams, wells, ponds, etc. are available in these areas. Generally, farmers take the cattle out for grazing around 6-8 am and bring them back to their homes around 3-4 pm. Mating usually takes place during grazing. In most areas, the cattle roam freely in the surrounding areas during the summer. It is observed that the distance of pastures ranged from 1 to 3.5 km from the villages. Most farmers preferred the natural service of breeding. In rural areas, livestock farmers do not adopt modern management practices in animal husbandry, but in the nearby cities, very few farmers are adopting modern management practices.

Constraint in animal husbandry in Narmadapuram division of Madhya Pradesh

The main factors limiting the production of livestock in Narmadapuram division of Madhya Pradesh are the quantity and quality of dry and green feed shortages as well as the gradually decreasing grazing land. Poor feed status may result from a large number of animals compared to the supply of feed and fodder. The scarcity of fodder can also be attributed to the dominance of small holding, frequent droughts, and poor management practices. To increase animal output in the state, there must be a sufficient supply of high-quality feeds and fodder.

Utility of the non-descript cattle in Narmadapuram division of Madhya Pradesh

The non-descript Mulki cow have poor genetic potential of milk production and they yield 0.5 to 3 kg milk per day. More than 70% farmers are using Mulki animals for milk and agriculture operation. Bullocks of the Mulki cattle are useful both agricultural operations and rural transportation. The heat tolerance and disease resilience of the Mulki cattle make it fit for draft purpose in the Narmadapuram division of Madhya Pradesh state. Cow dung is a cheap and easily available rich source of micro flora. It is a boon for farmers due to its wide applications in agriculture, energy/fuel resources, environmental protection, and medicinal applications. Moreover, indigenous breeds have s uniqueness at various levels, which need to be capitalized to improve the breed and production value.

References

BAHS (2024). Basic Animal Husbandry Statistics. Department of Animal Husbandry, Dairying & Fisheries. Ministry of Agriculture & Farmers' Welfare. Government of India. Krishi Bhawan, New Delhi.

http://ahd.mp.gov.in, Department Animal Husbandry and Dairying, Government of Madhya Pradesh.

https://www.mapsofindia.com/maps/madhyapradesh/

Sarang, S.K., Sreekumar, D. and Sejian, V. (2024). Indigenous cattle biodiversity in India: Adaptation and conservation, Reproduction and Breeding. **4**(4):254-266.

Sserunjogi, B. and Kaur, P. (2016). Spatial and temporal dynamics of bovine wealth in India: An economic analysis. Indian Journal Dairy Sciences, **69**: 571-580.

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