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"INDOOR PLANTS:
NATURE'S SILENT AIR
PURIFIERS,
BREATHING LIFE INTO
EVERY CORNER"

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from the editor

In an age where urban living and technology dominate our surroundings, the value of nature—particularly indoors—has never been more evident. Indoor plants are not just decorative additions to our homes and offices; they are silent allies in our pursuit of better health and well-being. Among their many benefits, one of the most remarkable is their natural ability to purify the air we breathe.

Scientific studies have shown that certain indoor plants can absorb harmful toxins, release oxygen, and maintain humidity levels, contributing to a cleaner and more balanced indoor environment. From the elegant peace lily to the hardy snake plant, these green companions help filter out pollutants like formaldehyde, benzene, and carbon monoxide—chemicals commonly found in everyday household products and furnishings.

This issue celebrates the quiet power of indoor plants and highlights how incorporating a bit of greenery into your living space can lead to significant improvements in air quality and overall wellness. Whether you're a seasoned plant enthusiast or just starting your green journey, we hope this inspires you to embrace indoor plants not just as decor, but as essential elements of a healthier lifestyle.

Let nature breathe with you—one leaf at a time.

Dr. Deepak Kumar
FOUNDER & EDITOR

EXPLORING KNOWLEDGE & DISCOVERING AGRICULTURE



AGRI ROOTS E-MAGAZINE

Indoor Plants: The Air Purifier

ARTICLE ID: 0207

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The indoor plant trend has intensified during recent years because they not only enhance home decor but they also remove pollutants from indoor air environments. With urbanization, increased indoor pollution levels, and less ventilation in modern homes, the role of indoor plants as natural air purifiers has grown more important than ever. Indoor plants revive the life, provide color, and peace to our homes, yet not all of them require special care. Many indoor plants are not only visually appealing but also quite easy to maintain. If you are looking for plants that will grow in your house with little effort, here are some lovely, low-maintenance alternatives for anybody who wants to reap the advantages of indoor gardening without devoting too much time to plant care.

1. Snake Plant (*Sansevieria trifasciata*)

Snake plants are extremely durable and may survive in a variety of indoor conditions. This plant, sometimes known as *mother-in-law's tongue*, is almost durable and ideal for those with little plant experience. These plants are distinguished by their erect, sword-like leaves, which come in a variety of colors, ranging from deep green to variegated yellow and green. They require little water and may thrive under low light conditions.

Their air-purifying properties

make them an excellent choice for any room.

2. ZZ Plant (*Zamioculcas zamiifolia*)

The ZZ plant is one of the easiest plants to care for due to its tough nature. It can tolerate minimal light, infrequent watering, and a wide temperature range, making it suitable for practically any home. The



glossy, dark green foliage gives beauty to environment, and the plant can tolerate a variety of indoor climates.

3. Aloe (*Aloe vera*)

People grow Aloe Vera plants with ease because the succulent offers natural treatment benefits for quicken healing of small burns and cuts. The succulent prefers to grow under conditions of direct and bright sunlight and needs minimal amounts of water. With its ability to store water in its fleshy leaves the plant remains moisture-rich to cope through dry seasons. Aloe Vera plants possess beautiful features that include their distinctive form and their green shiny leaf surface which adds visual appeal to any environment.

4. Peace Lily (*Spathiphyllum wallisii*)

The Peace Lily stands out with beautiful white blooms combined with glossy green leaves as it remains a smart, easy-to-care-for plant that needs low to medium light. Besides adding attractive visual appeal, the plant acts as an air purifying system that eradicates dangerous pollutants from indoor environments. Peace lilies notify their caretakers through slight drooping that they require watering. Besides water the plants need no hard and fast other care.

5. Spider Plant (*Chlorophytum comosum*)

Spider plants prove to be simple growers while displaying their appealing green leaves with white stripes. Freshly cultivated greens are an outstanding selection for novice gardeners because they successfully thrive within various indoor spaces. The needs of Spider plants include various light exposures as well as minimal care requirements. The plant system produces several baby plants which growers can clone into new plant specimens.

6. Philodendron (*Philodendron spp.*)

Philodendrons stand out because of their heart-shaped leaves as well as their attractive hanging vines which create perfect home decorations. These plants show great adaptability since they thrive best in both low and medium light settings. Philodendrons let forget occasional waterings with no problems while establishing themselves rapidly into robust green plants.

7. Chinese Evergreen (*Aglaonema costatum*)

The Chinese Evergreen is a hardy plant known for its variegated green leaves. The plant requires low-light environments and works best in spaces with limited outdoor light exposure such as offices. The plant demonstrates effective resistance to pests and requires little water maintenance which provides busy owners with a perfect houseplant choice.

8. Cast Iron Plant (*Aspidistra elatior*)

The Cast Iron Plant maintains its name by showing exceptional durability because it tolerates tough conditions and neglect well. The plant grows best when placed in areas with little light and survives conditions other plants find difficult to bear. The Cast Iron Plant presents dark green leaves in a broad form to decorate spaces while requiring little care from its owners.

9. Burro's Tail (*Sedum morganianum*)

Burro's Tail, also known as *Donkeys Tail*, is a stunning succulent with trailing stems covered in fleshy, blue-green leaves. This plant is perfect for hanging baskets or elevated shelves where its vines can cascade down. Burro's Tail thrives in bright light and requires very little water, making it perfect for those who have limited time to care for plants.

10. Money Plant (*Epipremnum aureum*)

Money plant is also known as <Devil's Ivy> a popular indoor vine that has heart-shaped, green or variegated foliage. It thrives in low to high indirect light, takes minimal water, and cleans indoor air. Easy for growing and propagate. Money plant is a great choice for homes and offices that want to improve air quality while adding a touch of greenery.

Conclusion

Indoor plants have more value than decoration because they naturally purify the air while improving both

indoor environment quality and health. A sustainable and appealing solution to indoor air pollution exists by placing different air-purifying plants throughout living or workspace areas.

Whether are an experienced plant lover or new to indoor gardening, these easy-to-care-for beauties will bring life and color to your home with little effort. From air-purifying plants like the Peace Lily to eye-catching succulents like the Burro's Tail, there's something for everyone.

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Bio-fortification: A Sustainable Solution for Nutritional Enhancement

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Bio-fortification refers to the enhancement of the nutritional content of crops through traditional breeding, agronomic techniques, or genetic modifications. This method provides a cost-effective and long-term solution to address micronutrient deficiencies, often termed as "hidden hunger." Millions of people, especially in developing nations, lack essential nutrients like vitamin A, iron, and zinc. Bio-fortified crops offer a practical way to improve human health without necessitating major dietary modifications.

Approaches to Bio-fortification

1. Agronomic Bio-fortification: This involves enriching crops with essential minerals by applying nutrient-rich fertilizers or soil amendments. For instance, selenium-enriched fertilizers are used to boost the selenium levels in cereals.

2. Conventional Breeding: Scientists crossbreed plant varieties with high nutrient content to develop more nutritious crops. Examples include iron-fortified beans, vitamin A-rich sweet potatoes, and zinc-enhanced rice.

3. Genetic Engineering (Transgenic Bio-fortification): This approach modifies plant genes to enhance their nutritional value. A notable example is Golden Rice, which has been engineered to contain high levels of beta-carotene, a precursor of vitamin A.

Notable Bio-fortified Crops

Several bio-fortified crops have been developed worldwide to address micronutrient deficiencies:

- 1. Golden Rice:** Designed to produce beta-carotene, which helps prevent vitamin A deficiency, a leading cause of blindness and weakened immunity.
- 2. Iron-Rich Beans:** Developed to combat anemia, particularly in women and children in Africa and Latin America.



3. Zinc-Fortified Wheat and Rice: Crucial for boosting immunity and cognitive functions, these crops help address zinc deficiency.

4. Vitamin A-Enhanced Sweet Potatoes: Common in Africa, these sweet potatoes are selectively bred to have higher beta-carotene content.

Advantages of Bio-fortification

- **Sustainable and Economical:** Unlike supplementation and industrial food fortification, bio-fortified crops require minimal recurring investment. Once developed, they can be grown repeatedly.
- **Effective in Reducing Malnutrition:** These crops enhance public health, particularly in rural areas with limited access to nutrient-rich foods.
- **Seamless Dietary Integration:** Since bio-fortified crops are consumed like regular food, people benefit from improved nutrition without altering their eating habits.
- **Improved Agricultural Resilience:** Many bio-fortified crops also exhibit increased resistance to pests, diseases, and environmental stresses.

Challenges and Future Outlook

Despite its potential, bio-fortification faces several hurdles:

- **Limited Awareness:** Many farmers and consumers remain unaware of bio-fortified crops and their

benefits, necessitating widespread education and outreach.

- **Regulatory Restrictions:** Some genetically modified (GM) bio-fortified crops, such as Golden Rice, encounter regulatory obstacles in certain regions.
- **Scaling Up Production:** Expanding the availability of bio-fortified seeds and crops requires substantial investment in research and distribution networks.

The future of bio-fortification appears promising, with continuous advancements in biotechnology and increasing global support from governments and organizations. Initiatives by groups such as Harvest Plus and the World Health Organization (WHO) are helping to drive the adoption of bio-fortified crops, ultimately improving global nutrition.

Conclusion

Bio-fortification presents a viable and long-term solution to malnutrition, particularly in low-income regions. By incorporating bio-fortified crops into mainstream agriculture, we can make significant strides in enhancing global health and food security. With continued research, public awareness, and supportive policies, bio-fortification has the potential to transform nutrition worldwide.

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Small Grain, Significant Benefits: Exploring the Advantages of Little Millet

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Little millet (*Panicum sumatrense*) is a highly nutritious and resilient grain that has gained prominence in India due to its health benefits and adaptability to diverse growing conditions. Cultivated primarily in Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, and Odisha, this minor cereal plays a crucial role in traditional Indian cuisine and offers numerous health advantages. Rich in fiber, protein, essential minerals, and antioxidants, little millet supports weight management, digestive health, heart health, bone strength, and diabetes management. Its low glycemic index and bioactive nutraceuticals make it particularly beneficial for individuals with diabetes and those seeking a balanced diet.

In addition to its nutritional value, little millet presents

economic opportunities for farmers. Its drought resistance, low input costs, and potential for value-added products make it a profitable crop, especially in dryland farming systems. The growing consumer demand for nutritious grains further enhances market

prospects. Government initiatives promoting millet cultivation contribute to its economic viability, encouraging sustainable agricultural practices.

Culinary versatility is another advantage, as little millet can be used in porridge, flour, snacks, and as a rice substitute. Despite its potential, the absence of ready-to-use products limits its widespread

adoption. Recent efforts focus on improving accessibility and consumer-friendly processing methods. This review highlights little millet's nutritional benefits, economic significance, and culinary applications, emphasizing its role in



sustainable agriculture, food security, and public health.

Little millet (*Panicum sumatrense*) is an exceptionally nutritious grain that has gained recognition in India for its health benefits and adaptability to diverse growing conditions. This ancient grain flourishes in arid and semi-arid climates, making it a resilient choice amid climate challenges. Major cultivation regions in India include Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, and Odisha. Little Millet-samai, one of several various millets, is an important part of the Indian cuisine. It is a great source of micronutrients and nutraceutical cereal, little millet (*Panicum sumatrense*) is known for a number of health advantages since it contains bioactive nutraceuticals such phenolic compounds, tocopherols, and carotenoids, as well as being low in glycaemic index, which is particularly advantageous for diabetes people. It contains fiber, which lowers body fat levels, and it is a rich supply of phosphorus. The samai's low calorie and antioxidant content aids in maintaining a healthy weight and diet, which can aid in weight loss. (Indirani *et al.* 2021)

Health Benefits of Little Millet

Little millets, known as "Nutri-cereals," are highly nutritious and rich in dietary energy, vitamins, minerals⁴particularly micronutrients like iron (9.3 mg/100 g), calcium, and zinc⁴insoluble dietary fiber, and phytochemicals with antioxidant properties. Their consumption offers protection against chronic illnesses such as Type II diabetes, obesity, cancer, cardiovascular disease, and ischemic strokes. The complex carbohydrates in little millet digest slowly,

making them particularly beneficial for diabetic patients. (RN *et al.*2022) Its high fiber content promotes fullness, helping to control appetite and support weight loss. Additionally, fiber plays a crucial role in maintaining digestive health by preventing constipation and encouraging regular bowel movements. Regular consumption of little millet may also improve heart health by lowering cholesterol levels and reducing the risk of heart disease. The abundance of calcium and magnesium in little millet supports bone density and strength, contributing to overall skeletal health. Furthermore, its low glycemic index makes it particularly beneficial for individuals managing diabetes, as it helps regulate blood sugar levels effectively.

Additionally, they help strengthen the body and raise healthy cholesterol levels, making them ideal for growing children and individuals with low body mass. With high phosphorus content (220 mg/100 g), little millets support overall health and development. Given their nutrient density, versatility, and health benefits, little millets are a valuable dietary addition. In rural India, small millet-based value-added products could enhance nutrition, empower farmers, and boost income. The increasing prevalence of malnutrition, exacerbated by modern dietary habits and fast-food consumption, necessitates the development of nutrient-dense, palatable food products that effectively support growth and well-being.

Culinary Uses Of Small Millets: Small millets are delicious, have a nut-like, slightly sweet taste, and are packed with healthy elements. 9314% protein, 703 80% carbs, and a high dietary fiber content are all

present in little millet. despite the fact that little millets' nutritional benefits have been well documented. Because there aren't any consumer-friendly, ready-to-use or ready-to-eat items like rice and wheat, their use drawn attention recently, mostly due to their recognition as meals high in fiber and ongoing initiatives to make them more easily accessible to consumers. (Saini *et al.*,2018)

Little millet is versatile and can be used in various dishes:

- **Porridge:** Cooked as porridge, it makes a nutritious breakfast.
- **Substitutes:** It can replace rice or other grains in salads, pilafs, and stir-fries.
- **Flour:** Ground into flour, it serves as a gluten-free option for baking.
- **Snacks:** Roasted little millet can be enjoyed as a healthy snack or added to trail mixes.

Nutritional Composition of Little Millet:

Little millet is a nutrient-dense grain that offers numerous health benefits. Rich in dietary fiber, it aids digestion and supports healthy cholesterol levels. It is also packed with essential minerals like iron, calcium, phosphorus, and magnesium, which contribute to bone health and overall bodily functions. With a higher protein content than many other grains, it serves as an excellent option for vegetarians and those looking to increase protein intake. Its low glycemic index helps regulate blood sugar levels, making it beneficial for diabetics. Additionally, the presence of antioxidants helps combat oxidative stress, potentially reducing the risk of chronic diseases.

Nutritional Content per 100g:

Nutrient	Amount
Protein	7.7 g
Carbohydrates	67.0 g
Dietary Fiber	7.6 g
Fat	4.7 g
Iron	9.3 mg
Calcium	17 mg
Phosphorus	220 mg

Economic Opportunities for Farmers:

Samai (little millet), one of the several millets, is a significant dryland crop that is farmed on a small scale as a grain for the poor that can endure both drought and waterlogging (Kamatar et al., 2013). The crop is sown when the area experiences early rainfall and is extremely drought tolerant; it is not appropriate for growing other dry land crops like ragi, sorghum, or groundnuts.

Due to their many uses, little millets are frequently referred to as "miracle crops." There are many advantages to using small millets in cropping systems, such as the use of grain for food and value-added food products, straw for forage, agro-diversity enrichment, erosion control in arid areas, increased carbon sequestration, and smallholders' assurance of food and nutritional security. (Mitra *et al.*,2019) Little millet presents significant economic opportunities for farmers, particularly in regions where it is traditionally cultivated. The increasing health consciousness among consumers has boosted the demand for nutritious grains, creating new market opportunities in the health food sector. Its natural drought resistance makes it a reliable crop in areas with unpredictable rainfall, ensuring stable yields. Additionally, little millet

requires fewer fertilizers and pesticides, leading to lower input costs and higher profit margins for farmers. The potential for value-added products, such as flour and snacks, further enhances its profitability. Moreover, integrating little millet into mixed cropping systems offers agroecological benefits by promoting biodiversity and improving soil health. Government initiatives supporting millet cultivation further strengthen its economic viability, making it an attractive crop for sustainable agricultural practices.

Conclusion

Little millet (*Panicum sumatrense*) is a highly nutritious and resilient grain with significant health, economic, and agricultural benefits. Its rich nutritional profile, including high fiber, protein, essential minerals, and antioxidants, makes it a valuable dietary addition, particularly for managing diabetes, heart health, and weight control. The growing awareness of health and nutrition has increased its demand, encouraging the development of value-added products and expanding market opportunities.

From an agricultural perspective, little millet thrives in

arid and semi-arid regions, requiring minimal inputs, making it a cost-effective and sustainable crop for farmers. Its adaptability to diverse climatic conditions and drought resistance ensure stable yields, even in challenging environments. Additionally, its integration into mixed cropping systems supports soil health and biodiversity.

Despite its nutritional advantages, the limited availability of consumer-friendly, ready-to-eat products has restricted its widespread adoption. However, recent initiatives to improve processing techniques and promote millet-based foods are addressing these challenges. Government support and policy interventions further strengthen the economic viability of little millet cultivation.

In conclusion, little millet holds great potential in addressing malnutrition, supporting sustainable agriculture, and providing economic benefits to farmers. Promoting its production, processing, and consumption can contribute to food security, public health, and environmental sustainability, making it an essential component of future food systems.

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Real-time Nitrogen Management in Agriculture: A Key to Sustainable Farming

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Nitrogen is one of the most essential nutrients for plant growth, playing a pivotal role in processes such as protein synthesis, photosynthesis, and overall plant metabolism. In agriculture, nitrogen management is critical because it directly influences crop productivity, soil health, and environmental sustainability. Traditionally, nitrogen fertilization has been based on broad recommendations or pre-season soil tests. However, these methods often fail to account for the dynamic nature of nitrogen availability and crop needs throughout the growing season.

Real-time nitrogen management has emerged as a cutting-edge solution to optimize nitrogen use in agriculture. By continuously monitoring nitrogen levels in the soil and crops, farmers can adjust fertilization practices to ensure crops receive the right amount of nitrogen at the right time. This approach not only enhances crop yield but also reduces

environmental impacts such as nitrogen leaching, runoff, and greenhouse gas emissions.

What is Real-time Nitrogen Management?

Real-time nitrogen management involves the use of advanced technologies to monitor nitrogen availability



in soil and crops on an ongoing basis. Rather than relying on static, pre-determined fertilization schedules, this approach allows farmers to make on-the-spot decisions about when and how much nitrogen to apply, based on up-to-the-

minute data.

The core idea behind real-time nitrogen management is to align nitrogen application with the crop's actual needs, minimizing waste and improving the efficiency of nitrogen use. Several technologies and tools can facilitate this approach, including soil sensors, crop sensors, remote sensing, and modeling tools.

Tools and Technologies for Real-time Nitrogen Management

1. Soil Sensors: Soil nitrogen sensors measure the amount of nitrogen available in the soil. These sensors can be placed at different depths to assess both surface and subsoil nitrogen levels. By measuring nitrate concentrations, ammonium levels, and other relevant soil properties, soil sensors provide real-time data on nitrogen availability. This helps farmers determine whether additional nitrogen is needed or if the soil already contains sufficient levels.

2. Crop Sensors: Crop sensors, such as the SPAD (Soil Plant Analysis Development) meter, measure chlorophyll content in the leaves of plants, which is directly related to nitrogen availability. Low chlorophyll levels often indicate nitrogen deficiencies, while high levels suggest sufficient nitrogen levels. Real-time crop sensing allows farmers to monitor the health of crops and make timely adjustments to fertilization practices.

3. Remote Sensing and Drones: Satellite imagery, drone-mounted sensors, and other remote sensing technologies are becoming increasingly popular for real-time nitrogen management. These tools capture images and data from the field, providing farmers with a detailed view of crop health and nitrogen status across large areas. Remote sensing can also help identify areas of a field that may require more nitrogen or areas where nitrogen application is unnecessary, ensuring that resources are allocated efficiently.

4. Climate and Weather Monitoring: Weather conditions significantly impact nitrogen dynamics. Temperature, rainfall, and humidity can all

influence nitrogen availability and the rate of nitrogen loss through leaching or volatilization. By integrating weather data into real-time nitrogen management systems, farmers can better predict nitrogen needs and adjust fertilization timing accordingly.

5. Decision Support Systems (DSS): Advanced software systems and models can analyze real-time data from soil sensors, crop sensors, and weather stations to provide actionable recommendations for nitrogen management. These systems help farmers decide on the optimal time and amount of nitrogen to apply, improving the precision and timing of fertilizer use.

Benefits of Real-time Nitrogen Management

1. Improved Nitrogen Use Efficiency: Real-time nitrogen management enables farmers to apply nitrogen fertilizers precisely when and where they are needed, reducing the likelihood of over- or under-fertilization. This results in more efficient use of nitrogen, maximizing crop yield without wasting resources.

2. Cost Savings: By applying nitrogen only when necessary, farmers can reduce the amount of fertilizer used, leading to significant cost savings. Additionally, precise nitrogen management can lead to higher crop yields, further enhancing profitability.

3. Enhanced Environmental Sustainability: Nitrogen is prone to leaching and volatilization, which can result in environmental pollution. By minimizing nitrogen losses through real-time management, farmers can reduce the risk of water

contamination, air pollution, and greenhouse gas emissions, contributing to more sustainable farming practices.

4. Improved Crop Yield and Quality: Real-time monitoring of nitrogen availability ensures that crops receive optimal levels of nitrogen at all stages of growth. This can lead to healthier plants, improved photosynthesis, and ultimately higher crop yields. In addition, more efficient nitrogen management can improve the quality of the harvested crop, such as better grain protein content in cereals or higher sugar content in fruits.

5. Reduction of Nitrogen Runoff and Leaching: Traditional methods of nitrogen application often result in excess fertilizer being applied to the soil, much of which can run off into water bodies, leading to eutrophication and water quality issues. Real-time nitrogen management ensures that nitrogen is applied only where it is needed, minimizing the risk of runoff and leaching.

Challenges and Considerations

While real-time nitrogen management offers significant advantages, there are several challenges that need to be addressed:

- 1. High Initial Investment:** Technologies such as soil sensors, remote sensing, and decision support systems can require a significant initial investment. For small-scale farmers or those in developing regions, this can be a barrier to adoption.
- 2. Data Interpretation and Expertise:** Interpreting real-time data and making accurate fertilization decisions requires a certain level of expertise. Farmers must be trained in using these technologies

and understanding the data they generate to ensure they make informed decisions.

3. Field Variability: Agricultural fields are rarely uniform, and factors such as soil texture, organic matter content, and crop variety can influence nitrogen availability. Real-time nitrogen management systems must be adapted to these variations to provide accurate recommendations across different parts of a field.

4. Integration with Other Farm Management Practices: Real-time nitrogen management is just one part of a larger farm management system. For it to be most effective, it must be integrated with other practices, such as irrigation management, pest control, and crop rotation, to optimize overall farm productivity and sustainability.

Future Outlook

The future of real-time nitrogen management looks promising, with continuous advancements in sensor technology, data analytics, and artificial intelligence. As these technologies become more affordable and accessible, it is expected that real-time nitrogen management will become a standard practice on farms worldwide. Furthermore, the integration of precision agriculture tools with farm management software and cloud-based platforms will allow for even more sophisticated, data-driven decision-making.

Moreover, with growing concerns over climate change and environmental sustainability, efficient nitrogen management is becoming more critical. Real-time nitrogen management offers a path toward reducing the environmental footprint of agriculture while maintaining or even increasing productivity.

Conclusion

Real-time nitrogen management represents a paradigm shift in how we approach fertilization in agriculture. By enabling farmers to adjust nitrogen inputs based on actual crop needs, it offers the potential to optimize yields, reduce costs, and minimize environmental impacts. While there are challenges to overcome, the

benefits of real-time nitrogen management, including increased efficiency, sustainability, and profitability, make it an essential tool for the future of agriculture. As technology continues to evolve, real-time nitrogen management will undoubtedly play an increasingly important role in achieving global food security and sustainable farming practices.

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Role of emerging technologies such as Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Cloud Computing, and the Internet of Things (IoT) in Agriculture

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The integration of emerging technologies such as Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Cloud Computing, and the Internet of Things (IoT) has revolutionized agriculture.

These tools are transforming traditional farming into precision agriculture, enabling enhanced productivity, sustainability, and resource management. This chapter explores how these technologies interlink to

create innovative practices, contribute to food security, align with Sustainable Development Goals (SDGs), and promote socially equitable and sustainable agricultural practices. It also provides a forward-looking perspective on leveraging these advancements to advance science and technology in agriculture.

Agriculture, a cornerstone of human survival, faces numerous challenges, including climate change, resource scarcity, and growing global populations. Emerging technologies offer solutions to modernize



farming practices, improve yields, and address food security challenges. This chapter delves into the role of AI, ML, DL, Cloud Computing, and IoT in agriculture, highlighting their importance in fostering innovation and

advancing science and technology.

Artificial Intelligence (AI)

AI involves the simulation of human intelligence by machines, enabling them to perform tasks such as decision-making, problem-solving, and pattern recognition. In agriculture, AI-powered systems

analyze data for predictive analytics, disease detection, and automation.

Machine Learning (ML) and Deep Learning (DL)

ML, a subset of AI, uses algorithms to learn from data and improve predictions over time. DL, a specialized branch of ML, employs neural networks to process complex datasets, such as high-resolution satellite imagery and crop health patterns.

Cloud Computing

Cloud Computing provides scalable and accessible platforms for storing, managing, and processing large datasets. It facilitates real-time data analysis and collaboration among stakeholders in the agricultural value chain.

Internet of Things (IoT)

IoT connects devices and sensors to the internet, enabling seamless data exchange. IoT in agriculture includes smart irrigation systems, weather monitoring

devices, and soil sensors to optimize resource use and improve productivity.

1. Innovative Practices in Agriculture

The integration of these technologies has resulted in groundbreaking agricultural practices, including:

- **Precision Farming:** AI and IoT enable precise monitoring of soil conditions, crop health, and weather patterns to optimize resource use.
- **Automated Equipment:** AI-powered drones and autonomous tractors improve efficiency in planting, spraying, and harvesting.
- **Smart Irrigation:** IoT sensors monitor soil moisture levels to provide water only when necessary, conserving water resources.
- **Disease and Pest Management:** ML models predict pest outbreaks and crop diseases, allowing for timely interventions.

Applications of Emerging Technologies in Agriculture

Technology	Application in Agriculture	Benefits	Examples
Artificial Intelligence (AI)	Crop monitoring, yield prediction	Precision farming, better decision-making	AI-powered yield prediction software
Machine Learning (ML)	Pest and disease identification	Adaptive solutions, real-time insights	ML-based pest identification apps
Deep Learning (DL)	Advanced image recognition for plant health	Enhanced accuracy in diagnostics	DL for detecting nutrient deficiencies
Cloud Computing	Centralized farm management platforms	Real-time data access and scalability	Cloud-based smart farming dashboards

Internet of Things (IoT)	Smart sensors for soil, weather, and crop health	Automated and data-driven farming	IoT-enabled irrigation systems
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2. Importance of Emerging Techniques in Creating Innovation

These technologies are fostering innovation by enabling:

- **Enhanced Productivity:** Real-time monitoring and predictive analytics improve crop yields.
- **Sustainability:** Efficient resource utilization minimizes environmental impact.
- **Data-Driven Decision-Making:** Cloud and AI tools provide actionable insights for farmers.

3. Advancing Science and Technology

Emerging techniques in agriculture drive advancements in:

- **Biotechnology:** Integration with AI enables genetic research for resilient crop varieties.
- **Climate Adaptation:** IoT and AI systems help farmers adapt to changing weather patterns.
- **Robotics:** Automated machines reduce labor dependency and increase operational efficiency.

4. Interlink of Techniques and Innovation

The synergy among AI, ML, DL, IoT, and Cloud Computing accelerates agricultural innovation by creating interconnected systems. For example, IoT sensors generate data processed by AI algorithms in the cloud, providing actionable insights. This integration fosters a collaborative ecosystem for stakeholders.

5. Food Security, SDG, and Emerging Agri-Techniques

Emerging technologies directly contribute to achieving SDGs, particularly:

- **SDG 2 (Zero Hunger):** Improved yields and efficient practices enhance food availability.
- **SDG 12 (Responsible Consumption and Production):** Precision farming reduces waste.
- **SDG 13 (Climate Action):** Sustainable practices mitigate climate impacts.

Social Equity and Sustainable Agricultural Practices

These technologies enable:

- **Access for Small Farmers:** Cloud-based platforms and affordable IoT devices empower small-scale farmers.
- **Reduced Inequality:** Democratizing access to technology promotes equitable resource distribution.
- **Sustainable Practices:** Smart systems reduce chemical use and environmental degradation.

Way Forward

- **Policy Support:** Governments should promote technology adoption through subsidies and training programs.
- **Public-Private Partnerships:** Collaboration can drive innovation and infrastructure development.
- **Capacity Building:** Training farmers in using emerging technologies is crucial.

- **Research and Development:** Continued innovation will address evolving agricultural challenges. a data-driven, sustainable sector. These tools not only enhance productivity but also align with global goals for food security and sustainability. By fostering collaboration and innovation, these advancements hold the potential to address future challenges and ensure a resilient agricultural ecosystem.

Conclusion

Emerging technologies like AI, ML, DL, Cloud Computing, and IoT are transforming agriculture into

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Growing Sweet Success: How Vertical Farming Transformed Strawberry Cultivation in Palampur

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Palampur, located in the scenic Kangra Valley of Himachal Pradesh, has become a hub for innovative agricultural practices. Among these, vertical farming of strawberries has emerged as a promising business venture, combining modern technology with traditional farming practices. One of the notable success stories is that of Mr. Vijay Thakur, a forward-thinking farmer from Palampur who embraced vertical strawberry farming to overcome the region's challenges while maximizing space, yield, and profit. Vertical farming

is a method of growing crops in stacked layers or vertically inclined surfaces, making efficient use of space. In a region like Palampur, where the terrain is hilly and land for traditional farming is limited, vertical farming presents a solution that allows farmers to grow high-value crops like strawberries in compact spaces. Vijay Thakur, who had been farming traditionally, saw

the potential in vertical farming to increase productivity and minimize the challenges posed by traditional farming.

Initial Stages of the Business

The initial stages of Mr. Thakur's strawberry vertical farming venture began with research and planning. Here's how he started:



1. Adoption of Vertical Farming

Concept: After attending agricultural workshops and conferences, Mr. Thakur decided to adopt vertical farming for strawberries. He started

small by setting up a trial farm with a vertical structure made of stacked shelves and pipes. This allowed him to experiment with growing strawberries without taking up large land areas.

2. Investing in Infrastructure: The first significant investment was in setting up the vertical farming infrastructure. This involved creating vertical racks,

installing an irrigation system, and ensuring proper lighting. Since strawberries thrive in controlled environments, Mr. Thakur also used polyhouses to regulate temperature and humidity.

3. Selection of Varieties: To ensure optimal growth in a vertical setup, Mr. Thakur selected strawberry varieties that are suitable for such systems. Varieties like Alba and Chandler proved to be ideal, offering high yields and quality fruits.

4. Research and Development: In the initial phase, Mr. Thakur worked closely with agricultural experts to fine-tune the vertical farming techniques. This involved constant monitoring of the water, nutrients, and light conditions to ensure the plants were growing optimally.

Income and Revenue Generation

Once the vertical strawberry farming system was set up and the plants matured, the returns were impressive. Although vertical farming requires a significant initial investment, the returns are often faster and higher than traditional farming.

- **Revenue per Square Meter:** Vertical farming allows for growing strawberries in a small area, significantly increasing yield per square meter. On average, vertical farming can produce up to 3-4 times the yield compared to traditional methods. For Mr. Thakur, his setup produced 3,000 to 4,000 kg of strawberries per year in just 500 square meters, which would have been unfeasible with conventional farming on the same plot of land.
- **Profitability:** The cost of setting up vertical farming systems was high, but by the second year, Mr. Thakur was already seeing a profitable return.

At an average price of Rs. 120-150 per kg, his yearly revenue reached Rs. 3,60,000 to Rs. 6,00,000. With multiple harvests per year (thanks to controlled growing conditions), the profits continued to grow, even with the cost of maintenance and inputs.

Marketing Strategy

Marketing played a crucial role in ensuring the success of Mr. Thakur's strawberry business. He utilized both traditional and modern techniques to reach consumers:

- 1. Local Market:** In Palampur and nearby towns, local markets and retail outlets were the primary channels for selling his strawberries. Direct-to-consumer sales in farmers' markets ensured fresh strawberries were available to the community at competitive prices.
- 2. Export to Major Cities:** With high-quality strawberries, Mr. Thakur also tapped into regional and national markets, particularly selling to high-end supermarkets in cities like Dharamshala, Shimla, and Delhi. He established relationships with retailers and distributors to ensure regular supply.
- 3. Online Sales:** As the demand for fresh, organic produce grew, Mr. Thakur began selling his strawberries online through local delivery platforms, catering to health-conscious consumers seeking fresh produce.
- 4. Packaging and Branding:** The farm also focused on creating attractive, eco-friendly packaging for its strawberries. With a brand name and consistent quality, Mr. Thakur was able to stand out in the market and build a loyal customer base.

Challenges Faced

While vertical strawberry farming presented several benefits, it also came with its own set of challenges:

- 1. Initial Investment:** Setting up a vertical farming system requires a high initial investment in infrastructure, including racks, lighting, irrigation systems, and polyhouses. Many farmers are hesitant to take the risk due to the initial capital required.
- 2. Technical Know-How:** Operating a vertical farming system requires specific knowledge and technical expertise. For Mr. Thakur, learning the ins and outs of the system, such as managing nutrient solutions and controlling light and humidity, was a steep learning curve.
- 3. Labor Intensity:** Although vertical farming reduces the land requirement, it still requires considerable manual labor, especially for tasks like planting, pruning, and harvesting strawberries.
- 4. Pest and Disease Management:** Like traditional farming, vertical strawberry farming is not free from pests and diseases. Though the controlled environment minimizes some risks, maintaining a pest-free environment requires constant monitoring and intervention.
- 5. Market Fluctuations:** Strawberry prices can fluctuate based on demand, and this impacted the profitability at times. Overproduction during peak seasons can sometimes lead to a drop in prices.

Message to Society

Mr. Thakur's success story in vertical strawberry farming sends a powerful message to society, especially to the younger generation of farmers:

- 1. Innovation is Key:** By embracing new farming methods, such as vertical farming, traditional farmers can overcome land constraints, increase productivity, and contribute to sustainability. Innovation in agriculture is vital for future growth.
- 2. Embrace Technology:** With the right use of technology, even small-scale farmers can expand their reach and improve yields. Vertical farming allows farmers to utilize limited space effectively, making it a viable option for hilly or land-scarce areas.
- 3. Sustainability Matters:** Vertical farming is eco-friendly and uses less water and pesticides than traditional farming, making it a sustainable practice that can be scaled up without harming the environment.
- 4. Diversification for Income:** Farmers should diversify their crops and farming methods to reduce risks and increase income potential. By growing strawberries in a vertical farming system, Mr. Thakur not only expanded his farm's output but also improved his overall profitability.

Conclusion

In conclusion, Mr. Vijay Thakur's strawberry vertical farming venture in Palampur is a great example of how traditional farming can evolve with modern techniques to achieve sustainable growth, higher yields, and improved profitability. His story is an inspiration to many and demonstrates that with vision, innovation, and determination, farmers can thrive even in challenging conditions.