

The Lost Seeds of India: How Ancient Genes Are Rescuing Modern Crops

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INTRODUCTION

India has nurtured agriculture for more than ten thousand years, developing thousands of crop varieties suited to different climates, soils and cultural traditions. Farmers carefully selected seeds generation after generation based on their performance under local environmental conditions. This long process of natural and human selection created enormous genetic diversity that became the backbone of Indian agriculture. Ancient Indian farming systems relied on diversity rather than uniformity. A single village often cultivated several varieties of rice, millet, wheat, pulses, vegetables and oilseeds, each adapted to specific ecological conditions. Some varieties matured early, others survived drought, while some tolerated floods or poor soils. This diversity ensured food security even under adverse climatic conditions.

The Green Revolution transformed Indian agriculture during the 1960s and 1970s by introducing improved high-yielding varieties supported by irrigation, fertilizers and pesticides. Although this revolution dramatically increased food production, it also encouraged the replacement of traditional landraces with genetically uniform cultivars. Thousands of indigenous varieties gradually disappeared from farmers' fields. Today, agriculture faces unprecedented challenges. Climate change is increasing the frequency of droughts, floods, heat waves and salinity intrusion. New pests and diseases continue to evolve, threatening crop productivity. Modern crop varieties often lack sufficient genetic diversity to cope with these changing conditions.

India's Rich Legacy of Traditional Seeds

India is one of the world's major centres of crop origin and diversification. Over thousands of years, farmers domesticated and improved numerous crop species through continuous selection. Traditional seeds are commonly known as landraces. These are locally adapted crop populations that evolved under natural and farmer selection. Unlike modern uniform varieties, landraces exhibit considerable genetic variation within populations, allowing them to adapt to changing environmental conditions.

Important characteristics of Indian traditional varieties include:

- High adaptation to local climatic conditions
- Tolerance to drought and moisture stress
- Resistance to local insect pests and diseases
- Better nutrient use efficiency
- Superior grain quality and taste
- Rich nutritional composition
- Ability to perform under low-input agriculture
- Cultural and religious significance

Genetic Erosion and the Disappearance of Ancient Seeds

Genetic erosion refers to the permanent loss of genetic diversity within crop species. Since the Green Revolution, the cultivation of thousands of indigenous varieties has declined sharply. Several factors have contributed to this loss.

Replacement by Modern Varieties: High-yielding cultivars gradually replaced traditional landraces because they produced greater yields under intensive management.

Agricultural Intensification: Large-scale monoculture farming reduced the cultivation of diverse local varieties.

Urbanization: Expansion of cities and industrial development reduced agricultural land where traditional crops were cultivated.

Market Preferences: Commercial markets often favour uniform grains with standardized

appearance, discouraging farmers from growing diverse traditional crops.

Climate Change: Extreme weather events have caused the disappearance of some locally adapted varieties.

Changing Farming Practices: Mechanization and intensive farming have encouraged uniform crop cultivation instead of mixed cropping systems. The reduction in crop diversity has increased vulnerability to pests, diseases and climate variability.

Importance of Genetic Diversity in Modern Agriculture

Genetic diversity acts as an insurance policy against environmental uncertainties. Diverse crops possess numerous genes that provide resilience under stressful conditions. Benefits of genetic diversity include:

- Improved adaptation to climate change
- Reduced pest outbreaks
- Enhanced disease resistance
- Stable crop production
- Better nutritional quality
- Increased breeding opportunities
- Sustainable agricultural systems

Ancient Genes and Their Role in Crop Improvement

Ancient genes refer to valuable hereditary traits preserved in traditional landraces and wild crop relatives. These genes have evolved naturally over centuries under diverse environmental conditions. Scientists identify useful genes using advanced genomic technologies before transferring them into modern cultivars through conventional breeding or molecular approaches. Important categories of ancient genes include:

Drought Tolerance Genes: Traditional millet, sorghum and rice varieties possess genes enabling plants to survive prolonged water scarcity. These genes regulate root growth, water conservation, osmotic adjustment and stress signalling.

Flood Tolerance Genes: Certain traditional rice varieties survive prolonged flooding. These

genes regulate oxygen transport and energy metabolism during submergence.

Heat Tolerance Genes: Ancient wheat and rice landraces possess genes that protect reproductive tissues under high temperatures.

Salinity Tolerance Genes: Coastal traditional rice varieties tolerate high salt concentrations through specialized ion regulation mechanisms.

Pest Resistance Genes: Traditional crops contain natural defence genes against insects. These genes reduce dependence on chemical pesticides.

Disease Resistance Genes: Landraces contain resistance genes against fungal, bacterial and viral pathogens. Such genes provide durable disease management.

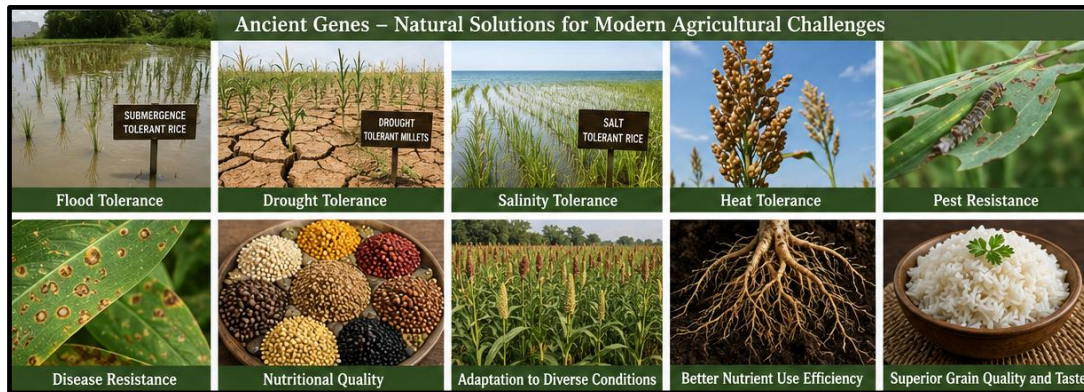


Figure 1: Valuable traits found in ancient Indian crop varieties that help address modern agricultural challenges.

Success Stories of Ancient Genes in Modern Crops

Numerous successful examples demonstrate how ancient genes have improved modern agriculture.

Flood Tolerant Rice: Traditional Indian rice varieties contributed genes responsible for submergence tolerance. Scientists incorporated these genes into modern high-yielding rice cultivars capable of surviving prolonged floods. Millions of farmers in flood-prone regions now benefit from these improved varieties.

Salt Tolerant Rice: Traditional coastal rice varieties possess genes enabling growth under saline conditions. These genes have helped develop rice suitable for salt affected coastal agriculture.

Drought Resistant Millets: Ancient millet varieties naturally tolerate water scarcity. Modern breeding programs utilize these genes to improve climate resilience.

Disease Resistant Wheat: Traditional wheat germplasm has provided resistance genes against rust diseases. These genes continue protecting wheat production worldwide.

Table 1: Examples of Valuable Traits Found in Ancient Indian Crop Varieties

Crop	Traditional Trait	Agricultural Importance	Modern Application
Rice	Flood tolerance	Survival under submergence	Climate-resilient rice breeding
Rice	Salinity tolerance	Coastal farming	Salt-tolerant varieties
Finger millet	Drought tolerance	Stable yield under low rainfall	Climate adaptation

Pearl millet	Heat tolerance	Productivity under high temperatures	Heat-resilient breeding
Chickpea	Disease resistance	Reduced crop losses	Resistant cultivars
Pigeon pea	Pest resistance	Lower pesticide requirement	Integrated pest management
Wheat	Rust resistance	Disease control	Improved wheat breeding
Sorghum	Water use efficiency	Dryland farming	Water-efficient cultivars
Barley	Salinity tolerance	Marginal land cultivation	Stress-tolerant breeding
Traditional rice landraces	High micronutrient content	Nutritional security	Biofortification programs

Conservation of Ancient Seeds

Conservation strategies are broadly classified into two categories.

In Situ Conservation

This involves conserving crops within their natural agricultural ecosystems where farmers continue cultivating traditional varieties.

Advantages include:

- Continuous natural evolution
- Preservation of farmer knowledge
- Maintenance of cultural traditions
- Adaptation to changing environments

Ex Situ Conservation

Seeds are stored outside their natural habitats in specialized facilities. Major methods include:

- National gene banks
- Seed banks
- Field gene banks
- Cryopreservation
- Botanical gardens

Role of Farmers in Conserving Ancient Seeds

Farmers remain the true custodians of agricultural biodiversity. Women play a particularly important role in seed selection and preservation in many rural communities. Community seed banks have become

increasingly important in preserving local genetic resources. Traditional farming communities continue conserving valuable seed varieties through:

- Seed selection
- Community seed exchange
- Local seed festivals
- Indigenous knowledge systems
- Mixed cropping
- Participatory breeding

Modern Technologies Unlocking Ancient Genes

Recent scientific advances have revolutionized the study of crop genetic resources.

Genome Sequencing: Whole-genome sequencing enables scientists to identify valuable genes rapidly.

Molecular Markers: DNA markers facilitate the selection of desirable traits during breeding.

Marker-Assisted Selection: This technique accelerates breeding by selecting plants carrying useful genes without waiting for visible characteristics.

Genomic Selection: Artificial intelligence and genomic prediction improve breeding efficiency.

Genome Editing: Genome editing technologies allow precise modification of crop genomes

while utilizing naturally occurring beneficial genes.

Bioinformatics: Large genomic databases help researchers analyze crop diversity and identify useful genetic variations.

Climate Change and the Need for Ancient Genes

Climate change represents one of the greatest threats to global food production. Ancient genes provide natural solutions for these challenges because they evolved under stressful environmental conditions over centuries. Climate-resilient agriculture increasingly depends on the conservation and utilization of traditional crop diversity. Major challenges include:

- Increasing temperatures
- Irregular rainfall
- Frequent droughts
- Flooding
- Salinity
- Emerging pests
- New diseases

Nutritional Importance of Traditional Crops

Many ancient crop varieties possess superior nutritional quality compared with modern cultivars. Examples include:

- Traditional rice varieties rich in antioxidants.
- Millets containing high calcium, iron, zinc, and dietary fibre.
- Traditional pulses with higher protein content.
- Coloured grains rich in anthocyanins and phenolic compounds.

Challenges in Utilizing Ancient Genetic Resources

Despite their enormous potential, several constraints limit the effective utilization of ancient genes. These include:

- Limited characterization of germplasm collections.
- Insufficient funding for biodiversity conservation.

- Loss of indigenous knowledge.
- Restricted access to remote farming communities.
- Complex inheritance of many adaptive traits.
- Lengthy breeding processes.
- Climate induced loss of wild relatives.
- Need for stronger collaboration among breeders, conservationists and farmers.

Future Perspectives

Future agriculture will increasingly depend upon genetic diversity. Priority areas include:

- Expansion of community seed banks.
- Digitization of germplasm collections.
- Greater investment in genomic research.
- Integration of artificial intelligence in breeding.
- Participatory breeding involving farmers.
- Promotion of traditional crops through value addition.
- Strengthening climate-resilient agriculture.
- Conservation of crop wild relatives.
- International collaboration for biodiversity conservation.

CONCLUSION

India's ancient seeds are invaluable genetic resources that hold the key to building resilient and sustainable agricultural systems. By combining traditional crop diversity with modern breeding and genomic technologies, these lost genetic treasures can help develop climate-resilient, pest-resistant and nutritionally superior crop varieties. Conserving and utilizing India's rich seed heritage through collaborative efforts among farmers, researchers and policymakers is essential for ensuring long term food security, protecting biodiversity and strengthening agriculture in the face of a changing climate.

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