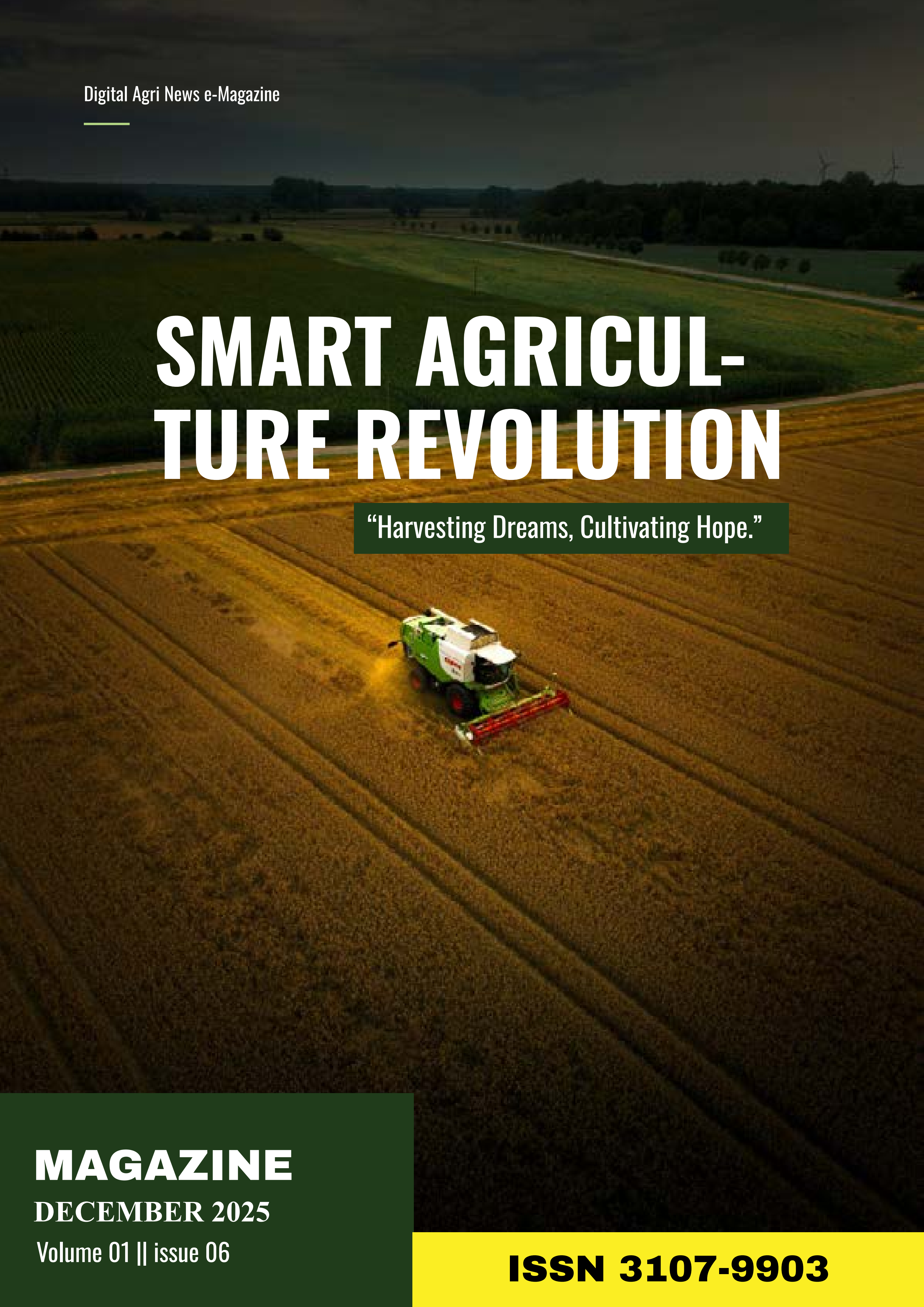
Digital Agri News e-Magazine

SMART AGRICULTURE REVOLUTION

"Harvesting Dreams, Cultivating Hope."



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From the Desk of the Founder

At **Digital Agri News**, we understand that farming is not just a profession — it's a way of life. It is the heartbeat of our economy, the foundation of our food security, and the lifeline of millions of families. With this in mind, our mission is simple yet powerful: to bring timely, accurate, and actionable agricultural news right to your fingertips. From market trends and crop prices to climate alerts and weather updates, from emerging technologies and sustainable practices to policy reforms and government schemes, we cover everything that matters to the agricultural community. Our goal is to empower you with knowledge that helps you make better decisions — in the field, in the marketplace, and for the future. We also believe in celebrating the spirit of farming. Through farmer success stories, expert interviews, and global agri innovations, we highlight the resilience and creativity that keep agriculture thriving even in challenging times. Every story we share is a step toward building a stronger, more connected, and more informed agri-ecosystem.

At Digital Agri News, we go beyond headlines — we provide insights, analysis, and solutions that matter. By bridging the gap between technology and tradition, policy and practice, local needs and global opportunities, we strive to create a platform where every voice in agriculture is heard and valued.

Thank you for trusting us as your partner in this evolving journey. Together, let's cultivate awareness, embrace innovation, and nurture a sustainable future for generations to come.

Dr. Mukesh Narwal

Warm Regards
Dr. Mukesh Narwal
Founder, Digital Agri News

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Role of WEEDS in Farming

Abstract

Weeds, often regarded as unwanted plants in agricultural fields, play a significant yet complex role in farming systems. While they compete with crops for nutrients, water, and light, weeds also contribute valuable ecological functions that support soil health and farm sustainability. Many weed species protect the soil from erosion by covering bare ground and improving moisture retention. Their root systems enhance soil structure, aid in water infiltration, and add organic matter when they decompose. Some weeds help recycle nutrients from deeper soil layers, while others act as indicator plants that reflect soil fertility and conditions. Weeds also provide habitat and food for beneficial insects that support natural pest control. Although excessive weed growth can reduce crop yields and increase production costs, balanced and informed weed management can harness their positive benefits. Understanding both advantages and challenges makes weeds an important component of sustainable farming.

Keywords: *Weeds, Farming, Soil Fertility, Biodiversity and Weed Management.*

Introduction

Weeds interfere with crop production by competing for nutrients, water, sunlight, and space. They reduce crop yields, harbor pests and diseases, and increase the overall cost of cultivation (Ross & Lembi, 2009). However, weeds are not entirely harmful. In many cases, they improve soil health, add organic matter, act as indicators of soil conditions, provide habitat for beneficial insects, and contribute to biodiversity. A balanced understanding of their roles helps farmers make informed decisions about weed management instead of simply eliminating all weeds from agricultural fields. Weeds are commonly viewed as unwanted plants in agricultural fields, yet their role in farming is far more complex than simply competing with crops. While weeds can reduce yields by competing for nutrients, water, light, and space, they also contribute to ecological balance in several ways. In many traditional and sustainable farming systems, certain weeds support soil health, provide habitat for beneficial insects, and help prevent erosion. (Altieri, 1999).

WEEDS:

Weeds are unwanted and undesirable plants that grow out of place in a field or cropping system, competing with crops for essential resources such as nutrients, water, sunlight, and space, ultimately reducing crop yield and quality (Zimdahl, 2018).

TYPES OF WEEDS:

1. Based on Life Cycle

a) Annual Weeds

- Complete their life cycle in one season or one year
- Examples: Euphorbia hirta, Amaranthus viridis, Chenopodium album (Ross & Lembi, 2009).

b) Biennial Weeds

- Complete their life cycle in two years.
- First year: vegetative growth
- Second year: flowering and seed production
- Examples: Wild carrot, Raphanus raphanistrum (Zimdahl, 2018)

c) Perennial Weeds

- Live for more than two years.
- Regenerate from roots, rhizomes, tubers, or stolones.
- Examples: Cynodon dactylon, Cyperus rotundus, Convolvulus arvensis (Ross & Lembi, 2009).

2. Based on Habitat

a) Aquatic Weeds

- Grow in water (floating, submerged, emergent).
- Examples: Eichhornia crassipes (water hyacinth), Azolla, Hydrilla (Zimdahl, 2018).

b) Terrestrial Weeds

- Grow on land.
- Examples: Amaranthus, Parthenium hysterophorus (Ross & Lembi, 2009).

c) Marsh or Wetland Weeds

- Grow in moist, marshy soil.
- Examples: Cyperus, Paspalum spp. (Altieri, 1999).

3. Based on Morphology

a) Grasses

- Narrow leaves, hollow stems, monocots.
- Examples: Cynodon dactylon, Eleusine indica (Ross & Lembi, 2009).

b) Sedges

- Triangular stems, monocots, thrive in moist areas.
- Example: Cyperus rotundus, Cyperus iria (Zimdahl, 2018)

c) Broad-leaved Weeds

- Wide leaves, dicots.
- Example: Parthenium, Amaranthus (Ross & Lembi, 2009).

4. Based on Origin

a) Native (Indigenous) Weeds

- Naturally present in the region.
- Example: Cynodon dactylon (Altieri, 1999)

b) Introduced (Exotic) Weeds

- Brought from other regions/countries.
- Example: Parthenium hysterophorus, Lantana camara (Zimdahl, 2018).

5. Based on Soil and Crop Conditions

a) Dryland Weeds

- Found in dry, rainfed fields.
- Example: Tribulus terrestris. (Ross & Lembi, 2009).

b) Irrigated Weeds

- Thrive in irrigated fields.
- Example: Cyperus spp. (Zimdahl, 2018).

c) Crop-Associated Weeds

- Occur mostly in specific crops.
- Example: Phalaris minor in wheat. (Ross & Lembi, 2009).

IMPORTANCE

1. Weeds help prevent soil erosion by covering the soil.
2. They add organic matter when decomposed.
3. Some weeds improve soil fertility by fixing nitrogen or bringing nutrients up. (Ross & Lembi, 2009).
4. They provide habitat and food for beneficial insects.
5. Certain weeds act as indicator plants of soil conditions. (Zimdahl, 2018).
6. Some weeds have medicinal or economic value. (Ross & Lembi, 2009).
7. They support biodiversity in farming ecosystems. (Altieri, 1999).
8. Weeds can improve soil structure with their root systems. (Zimdahl, 2018).
9. They help retain soil moisture by acting as natural mulch. (Ross & Lembi, 2009).

NEGATIVE ROLES OF WEEDS IN FARMING

1. **Competition with Crops:** Weeds are highly competitive and can grow vigorously under different environmental conditions. They utilize resources such as light, nutrients, and moisture that would otherwise be available to crops. For example, weeds like Amaranthus, Cyperus, and Echinochloa can dominate fields quickly, reducing crop Vigor and yield drastically. Early-season weeds are particularly harmful because they affect crop establishment. (Ross & Lembi, 2009).
2. **Reduction in Crop Quality:** Certain contaminate harvested produce and reduce its market quality. Weed seeds mixed with grains increase cleaning costs, while toxic weeds may make food unsafe. Some weeds release allelopathic chemicals that inhibit crop growth. Examplesinclude Parthenium hysterophorus and Lantana camara, which release toxins that negatively affect germination and growth. (Zimdahl, 2018).
3. **Increase in Cost of Cultivation:** Farmers spend significant amounts of money and labor on weed control. Costs include manual weeding, chemical herbicides, machinery usage, and additional irrigation.

1. In many crops, more than 30% of cultivation expenses are due to weed management. (Ross & Lembi, 2009).

2. **Increase in Cost of Cultivation:** Farmers spend significant amounts of money and labor on weed control. Costs include manual weeding, chemical herbicides, machinery usage, and additional irrigation. In many crops, more than 30% of cultivation expenses are due to weed management. (Ross & Lembi, 2009).

3. **Interference with Farm Operations:** Weeds hinder normal farm activities such as sowing, irrigation, and harvesting. Tall or dense weeds make machinery movement difficult and increase harvesting time. (Zimdahl, 2018).

4. **Water Loss and Nutrient Depletion:** Weeds consume large quantities of soil nutrients and moisture, causing severe moisture stress in crops. (Ross & Lembi, 2009).

POSITIVE ROLES OF WEEDS IN FARMING

1. **Soil Protection and Erosion Control:** Weeds provide ground cover that protects soil from erosion by wind and water. (Altieri, 1999).

2. **Contribution to Soil Fertility:** When weeds decompose, they add organic matter to the soil, improving structure and microbial activity (Zimdahl, 2018).

3. **Indicator Plants for Soil Conditions Certain weeds indicate soil conditions:** Cyperus: waterlogged soil – Chenopodium: fertile/ alkaline soil– Chenopodium: fertile/alkaline soil – Rumex: acidic soil (Ross & Lembi, 2009).

4. **Food, Fodder, and Green Manure:** Some weeds are edible, while others serve as fodder or green manure e.g., Sesbania (Altieri, 1999).

5. **Medicinal Uses:** Several weeds have medicinal value such as Centella asiatica and Achyranthes aspera. Zimdahl, 2018).

6. **Habitat for Beneficial Insects:** Flowering weeds attract pollinators and natural predators that support biological pest control.

7. **Enhancing Biodiversity:** Weeds support birds, insects, microorganisms, and wildlife, improving ecological balance on farms. (Altieri, 1999).

Conclusion

Weeds play both harmful and beneficial roles in farming. While they reduce yields and increase cultivation costs, they also protect soil, enhance biodiversity, improve fertility, act as indicator plants. Integrated Weed Management (IWM) helps balance weed control and ecological benefits. (Zimdahl, 2018).

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Soil Fertility Management in Crop Production

Abstract

Soil fertility management is fundamental to achieving sustainable crop production, food security, and long-term agricultural resilience. The fertility of soil determines its ability to supply essential nutrients in adequate and balanced amounts to crops while supporting favorable physical and biological conditions. Effective soil fertility management integrates chemical, physical, and biological approaches including soil testing, balanced fertilization, organic matter enhancement, integrated nutrient management, soil conservation measures, and precision agriculture tools. As modern agriculture faces challenges such as soil degradation, nutrient mining, climate change, and declining organic matter levels, the development of holistic fertility management strategies becomes increasingly vital. This article provides an in-depth exploration of the principles, methods, challenges, and innovations in soil fertility management, highlighting its pivotal role in improving crop yields, sustaining soil health, and ensuring environmental protection.

Keywords: Soil fertility management, sustainable crop production, nutrient management, soil health, food security.

Introduction

Soil fertility is one of the most important determinants of agricultural productivity. It influences the ability of soil to supply nutrients, retain moisture, support root development, and sustain biological activity. As global demand for food increases, maintaining and enhancing soil fertility is critical for meeting crop production goals while ensuring environmental sustainability. The increasing pressure from population growth, intensive cultivation, and climate change has intensified the need for improved soil fertility management strategies that can maintain soil health and optimize nutrient use efficiency.

Modern approaches emphasize integrating conventional and organic nutrient sources, using soil and crop diagnostics, incorporating crop rotations, and adopting precision farming tools (Lal R. 2004). These evidence-based interventions help restore soil productivity, reduce nutrient losses, and improve long-term soil health.

Principles of Soil Fertility

Soil fertility is governed by chemical, physical, and biological properties that determine its capacity to support plant growth. Key principles include:

1. Nutrient Availability: Fertile soils contain sufficient quantities of essential nutrients (macro and micronutrients) in plant-available forms.

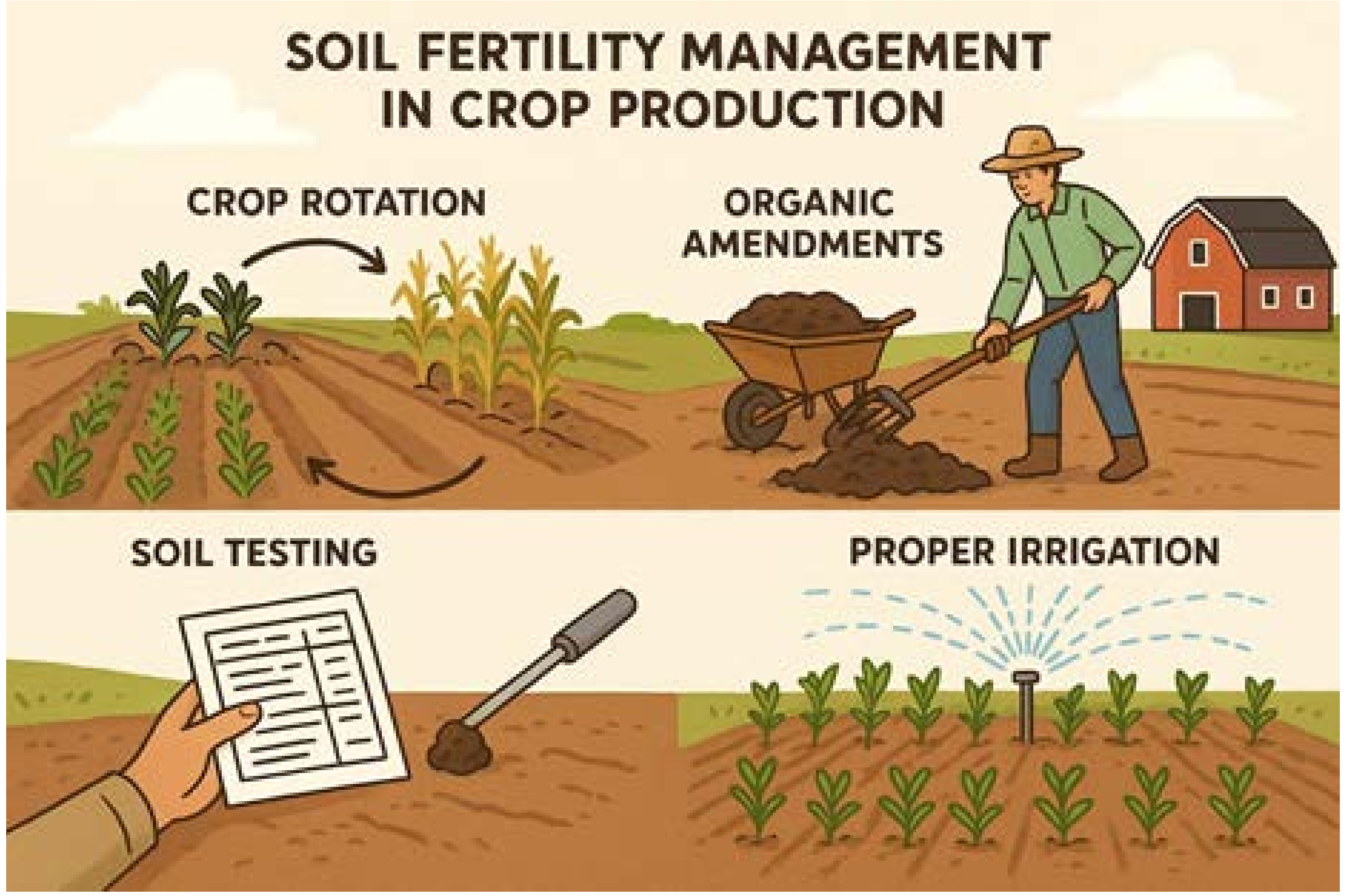
2. Soil Organic Matter (SOM): SOM enhances soil structure, water-holding capacity, nutrient retention, and microbial activity.

3. Soil Reaction (pH): Soil pH regulates nutrient solubility and microbial processes. Most crops prefer a pH between 6.0 and 7.5.

4. Soil Structure and Texture: These influence water infiltration, aeration and root penetration.

5. Biological Activity: Soil organisms drive decomposition, nutrient mineralization, and organic matter turnover.

Understanding these principles is crucial for designing appropriate soil fertility interventions.



Essential Plant Nutrients and Their Roles

Plants require 17 essential nutrients, categorized as macronutrients and micronutrients:

Macronutrients: Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulfur (S)

Micronutrients: Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo), Chlorine (Cl), Nickel (Ni)

These nutrients play vital roles including chlorophyll formation, energy transfer, enzyme activation, and structural integrity. Deficiency or excess of any nutrient affects crop health, yield, and quality, making balanced nutrient supply essential.

Soil Testing and Nutrient Diagnosis

Soil testing is the foundation of scientific soil fertility management. It assesses soil nutrient status, pH level, organic carbon content, and presence of problematic salts.

Benefits of soil testing include:

- Formulation of balanced fertilizer recommendations.
- Avoidance of excessive fertilizer use.
- Cost savings for farmers.
- Improved nutrient use efficiency.

Diagnostic tools like leaf tissue analysis, rapid soil test kits, and digital soil maps further support nutrient decision-making.

Organic Sources of Nutrients

Organic amendments are essential for improving soil fertility, especially in regions with low soil organic matter (Giller et al., 2009). Common organic sources include:

1. **Farmyard Manure (FYM):**

1. Enhances soil structure and provides slow-release nutrients.
2. **Compost:** Improves microbial activity and nutrient retention.
3. **Green Manure:** Increases nitrogen content and organic matter through leguminous crops.
4. **Crop Residues:** Improve soil organic carbon and moisture retention.
5. **Biofertilizers:** Such as Rhizobium, Azotobacter, and Mycorrhizae enhance biological nitrogen fixation and nutrient uptake.

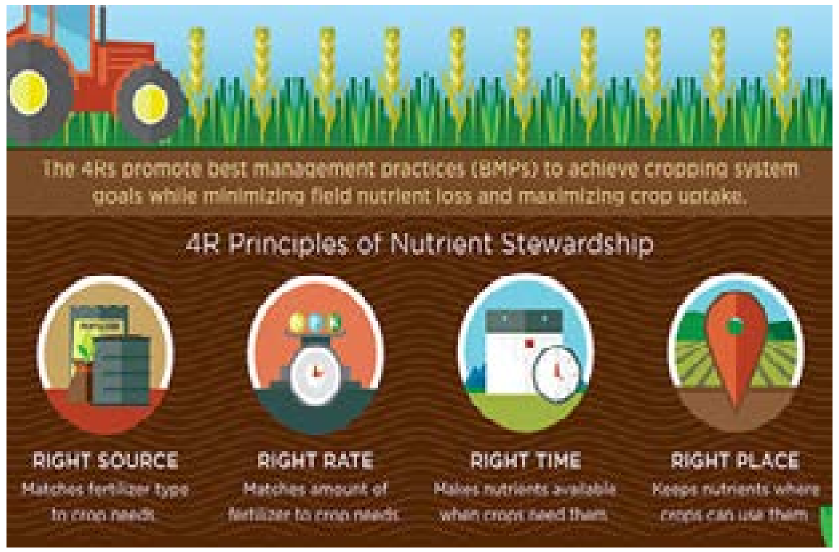
Organic sources improve soil health and reduce dependency on chemical fertilizers.

Inorganic Fertilizers and Balanced Nutrient Application

Chemical fertilizers supply nutrients in concentrated forms and remain essential for achieving high yields. Balanced nutrient application considers the crop's nutrient requirement, soil nutrient supply, and expected yield.

The 4R nutrient stewardship principle ensures efficient fertilizer use:

- Right Source of nutrient
- Right Rate of application
- Right Time of application
- Right Place of placement



Balanced application prevents nutrient deficiencies, toxicities, and environmental pollution.

Integrated Soil Fertility Management (ISFM)

ISFM combines organic and inorganic nutrient sources with improved crop varieties and sound agronomic practices. It aims to maximize nutrient use efficiency and sustain long-term soil productivity (Nziguheba et al., 2016).

Key components include:

- Combined use of organic matter and mineral fertilizers
- Site-specific nutrient management (SSNM)
- Use of high-yielding and nutrient-efficient crop varieties
- Soil conservation measures

ISFM is especially effective in nutrient-depleted regions and smallholder farming systems.

Soil Conservation and Erosion Control

Soil erosion removes nutrient-rich topsoil, reducing soil fertility. Preventive measures include:

- Contour bunding
- Terracing
- Strip cropping
- Cover cropping
- Mulching
- Reduced or zero tillage

These measures preserve soil structure, enhance moisture retention, and improve long-term productivity.

Role of Crop Rotation and Intercropping

Crop rotation helps maintain soil fertility by alternating nutrient-demanding crops with legumes or less exhaustive crops (Tonitto et al., 2006).

Benefits include:

- Improved nitrogen availability through biological nitrogen fixation
- Breaking pest and disease cycles
- Improved soil structure and organic matter
- Better nutrient recycling

Intercropping enhances nutrient use efficiency and ensures better overall resource utilization.

Precision Agriculture in Soil Fertility Management

Precision nutrient management uses advanced tools such as GPS, GIS, drones, sensors, and satellite imagery to apply fertilizers more accurately (Bationo et al., 2007).

Advantages include:

- Reduced input cost
- Higher nutrient use efficiency
- Reduced environmental pollution
- Tailored nutrient application based on spatial variability

Precision agriculture is transforming modern soil fertility management.

Challenges in Soil Fertility Management

Despite technological advancements, many challenges persist:

- Declining soil organic matter
- Excessive and imbalanced fertilizer use
- Soil salinization and acidification
- Nutrient mining due to insufficient fertilizer application
- Limited access to soil testing facilities
- Climate change impacts on soil health

These challenges highlight the need for sustainable and adaptive soil fertility practices.

Strategies for Future Soil Fertility Enhancement

To sustain soil health for future generations, the following strategies are essential:

- Promoting integrated nutrient management
- Enhancing soil organic carbon levels
- Wider adoption of precision agriculture
- Strengthening extension and farmer education
- Encouraging the use of renewable nutrient sources
- Improved soil research and policy support

CONCLUSION

Soil fertility management is a cornerstone of sustainable crop production. Integrating organic and inorganic nutrient sources, adopting soil conservation practices, utilizing diagnostic tools, and embracing precision technologies can significantly enhance soil health and crop productivity. With growing concerns about soil degradation, climate change, and food insecurity, implementing comprehensive soil fertility management strategies is more important than ever. A holistic, scientific, and farmer-friendly approach will ensure productive soils, healthier crops, and a sustainable future for agriculture.

FUTURE THRUST

Increasing soil organic carbon, growing precision nutrient management, encouraging integrated nutrient systems, and creating climate-resilient soil practices must be the top priorities for future soil fertility management. Maintaining soil productivity and ensuring long-term agricultural sustainability will require bolstering farmer training, improve soil testing infrastructure, and promote cutting-edge biofertilizers and sustainable technology.

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Future of food: Why millets matter-connecting health, economy & sustainability

Introduction: *rethinking what we eat for a sustainable tomorrow*

Food is more than just nourishment; it shapes health, livelihoods, and ecosystems. Yet, the global food system today faces an unprecedented crisis. While one part of the world battles hunger, another struggles with obesity and lifestyle-related diseases (Thakur et al., 2024). At the same time, farmers are facing climate-induced crop failures, and our agricultural systems are depleting natural resources at alarming rates. In this complex web of nutritional insecurity, economic instability, and environmental degradation, a set of ancient, resilient grains known as millets are emerging as a beacon of hope. Once regarded as "poor man's food," millets are now being rebranded as "smart foods" good for you, good for the farmer, and good for the planet. They offer a unique blend of nutrition, adaptability, and ecological harmony, making them indispensable for the future of food.

Millets: *the forgotten grains with a glorious past*

Millets are among the earliest domesticated crops known to humankind, cultivated for over 5000-6000 years across Asia and Africa (Winchell et al., 2018). They were the primary staple before rice and wheat took over during the Green Revolution. India has a rich history of millet cultivation from pearl millet (bajra) and finger millet (ragi) to small millets like foxtail, barnyard, kodo, proso, and little millet. However, modernization of agriculture and consumer preference for polished rice and refined wheat led to a gradual decline in millet cultivation. The share of millets in India's total cereal production fell from 40% in the 1950s to less than 10% by the early 2000s. Now, driven by rising health awareness and the need for climate-smart agriculture, millets are

making a remarkable comeback. The United Nations declared 2023 as the International Year of Millets on India's proposal has put these grains back in the global spotlight (Jadhav et al., 2024).

Health: rediscovering nature's nutritious grains

The modern diet, dominated by processed foods and refined cereals, is a major cause of malnutrition and chronic diseases. Millets, in contrast, are nutritionally superior and can play a key role in combating both undernutrition and overnutrition. Millets are rich in protein, dietary fiber, essential amino acids, and micronutrients such as calcium, iron, zinc, and magnesium (Ingle et al., 2023). For instance:

- **Finger millet (ragi)** contains nearly 10 times more calcium than rice or wheat ideal for bone health.
- **Pearl millet (bajra)** is high in iron and zinc, combating anaemia.
- **Foxtail millet and little millet** have low glycaemic indices, beneficial for diabetes management. Their high fibre content aids digestion, prevents constipation, and contributes to a feeling of satiety reducing overeating and obesity risk.

Tackling lifestyle diseases

Globally, the incidence of diabetes and cardiovascular diseases is rising at an alarming rate. Millets help regulate blood sugar levels and lower cholesterol, making them an excellent dietary choice for managing metabolic disorders. Research from ICRISAT and other institutions has shown that millet-based diets can reduce blood glucose levels by up to 17% compared to refined cereal diets (Rathor, 2021). Being naturally gluten-free, millets are also suitable for individuals with celiac disease or gluten intolerance. They serve as a healthier alternative to refined flours in bakery items, snacks, and processed foods. In many developing countries where malnutrition and micronutrient deficiencies persist, millets offer a cost-effective way to deliver essential nutrients. Incorporating them into midday meal programs, Anganwadi nutrition schemes, and school feeding initiatives can help combat hidden hunger among children and women. In essence, promoting millets is not merely a dietary preference; it is a public health strategy that addresses both undernutrition and lifestyle-related diseases simultaneously.

Economy: reviving rural livelihoods and farmer prosperity

Millets are not only nutritious but also economically empowering, especially for smallholder farmers in dryland regions.

Low input, high resilience

Unlike rice and wheat, millets thrive on marginal lands with low water, minimal fertilizer, and very little pesticide requirements. Their ability to grow in poor soils and withstand drought makes them a lifeline for farmers in semi-arid tropics like India and sub-Saharan Africa (Mukherjee et al., 2025). For instance, while rice needs around 2,500 liters of water to produce one kilogram of grain, millets can yield the same quantity with less than 500 liters (Bouman, 2009). This water-use efficiency makes them ideal for water-scarce regions. Because of their hardy nature, millets minimize crop failure risks during erratic rainfall and high-temperature spells. Lower production costs mean farmers retain higher net incomes even when market prices are moderate.

Creating new value chains

The growing consumer demand for healthy and organic foods is driving the establishment of millet-based industries. Startups and food companies are innovating with millet-based products from in stant mixes, noodles, and breakfast cereals to cookies, energy bars, and beverages. This expanding millet value chain is creating jobs in processing, packaging, and marketing, contributing to rural entrepreneurship. The government's initiatives, such as the "Millet Mission" and "Smart Food Campaign," are promoting these value-added opportunities (Tiwari et al., 2024).

Enhancing export potential

India, being the largest producer of millets globally, is well-positioned to lead the international millet market. Export demand for organic and processed millet products is growing in North America, Europe, and the Middle East. With proper branding, certification, and quality assurance, millets could become the next global superfood export from India.

Sustainability: millets as climate-smart crops

In an era of accelerating climate change, millets represent the essence of climate-smart agriculture. They thrive in arid and semi-arid regions with rainfall as low as 250–400 mm and temperatures exceeding 40°C. Their ability to withstand drought, heat, and poor soil fertility makes them ideal for climate adaptation. Millets have a low carbon and water footprint, contributing to environmental sustainability. While rice cultivation emits methane and consumes vast amounts of groundwater, millets are naturally energy-efficient and require no standing water. Research suggests that replacing 20% of rice or wheat with millets could reduce water demand by 33% and a significant amount of emissions of greenhouse gas (Davis et al., 2018; Tata Power, 2025). They also improve soil health and biodiversity. Grown with minimal chemical inputs, millets support microbial activity, prevent erosion, and enhance organic matter in soils. Their diverse species add stability to farming systems and foster ecological balance. By aligning with multiple UN Sustainable Development Goals (SDGs), including Zero Hunger (SDG 2), Good Health and Well-being (SDG 3), Climate Action (SDG 13), and Responsible Consumption and Production (SDG 12) (Smaller Footprint, 2024). Millets are more than crops; they are instruments of sustainability that connect ecology with economy.

Global revival: from ancient traditions to modern tables

Millets are no longer confined to traditional diets; they are becoming a global food movement. Governments, researchers, chefs, and entrepreneurs are working together to mainstream these ancient grains and position them at the centre of sustainable food systems.

Policy Momentum and Global Partnerships

A strong policy push has accelerated the millet revival. The Indian government has integrated millets into Public Distribution Systems (PDS) and Integrated Child Development Services (ICDS), ensuring their inclusion in daily diets across rural and urban areas (Smaller Footprint, 2024). Events such as the Global Millets (Shree Anna) Conference 2023 have further amplified their visibility, establishing India as a global hub for millet promotion.

This momentum is also supported through international collaborations. Countries in Africa, including Nigeria, Ethiopia, and Kenya, along with several Asian nations, are partnering with India to promote millet-based farming and nutrition. Global agencies such as FAO and IFAD have recognized millets as essential crops for climate adaptation, nutrition improvement, and smallholder livelihood resilience, reinforcing their significance on the world stage.

CULINARY REINVENTION AND SCIENTIFIC INNOVATION

Parallel to policy advances, the culinary and research sectors are driving innovation. From five-star hotels to local cafés, millets are being creatively reintroduced in modern cuisines. Dishes like millet risottos, dosas, and desserts are now gaining popularity on global menus. This urban acceptance is crucial not only for consumer awareness but also for stimulating demand that encourages farmers to expand millet

cultivation. On the research front, institutions like International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Indian Council of Agricultural Research (ICAR), and State Agricultural Universities (SAUs) are developing high-yielding, biofortified, and climate-resilient millet varieties. Advances in genomics, breeding, and post-harvest processing are improving grain quality, shelf life, and product diversity, making millets more appealing to modern consumers. Together, these innovations bridge traditional wisdom with scientific progress, ensuring that millets evolve from ancient heritage grains to future-ready foods.

THE ROAD AHEAD: BUILDING A MILLET-BASED FUTURE

To ensure the millet movement continues beyond short-term campaigns, a multi-dimensional and sustained approach is essential, combining consumer awareness, market development, research support, and strong policy backing.

DRIVING AWARENESS AND STRENGTHENING VALUE CHAINS

Long-term success depends on changing perceptions and creating steady consumer demand. Public awareness campaigns highlighting the health, nutritional, and environmental benefits of millets can inspire lifestyle shifts and build lasting acceptance. Introducing millet-based meals in schools, hospitals, canteens, and restaurants can normalize their consumption across generations. Equally important is building efficient value chains that connect farmers to markets. Investments in post-harvest infrastructure, including dehulling, grading, milling, and packaging units, are vital to maintain quality and ensure competitiveness. Strengthening farmer-producer organizations (FPOs) can integrate smallholders into organized supply systems, improve price realization, and create rural employment opportunities. Together, awareness and infrastructure development form the backbone of a sustainable millet economy from farm to fork.

RESEARCH, INNOVATION, AND POLICY SUPPORT

Continuous research and extension will be critical to improve productivity, processing efficiency, and consumer appeal. Efforts to develop high-yielding, biofortified, and climate-resilient varieties, along with innovations in product formulation and shelf life, can help millets compete with mainstream cereals. Training programs for farmers, entrepreneurs, and food processors can further bridge the gap between production and processing. At the policy level, integrating millets into national frameworks such as climate adaptation plans, nutrition missions, and public procurement systems will solidify their role in food security strategies. Institutionalizing millet inclusion in government programs ensures long-term commitment beyond international observances or short-term projects (GOI-PIB, 2025). A coordinated approach linking science, markets, and governance will pave the way for a truly millet-based future, one that nourishes people, supports farmers, and sustains the planet.

CONCLUSION: MILLETS AS THE GRAINS OF THE FUTURE

Millets embody the perfect synergy between tradition and technology, health and sustainability, people and the planet. In a time when global food systems are under stress, these humble grains offer a roadmap to resilience. By reviving millet cultivation and consumption, we can:

- Nourish populations with balanced, nutritious diets,
- Empower farmers with sustainable income opportunities, and
- Protect natural resources for future generations.

The future of food does not always lie in discovering something new sometimes, it lies in rediscovering the wisdom of the past. Millets, once forgotten, are now the grains of hope, shaping a healthier, greener, and more sustainable future for all.

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Black wheat: A nutritional revolution for health-conscious INDIA

Introduction:

India's food consumption landscape is undergoing a significant transformation driven by growing concern over lifestyle-related disorders such as diabetes, obesity, cardiovascular diseases, and hypertension. Consumers are increasingly moving away from energy-rich but nutritionally poor foods and are actively seeking cereals that offer functional and therapeutic value. In this evolving scenario, black wheat has gained attention as a novel and health-oriented alternative to conventional wheat. Unlike genetically modified crops, black wheat has been developed through classical plant breeding techniques by incorporating genes responsible for anthocyanin pigmentation into bread wheat. The deep purple to black coloration of its grains reflects the presence of powerful antioxidants, comparable to those found in black rice and berries. This unique combination of enhanced nutritional quality and premium market value positions black wheat as a promising crop for both health-conscious consumers and progressive farmers in India.

What is Black Wheat?

Black wheat is a nutritionally enriched wheat type distinguished by its high concentration of anthocyanins—natural pigments belonging to the flavonoid group known for their antioxidant properties. These pigments are primarily concentrated in the bran portion of the grain, giving black wheat its characteristic dark appearance.

Salient features of black wheat include:

- Developed through conventional breeding, not genetic engineering
- High levels of antioxidants, dietary fibre, iron, zinc, and protein
- Lower glycemic index compared to common wheat
- Adapted to Indian agro-climatic conditions

Leading Indian research institutions, including ICAR and Punjab Agricultural University, have successfully developed black wheat varieties suitable for cultivation in the northern wheat-growing regions of the country.

Nutritional Advantages of Black Wheat

The increasing acceptance of black wheat is largely attributed to its superior nutritional composition, which offers clear advantages over traditional wheat varieties.

1. Rich Source of Antioxidants

Anthocyanins present in black wheat help counter oxidative stress by neutralizing free radicals, thereby reducing cellular damage and the risk of chronic diseases.

2. Lower Glycemic Response

Black wheat exhibits a significantly lower glycemic index, resulting in slower glucose release into the bloodstream. This makes it particularly beneficial for:

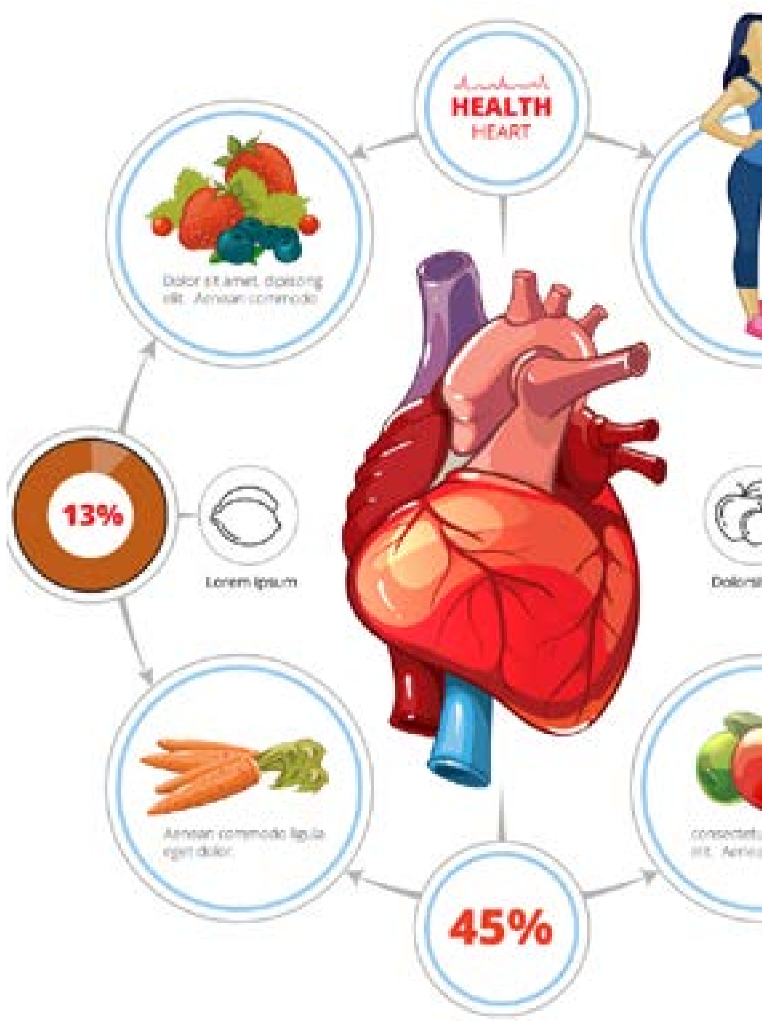
- Individuals with diabetes
- People at risk of metabolic disorders
- Consumers aiming for weight control

3. Higher Dietary Fiber Content

Enhanced fibre levels support digestive health, improve gut function, and help regulate cholesterol levels, thereby contributing to better cardiovascular health.

4. Improved Micronutrient Density

Black wheat grains contain elevated concentrations of essential micronutrients such as iron, zinc, magnesium, and protein, helping combat micronutrient deficiencies prevalent among women and urban populations.



Health Benefits for Indian Consumers

1. Diabetes Control :- Given India's high diabetes prevalence, black wheat offers a dietary solution by moderating post-prandial blood sugar levels through slow carbohydrate digestion and antioxidant activity.

2. Heart Health :- Anthocyanins contribute to improved vascular function, reduction of bad cholesterol (LDL), and prevention of arterial plaque formation.

3. Weight Management :- The combination of high fibre and low glycemic index promotes prolonged satiety, helping reduce excessive calorie intake.

4. Immunity and Anti-Aging :- The antioxidant-rich profile of black wheat supports immune function and slows age-related cellular degeneration, making it especially beneficial for elderly individuals.

NUTRITIONAL COMPARISON OF BLACK WHEAT AND CONVENTIONAL WHEAT

PARAMETER	NORMAL WHEAT	BLACK WHEAT	HEALTH RELEVANCE
Grain colour	Light brown	Dark purple/black	Indicates anthocyanins
Energy (kcal/100 g)	340	330–335	Slightly reduced calories
Protein (%)	11.5–12.0	13.0–14.5	Improved tissue repair
Dietary fibre (%)	2.0–2.5	3.5–4.5	Better digestion
Anthocyanins (mg/100 g)	Nil	40–140	Strong antioxidant effect
Glycemic Index	70–75	45–55	Diabetic-friendly
Iron (mg/100 g)	3.5–4.0	5.0–6.5	Reduces anemia risk
Zinc (mg/100 g)	2.5–2.8	3.8–4.5	Enhances immunity
Antioxidant capacity	Low	High	Disease prevention

AGRONOMIC FEASIBILITY IN INDIAN CONDITIONS

From a cultivation standpoint, black wheat closely resembles conventional wheat and does not demand specialized equipment or drastic changes in farming practices.

Climate and Soil Requirements

- Suitable for rabi season cultivation
- Performs best in well-drained loam to clay loam soils
- Neutral soil pH is ideal

Crop Duration and Productivity

- Maturity period: 135–145 days
- Yield levels: Comparable or slightly lower than popular wheat varieties
- Productivity improves with balanced nutrition and effective weed control

ECONOMIC PROSPECTS FOR FARMERS

1. Higher Market Returns

Black wheat commands prices two to three times higher than normal wheat due to its health-oriented positioning.

2. Emerging Market Advantage

Limited cultivation at present ensures reduced competition and better profitability for early adopters.

3. Marketing Opportunities

Farmers can benefit through:

- Contract farming with nutraceutical and health-food companies
- Sales via FPOs, specialty stores, and digital platforms

4. Scope for Value Addition

Additional income can be generated through processing into:

- Whole grain flour
- Multigrain atta
- Bakery products, pasta, breakfast cereals, and snacks

ROLE IN SUSTAINABLE & CLIMATE-RESILIENT AGRICULTURE

Black wheat supports sustainable farming practices by:

- Exhibiting improved tolerance to heat and moisture stress
- Performing well under low-input and organic systems
- Encouraging crop diversification and reducing monocropping risks

These traits make black wheat a suitable choice under climate variability and resource-limited conditions.

MARKET AWARENESS AND CONSTRAINTS

Key challenges include limited consumer familiarity, relatively higher processing costs, and hesitation due to the dark grain colour. However, awareness campaigns, nutrition education, and policy support are steadily improving market acceptance, particularly in urban areas.

CONTRIBUTION TO NATIONAL NUTRITION SECURITY

Despite adequate food production, India continues to face widespread nutritional deficiencies. Black wheat can play a meaningful role in:

- Improving dietary quality
- Supporting preventive healthcare
- Reducing the burden of lifestyle diseases

Its inclusion in public nutrition programs, hospitals, and wellness initiatives could yield long-term health benefits.

CONCLUSION

Black wheat represents a strategic integration of agriculture, nutrition, and economic sustainability. It offers farmers a high-value crop with familiar cultivation practices while providing consumers with a functional food capable of addressing modern health challenges. With supportive policies, effective market linkages, and increased awareness, black wheat has the potential to emerge as a mainstream cereal in India's journey toward sustainable agriculture and improved public health.

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Smart: irrigation systems to combat water scarcity

Introduction:

Water is the foundation of agriculture, with farming accounting for approximately 70% of global freshwater withdrawals (United Nations Water, 2021). Yet, mounting pressures threaten the sustainability of this essential resource. Climate change is intensifying drought conditions, growing populations are driving demand, and much of today's irrigation infrastructure remains outdated and inefficient. Against this backdrop, agriculture faces a critical challenge: producing more food with less water. Meeting this challenge requires not discovering new water sources, but using existing supplies more efficiently. Smart irrigation technologies provide a promising, data-driven pathway toward enhanced water security.

Limitations of Conventional Irrigation

Traditional irrigation methods, such as flood irrigation or timer-based sprinklers, operate on fixed schedules that do not respond to real-time soil or climate conditions. As a result, water is often applied when it is not needed, leading to substantial losses through evaporation, runoff, and deep percolation beyond the root zone. These inefficiencies deplete scarce water resources and exacerbate environmental concerns, including soil salinization and nutrient runoff into waterways (Food and Agriculture Organization, 2020).

Principles of Smart Irrigation

Smart irrigation systems address these inefficiencies by leveraging technology to deliver water precisely when and where it is required. The central principle is the replacement of rigid schedules with responsive, data-driven decisions. Key components include:

1. **Soil Moisture Sensors:** Installed at multiple depths, these sensors provide real-time data on soil water content, preventing unnecessary irrigation when sufficient moisture is already available (Vellidis et al., 2017).
2. **Weather Data Integration:** Advanced systems draw on local weather stations and online services, incorporating variables such as rainfall, temperature, humidity, and evapotranspiration (ET) to calculate precise water requirements.
3. **Automated Controllers:** These devices process sensor and weather data to dynamically adjust irrigation schedules. They can delay irrigation after rainfall, reduce application during cooler conditions, or increase it during periods of extreme heat.
4. **Efficient Delivery Systems:** Smart controls achieve maximum impact when paired with technologies such as drip irrigation, which delivers water directly to the root zone, minimizing evaporation and runoff.

Tangible Benefits

The integration of smart irrigation technologies provides clear, measurable benefits for both water and food security:

- Significant Water Savings: Research demonstrates reductions in outdoor water use ranging from 20% to 50% compared to conventional methods (Garcia et al., 2020).
- Improved Crop Performance: Precise water management reduces plant stress, strengthens root systems, and can improve both yields and crop quality.
- Reduced Energy and Costs: Lower water use decreases the energy required for pumping and distribution, resulting in cost savings and improved operational sustainability.
- Climate Resilience: By adapting in real-time to fluctuating weather conditions, smart systems enhance agricultural resilience to droughts, heatwaves, and other climate-related disruptions.

Tangible Benefits

Despite their advantages, smart irrigation systems face adoption barriers. High initial investment costs can deter smallholder farmers, while technical complexity requires training for effective use. Widespread implementation will therefore depend on targeted interventions, including:

- Financial Incentives: Subsidies, low-interest loans, and cost-sharing programs to offset upfront expenses.
- Capacity Building: Training programs to equip farmers and technicians with the skills required to install, operate, and maintain these systems.
- Research and Development: Continued innovation to reduce costs and enhance usability.

Conclusion

Water security is one of the most pressing challenges of the 21st century. For agriculture — a sector both highly dependent on and vulnerable to water scarcity — the transition to efficient irrigation practices is essential. Smart irrigation systems represent a convergence of sensor technology, weather data, and automation that allows farmers to optimize water use while sustaining yields.

By enabling agriculture to "produce more with less," smart irrigation technologies play a vital role in building a future that is both water-secure and food-secure.

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