



Participatory Breeding for Smallholder Farmers: Bridging the Gap Between Science and Farmer Needs

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Agriculture is the backbone of the Indian economy, employing over 50% of the population and contributing around 17-18% to the GDP. Among India's farming community, smallholder farmers constitute over 85%, cultivating less than 2 hectares of land. These farmers are critical for food security, yet they face numerous challenges such as limited access to quality seeds, unpredictable climate conditions, resource constraints, and a lack of crop varieties suited to their specific agro-ecological contexts. Participatory Plant Breeding (PPB) has emerged as an innovative and inclusive approach to address these challenges by involving farmers directly in the development of crop varieties that align with their needs and preferences. This article explores the importance, methodology, benefits, challenges, and future prospects of PPB with a focus on India, supplemented by insights from other countries.

What is Participatory Plant Breeding (PPB)?

PPB is a collaborative approach where farmers, researchers, and other stakeholders work together in the selection, evaluation, and development of crop varieties. Unlike conventional breeding methods, which are often centralized and disconnected from the field, PPB is decentralized, farmer-centric and focused on real-world conditions. This approach leverages farmers' indigenous knowledge and preferences, ensuring that the developed varieties are better suited to diverse agro-climatic conditions and farming practices.

The Relevance of PPB in India

1. Agro-Ecological Diversity

India has 15 agro-climatic zones and 127 agro-ecological sub-zones, each with unique environmental challenges such as drought, salinity, submergence, and extreme temperatures. Conventional breeding often fails to address this diversity, whereas PPB enables the development of region-specific solutions.

2. Empowering Smallholder Farmers

Smallholder farmers often lack access to high-yielding and stress-tolerant seeds. PPB empowers them to develop and access crop varieties tailored to their specific needs, thereby enhancing productivity and resilience.

3. Leveraging Indigenous Knowledge

Farmers' deep understanding of local soils, climates, pests, and diseases provides valuable insights for breeding programs. PPB integrates this knowledge with scientific expertise to develop better-performing varieties.

4. Addressing Climate Change

India is highly vulnerable to climate change, with increasing incidences of droughts, floods, and heatwaves. PPB facilitates the rapid development of climate-resilient crop varieties by involving farmers in selecting traits such as drought tolerance, submergence tolerance, and early maturity.

Methodology of PPB

PPB typically involves the following steps:

- 1. Site Selection:** Identifying regions with active farmer participation and unique agro-ecological challenges.
- 2. Farmer Engagement:** Conducting participatory workshops, surveys, and focus group discussions to understand farmers' preferences and constraints.



3. Germplasm Selection: Using diverse germplasm, including landraces, wild relatives, and advanced breeding lines, as the starting material.

4. On-Farm Trials: Testing multiple varieties on farmers' fields under real-world conditions to evaluate performance and adaptability.

5. Joint Selection: Farmers and scientists collaboratively evaluate traits such as yield, taste, pest resistance, resilience, and marketability.

6. Seed Multiplication and Dissemination: Promising varieties are multiplied and distributed to a broader community of farmers for adoption.

Case Studies from India

1. Wheat Breeding in Uttar Pradesh: In collaboration with CIMMYT (International Maize and Wheat Improvement Center), farmers in Uttar Pradesh participated in selecting wheat

varieties with high yield potential and resistance to leaf and stem rust. Over three years, farmer-selected varieties outperformed existing ones by 15-20% in yield. Adoption rates increased significantly as farmers trusted varieties they had helped develop.

2. Rice Varietal Development in Odisha

Farmers in Odisha's flood-prone regions worked with ICAR (Indian Council of Agricultural Research) and IRRI (International Rice Research Institute) to develop Swarna-Sub1, a submergence-tolerant rice variety. By incorporating farmers' preferences for grain quality and cooking characteristics, Swarna-Sub1 saw rapid adoption, covering over 1.5 million hectares within five years, ensuring food security for millions.

3. Pigeon Pea Improvement in Maharashtra

In Vidarbha, Maharashtra, smallholder farmers collaborated with ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) to develop drought-tolerant pigeon pea varieties. The variety ICPH 2671, selected through PPB, yielded 30% higher than traditional varieties and fetched premium prices in the market due to its superior quality.

4. Millet Breeding in Tamil Nadu

Millets, often called "nutri-cereals," are critical for nutrition and climate resilience. Farmers in Tamil Nadu, in collaboration with MSSRF (M. S. Swaminathan Research Foundation), developed high-yielding and disease-resistant pearl millet varieties. These varieties addressed malnutrition while ensuring sustainable farming practices in semi-arid regions.

5. Barley Breeding in Syria

ICARDA (International Centre for Agricultural Research in the Dry Areas) implemented PPB for barley breeding in Syria. Farmers selected varieties with improved drought tolerance and grain quality, increasing adoption rates by over 60%.

6. Maize Improvement in Mexico

CIMMYT's participatory breeding program in Mexico led to the development of drought-tolerant maize varieties that improved yields by 20-30% in water-scarce regions.

Challenges in Implementing PPB

- 1. Awareness and Training:** Farmers often lack awareness of PPB and the skills to actively participate.
- 2. Funding and Resources:** Limited financial and infrastructural support hampers large-scale implementation.
- 3. Policy and Institutional Support:** Absence of robust policies to integrate PPB into national breeding programs.
- 4. Intellectual Property Issues:** Uncertainty over ownership of farmer-developed varieties and benefit-sharing mechanisms.

Benefits of PPB

- 1. Higher Adoption Rates:** Farmers are more likely to adopt varieties they helped develop, ensuring faster dissemination.
- 2. Enhanced Genetic Diversity:** PPB promotes the use of diverse germplasm, reducing genetic erosion and increasing resilience to biotic and abiotic stresses.
- 3. Empowerment:** Farmers gain technical knowledge and decision-making power, fostering a sense of ownership and self-reliance.
- 4. Improved Livelihoods:** Locally adapted varieties enhance yields, reduce input costs, and improve marketability, boosting farmers' incomes.
- 5. Climate Resilience:** Varieties developed through PPB are better suited to local climatic conditions, ensuring stable production despite adverse weather.

Future Prospects

- 1. Integration with Modern Technologies:** Combining PPB with genomics, phenomics, remote sensing, and artificial intelligence can enhance the efficiency of breeding programs.
- 2. Policy Support:** Governments should institutionalize PPB by providing funding, training, and incentives for collaboration between research institutions and farming communities.

3. Scaling Successful Models: Expanding successful PPB initiatives to other crops and regions can amplify their impact.

4. Strengthening Farmer Networks: Establishing participatory groups and cooperatives can enhance knowledge-sharing and collective decision-making.

5. Climate-Smart Breeding: PPB can play a crucial role in developing climate-smart agriculture by focusing on traits like water-use efficiency, heat tolerance, and carbon sequestration.

Conclusion

Participatory Plant Breeding represents a paradigm shift in agricultural research, moving from a top-down to a bottom-up approach. By involving farmers as equal partners, PPB addresses the unique challenges faced by smallholder farmers in India and beyond. It not only enhances agricultural productivity and resilience but also empowers rural communities, making them active contributors to sustainable development. Scaling up PPB initiatives, supported by robust policies and modern technologies, will be instrumental in achieving food security, climate resilience, and socio-economic equity in the coming decades.

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