

MODERN AGRICULTURE

SCIENCE AND SUSTAINABILITY

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CHAPTER 9

CEREALS AND MILLETS PRODUCTION AND PRACTICES

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Abstract

Cereals and millets form the dietary backbone of millions across the globe, particularly in developing countries where they serve as staple foods and primary sources of energy and nutrition. This chapter provides an in-depth exploration of their agronomic significance, cultivation practices, and contributions to food security and sustainable agriculture. It outlines the historical and nutritional importance of major cereals like rice, wheat, and maize, alongside nutritionally rich and climate-resilient millets such as sorghum, pearl millet, and finger millet. The chapter discusses improved varieties, advancements in crop improvement, and modern cultivation techniques that enhance productivity and quality. It also critically examines the challenges impeding production, including climate change, soil degradation, pest outbreaks, post-harvest losses, and inadequate market access. By highlighting both the opportunities and obstacles in cereal and millet farming, the chapter emphasizes the need for integrated strategies, policy support, and farmer-centric innovations to ensure sustainable production and food system resilience.

9.Cereals and Millets Production and Practices'

Cereals and millets form the foundation of global food systems, especially in developing countries, where they serve as dietary staples. This chapter explores the agronomy, production technologies, and economic significance of major cereals and millets, along with region-specific cultivation practices, constraints, and future prospects.

9.1 Introduction to Cereals and Millets

Cereals and millets are cultivated grasses that produce edible grains. Cereals such as **rice, wheat, and maize** dominate global food production, while millets, including **sorghum, pearl millet, finger millet**, and minor millets, play a vital role in food security, especially in arid and semi-arid regions.

- **Cereals:** Known for their high carbohydrate content, they are energy-rich and form the bulk of caloric intake worldwide.
- **Millets:** Although lower in yields, they are rich in dietary fiber, micronutrients, and drought resistance, making them vital for nutritional security and sustainable agriculture.

9.2 Importance in Food Security and Nutrition

Cereals and millets are indispensable to global food security and human nutrition. As staple foods for the majority of the world's population, especially in developing nations, they supply a substantial portion of daily caloric intake, proteins, and essential nutrients. Their cultivation, consumption, and trade form the backbone of national and international food systems.

Food Security Contribution

Cereals such as rice, wheat, and maize account for more than 70% of the global grain production. They are widely cultivated, easy to store and transport, and adaptable to various agro-climatic zones. Because of their scalability and high energy content, cereals are central to the fight against hunger. Government food security schemes, such as the Public Distribution System (PDS) in India or global grain reserves, heavily rely on cereals to maintain buffer stocks and ensure the availability of affordable food.

Millets, though historically underutilized, are gaining attention as “climate-smart” crops that contribute significantly to **food security in marginal and rainfed areas**, where major cereals may fail due to poor soils or erratic rainfall. Millets have short growing cycles, require minimal inputs, and are resilient to pests and diseases, making them vital for small and marginal farmers in arid and semi-arid regions.

Nutritional Significance

While cereals are rich in carbohydrates and form a primary energy source, their protein content is moderate, and they may lack certain essential amino acids like lysine. However, when consumed with pulses or dairy, cereals provide balanced nutrition.

Millets, on the other hand, offer superior nutritional benefits:

- **Finger millet (ragi)** is high in calcium and iron.
- **Pearl millet (bajra)** contains high levels of iron, zinc, and fiber.
- **Foxtail millet** and **little millet** are rich in antioxidants and slow-digesting carbohydrates, making them ideal for diabetic and gluten-intolerant populations.

These properties make millets particularly effective in addressing “**hidden hunger**

Role in Dietary Diversity and Health

Modern diets, especially in urban areas, are increasingly dependent on processed, refined cereals, often leading to non-communicable diseases (NCDs) like obesity, diabetes, and cardiovascular conditions. Millets and whole grains can restore dietary balance by:

- Lowering glycemic index and promoting satiety.
- Improving gut health due to high fiber content.
- Enhancing immunity through natural phytochemicals and minerals.

Government programs such as **mid-day meals**, **ICDS**, and **nutrition gardens** are beginning to incorporate millets and whole grains to improve public health outcomes.

Strategic Importance in Policy

Recognizing their dual role in food security and nutrition, several national and international initiatives are promoting the cultivation and consumption of diverse grains. The **International Year of Millets (2023)** declared by the UN and supported by India emphasized the global need to mainstream millets in food systems. Subsidies, minimum support prices, research funding, and supply chain development are increasingly being directed toward these crops to enhance both availability and accessibility.

9.3 Major Cereals and Their Cultivation Practices

Cereals are the most widely cultivated crops in the world due to their adaptability, storability, and role as staple food sources. The primary cereals—**rice, wheat, and maize**—are essential for global food security. Each cereal has specific ecological requirements, cultivation practices, and regional importance. Understanding their agronomic management is critical for optimizing yields, ensuring food availability, and maintaining sustainability.

9.3.1 Rice (*Oryza sativa*)

Importance: Rice is the staple food for more than half the global population, particularly in Asia. It is a key crop in tropical and subtropical regions.

Climate Requirements:

- Requires a warm, humid climate.
- Optimal temperature: 25–35°C.
- Needs 1,000–2,000 mm of rainfall or assured irrigation.

Soil Requirements:

- Prefers clayey loam to clay soils with good water retention.
- Slightly acidic to neutral pH (5.5 to 7.0).

Cultivation Practices:

- **Land Preparation:** Fields are puddled (wet tilled) to create a soft bed for transplanting.
- **Sowing:** Two methods—direct seeding or transplanting from nurseries.
- **Nutrient Management:** Split application of nitrogen, with phosphorus and potassium based on soil test values.
- **Water Management:** Continuous flooding or alternate wetting and drying to conserve water.
- **Pest & Disease Management:** Common problems include rice blast, sheath blight, and stem borers.
- **Harvesting:** Done when grains are firm and golden; moisture content around 20–24%.

9.3.2 Wheat (*Triticum aestivum*)

Importance: Wheat is a major winter cereal in temperate and subtropical zones. It is rich in carbohydrates and is the primary ingredient in bread, pasta, and baked goods.

Climate Requirements:

- Cool climate during growth (10–15°C), with warm and dry conditions at maturity.
- Sensitive to high humidity during grain filling.

Soil Requirements:

- Grows best in loamy to clay loam soils with good drainage.
- Neutral to slightly alkaline pH (6.5–7.5).

Cultivation Practices:

- **Land Preparation:** Fine seedbed prepared using ploughing and harrowing.
- **Sowing Time:** October–December depending on the region.
- **Seed Rate & Spacing:** 100–125 kg/ha; row spacing of 20–22 cm.
- **Fertilization:** Requires balanced fertilization, especially nitrogen in split doses.
- **Irrigation:** Critical stages include crown root initiation (CRI), booting, and grain filling.
- **Weed Control:** Weeds like *Phalaris minor* are managed using herbicides and crop rotation.
- **Harvesting:** When grains are hard and moisture is around 12–14%.

9.3.3 Maize (*Zea mays*)

Importance: Maize is a versatile cereal used as food, feed, and industrial raw material. It is grown in both kharif and rabi seasons in India and across all continents.

Climate Requirements:

- Grows well in warm climates (21–30°C).
- Requires moderate rainfall (500–800 mm), especially during the flowering period.

Soil Requirements:

- Thrives in well-drained, fertile loamy soils with a pH of 6.0–7.5.
- Sensitive to waterlogging.

Cultivation Practices:

- **Land Preparation:** Deep ploughing followed by harrowing and leveling.
- **Sowing:** Direct seeding; line sowing at 60–75 cm row spacing.
- **Seed Rate:** 20–25 kg/ha depending on the variety.
- **Nutrient Management:** Requires high nitrogen; also responds to zinc and boron.
- **Irrigation:** Critical at tasseling, silking, and grain filling.
- **Pest & Disease Management:** Key threats include stem borers, fall armyworm, and downy mildew.
- **Harvesting:** Done when husks dry and grains are hard; moisture content around 20%.

Common Considerations Across Cereals

- **High-Yielding Varieties (HYVs):** Adoption of HYVs tailored to local conditions is essential for productivity.
- **Integrated Nutrient and Pest Management:** Promotes sustainability and reduces dependence on chemical inputs.

- **Mechanization:** Use of seed drills, combine harvesters, and threshers increases efficiency and reduces labor costs.
- **Post-Harvest Handling:** Proper drying and storage are crucial to minimize losses and maintain quality.

9.4 Major Millets and Their Cultivation Practices

Sorghum (Jowar)

- **Climate:** Drought-tolerant; prefers dry, warm regions.
- **Soil:** Alluvial to black cotton soils.
- **Practices:** Direct seeding, moderate fertilization, wide spacing, control of shoot fly and smut diseases.

Pearl Millet (Bajra)

- **Climate:** Hot and arid; performs well in sandy soils.
- **Practices:** Broadcast sowing or dibbling, intercropping with legumes, low-input cultivation.

Finger Millet (Ragi)

- **Climate:** Grows in hilly, rainfed areas.
- **Soil:** Tolerant of acidic and degraded soils.
- **Practices:** Nursery sowing and transplanting, weed management in early stages, minimal fertilization.

9.5 Crop Improvement and Varieties

Crop improvement is a crucial pillar in agricultural advancement, aimed at enhancing the yield potential, quality, resistance to biotic and abiotic stresses, and adaptability of cereal and millet crops. Over the decades, plant breeding programs and biotechnology interventions have significantly contributed to the development of improved crop varieties that address the challenges of food security, climate change, and nutritional deficiencies.

Objectives of Crop Improvement

The primary goals of cereal and millet crop improvement include:

- **Higher yield potential** to meet the growing food demand.
- **Resistance to pests and diseases** to reduce dependency on pesticides.
- **Tolerance to abiotic stresses** such as drought, salinity, and temperature extremes.
- **Improved nutritional quality**, including protein content, micronutrients (e.g., iron, zinc), and digestibility.
- **Shorter maturity periods** to suit multiple cropping systems and diverse agro-climatic conditions.

Methods of Crop Improvement

1. **Conventional Breeding:** Includes selection, hybridization, and backcrossing to combine desirable traits. For instance, hybrid maize and semi-dwarf wheat are products of this approach.

2. **Mutation Breeding:** Utilizes radiation or chemicals to induce mutations and develop new traits, such as disease resistance or early maturity.
3. **Biotechnology and Genetic Engineering:** Involves genetic modification to introduce specific traits, such as insect resistance (e.g., Bt maize) or biofortification (e.g., Golden Rice).
4. **Marker-Assisted Selection (MAS):** Accelerates breeding by using molecular markers linked to desired traits, allowing faster and more precise development of improved varieties.
5. **Participatory Breeding:** Involves farmers in the selection process to ensure varieties meet local preferences and needs.

Notable Improved Varieties in Cereals

- **Wheat:**
 - *HD 2967, PBW 343, and WH 1105* – high-yielding, disease-resistant varieties adapted to North India.
 - *MACS 6222* – suitable for peninsular India, known for drought tolerance.
- **Rice:**
 - *IR 64, MTU 1010, and Swarna Sub1* – flood-tolerant and high-yielding varieties.
 - *Pusa Basmati 1121* – premium aromatic rice with export value.
- **Maize:**
 - *HQPM 1, HM 4, and Bio-9637* – hybrid maize with high yield and quality protein content (QPM).
 - *DKC 9125 and Pioneer 30V92* – suitable for high-density planting and drought conditions.

Notable Improved Varieties in Millets

- **Finger Millet (Ragi):**
 - *GPU 28, PR 202, and CO 15* – high-yielding and blast-resistant varieties.
- **Pearl Millet (Bajra):**
 - *HHB 67 Improved and ICMH 356* – drought-resistant hybrids with good fodder value.
- **Sorghum (Jowar):**
 - *CSH 14, CSV 17, and SPV 2217* – dual-purpose varieties for grain and fodder.
- **Foxtail and Little Millet:**
 - *SiA 3085* (foxtail) and *OLM 203* (little millet) – suitable for semi-arid regions with early maturity.

Biofortified and Climate-Resilient Varieties

Recent breeding efforts focus on developing **biofortified cereals and millets** enriched with iron, zinc, and vitamin A to combat hidden hunger. For example:

- **DRR Dhan 45** – zinc-rich rice variety.
- **Pusa Vivek QPM 9** – quality protein maize.
- **Dhanashakti** – iron and zinc-rich pearl millet.

Additionally, **climate-resilient varieties** that can withstand erratic weather patterns, salinity, or submergence are gaining prominence in breeding programs supported by ICAR, CGIAR centers, and international seed companies.

9.6 Agronomic Practices for Higher Yield

- **Seed treatment:** Protects from early-stage diseases and enhances vigor.
- **Balanced fertilization:** Based on soil tests; application of macro and micronutrients.
- **Timely weeding:** Critical in early growth stages; inter-row cultivation in millets.
- **Water management:** Key for cereals like rice (alternate wetting and drying techniques) and maize (critical irrigation).
- **Harvesting and storage:** Grains should be harvested at physiological maturity and dried to safe moisture content for storage.

9.7 Challenges in Production

Despite being the cornerstone of food security in many countries, the production of cereals and millets faces a range of complex and interconnected challenges. These issues impact not only the quantity and quality of harvests but also the sustainability and profitability of farming systems. Addressing these challenges is essential to ensure resilient food systems and the well-being of millions of smallholder farmers.

1. Climate Change and Weather Extremes

Unpredictable weather patterns such as erratic rainfall, prolonged droughts, floods, and extreme temperatures have increasingly affected the productivity of cereals and millets. Drought-prone areas struggle to maintain crop yields, while excessive rainfall leads to waterlogging and disease outbreaks. Many cereal crops are particularly sensitive during flowering and grain-filling stages, which are easily disrupted by climatic anomalies.

2. Declining Soil Fertility and Degradation

Intensive cultivation, excessive use of chemical fertilizers, poor organic matter management, and lack of crop rotation have led to declining soil health. Problems such as salinization, erosion, compaction, and nutrient imbalance directly reduce crop productivity and sustainability. Millets, though hardy, can also show reduced yields in severely degraded soils.

3. Pest and Disease Pressure

Cereal and millet crops are vulnerable to numerous pests and diseases. For example, rice suffers from stem borers, leaf folders, and blast disease; wheat is affected by rusts; maize is vulnerable to fall armyworm; and millets face shoot fly and downy mildew. Climate change further intensifies pest and disease dynamics, leading to new outbreaks and requiring adaptive management strategies.

4. Limited Access to Quality Seeds

In many regions, farmers lack timely access to improved and certified seeds of high-yielding, pest-resistant, or climate-resilient varieties. Seed distribution systems are often inefficient or

unavailable in remote areas. This results in the use of outdated or low-performing local varieties, constraining yield potential.

5. Inadequate Irrigation Infrastructure

While rice and wheat are heavily water-dependent, a significant portion of their cultivation relies on rainfall. Inadequate or poorly maintained irrigation facilities limit farmers' ability to cope with dry spells, especially in millet-growing areas that typically lack irrigation support. Water scarcity is becoming a critical barrier to productivity across all major cereal crops.

6. High Input Costs and Resource Constraints

The rising prices of fertilizers, pesticides, labor, machinery, and energy make cereal and millet farming increasingly expensive. Small and marginal farmers often cannot afford recommended levels of input, leading to suboptimal production. In addition, lack of credit and insurance options compounds their vulnerability.

7. Post-Harvest Losses and Storage Issues

Poor infrastructure for harvesting, drying, storage, and transport leads to significant post-harvest losses, particularly in cereals like rice and maize. Traditional storage practices often fail to protect grains from moisture, insects, rodents, and fungal contamination, resulting in both quantitative and qualitative losses.

8. Limited Market Access and Price Fluctuations

Farmers frequently face challenges in accessing reliable markets due to poor transportation networks, middlemen exploitation, and a lack of price information. Price volatility, particularly in non-MSP-covered cereals and millets, discourages investment in production and affects income stability.

9. Neglect of Millets in Policy and Research

Despite their nutritional value and climate resilience, millets have historically received less attention in terms of research, subsidies, marketing, and policy support compared to major cereals like rice and wheat. This neglect has limited their adoption and commercialization, although recent efforts like the International Year of Millets 2023 have begun reversing this trend.

10. Knowledge and Extension Gaps

Many farmers are not fully aware of best practices in crop management, pest control, soil fertility, and post-harvest handling. Weak extension systems and limited training opportunities prevent the widespread dissemination of new technologies and techniques that could enhance cereal and millet productivity.

Conclusion

Cereals and millets continue to be the cornerstone of food and nutritional security. With advancements in agronomy, crop breeding, and market support, their potential in combating hunger, malnutrition, and climate change is being increasingly recognized. Promoting sustainable production practices and re-integrating traditional crops like millets into modern farming systems is essential for achieving resilient and inclusive agriculture.

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