Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 04, Issue: 05 (SEP-OCT, 2024)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Participatory Plant Breeding: Re-Examining an Ancient Art through the Sharing of Knowledge

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To meet specific needs of various groups of farmers in different growing environments *like*, regions, countries, soil or climatic conditions *etc.* are fulfilled by **formal or conventional plant breeding programs** (centralized breeding programs). Farmers who can improve crop growth conditions by applying additional inputs such as fertilizer, pesticides, and irrigation or who can generate more supportive growing conditions for new varieties, have benefited more from formal or conventional plant breeding programs. Certain farmers grow their crops on marginal soils in high-stress conditions, and traditional plant breeding results could not always fulfill their requirements (Sperling *et al*., 2001). Plant breeding has traditionally been dominated by researchers, with little participation from farmers and end consumers. As a result, new breeding strategies must be designed to meet the needs of these farmers. However, this top-down strategy sometimes leads to the production of crop varieties that do not fully meet farmers' needs or perform ideally in local growing conditions. Participatory Plant Breeding (PPB) evolved as a response to these constraints, with the goal of facilitating the breeding process and encouraging farmers to play an active role in variety development. PPB allows particular adaptation to the local environment as compared to conventional plant breeding, which picks genotypes with "broad adaptability." Important benefits for organic farming are conferred by this "specific adaptability." Identification of beneficial genotype-by-environment (G × E) interactions that would be overlooked in traditional breeding is made possible by carrying out the selection cycles in the agro-systems where the varieties will be farmed. PPB not only enhances genetic diversity but also strengthens farmers' resilience to environmental challenges and contributes to sustainable agriculture.

Over the last decade, participatory variety selection (PVS) and participatory plant breeding (PPB) methods have emerged as another substitute to traditional or formal plant breeding. In the developing countries, the farmer's facing the limited resources for growing crops with marginal unit of land in remote locations at that time this method can apply. It can be employed in situations when the adoption rate of current cultivars or technology transfer is low (farmers are unwilling to take the risk of replacing their known and trustworthy conventional varieties with newly developed varieties) or modern cultivars are inaccessible. As a result, PPB was founded to assist poor farmers in developing nations who have limited resources and access to modern technologies to solve agricultural obstacles. It is primarily utilized to reap benefits from **poor yield potential, excessive stress or drought and different environments**.

The International Development Research Center (IDRC) of Canada sponsored a workshop in 1995 where **terms such as PPB were initially introduced**. In 1996, the idea of Participatory Research and Gender Analysis (PRGA) was presented, and in the year **2000**, PPB was an essential component of the plant breeding programs of every **CGIAR centre.**

Participatory plant breeding is defined as "the art and science of modifying the biological makeup of plants and crops to increase their yield and usefulness through the use of various techniques." Participation is defined as "taking part in a process or activity." It is a collaborative approach which includes scientists, farmers, consumers, extension agents, farmers' cooperatives, vendors, traders, processors, government and non-government organizations in plant breeding research. Participatory plant breeding (PPB) is **cropping breeding with farmers in the driver's seat**. In short, PPB is the collaborative process between farmers and researchers wherein farmers are the primary decision-makers for the planning, execution and assessment of the breeding materials.

Several Research organizations *viz*. International Crop Research Institute for Semi-Arid Tropics (**ICRISAT**), International Center for Agricultural Research in the Dry Areas (**ICARDA**), International Maize and Wheat Improvement Center (**CIMMYT**), International Centre for Tropical Agriculture (**CIAT**), National Institute for Agricultural Research (**INRA**), Local Initiative for Biodiversity, Research and Development (**LI-BIRD**), and Centre for Sustainable Development (**CENESTA**) along with various governments are **actively engaged in PPB activities**.

Why do we need PPB?

- Many scientists have observed that participatory plant breeding has resolved the challenges of conventional plant breeding by offering farmers to choose which varieties are ideal suited to their needs and conditions despite of exposing the household to any kind of risk throughout the selection process.
- Conventional plant breeding (CPB) develops varieties without understanding if farmers like them, and the process is mostly supply-driven.
- After the selection of plant by farmer according to their needs, the complete cycle of selection, it is a demand-driven process, which means that in Participatory Plant Breeding (PPB), the delivery phase is totally reversed. (Nelson *et al*., 2015, Bhargav *et al*., 2014).
- More sustainable cultivars can deleveped by this PPb approach

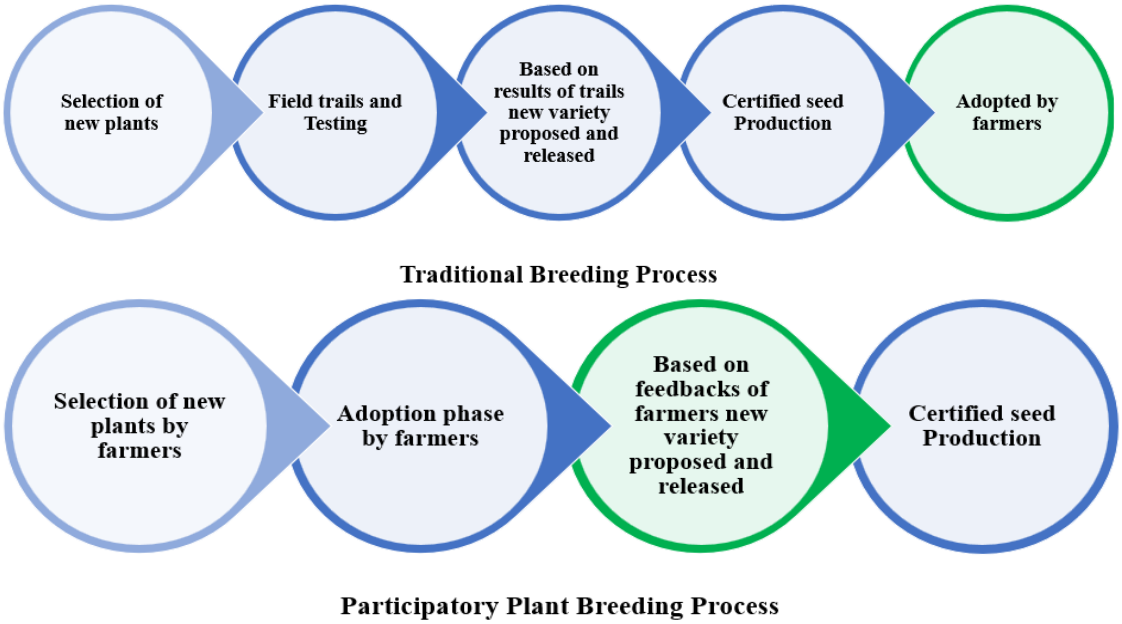

Fig. 1: The difference and similarity between TPB and PPB (Image created from the Merga, 2017)

Limitation of conventional plant breeding

- Non-connectivity with ground reality
- Limited beneficiaries
- Limited role of actual stakeholders
- Persistence of poverty and food insecurity
- Nutrient availability
- Environmental issues
- Greater incidence of diseases

From the perspective of participation, PPB encourages the following type of participation:

1) Functional Participation: The kind of involvement in which plant breeders immediately begin their study based on the demands of certain groups of farmers. Farmers can ensure that plant breeders accurately evaluate trait choices. On-farm research trials ensure that cultivars will perform effectively under "real-life" environments. Farm research trials might be managed by the researcher, the farmer, or both. PPB promotes farmer adoption of innovation (Bhargav *et al*., 2014).

2) Empowering Participation: This participation is depends mostly on farmers knowledge and their skills. Through the participation farmer knowledge and skills were rising, so that farmers can more participate in the collaborative breeding efforts and be better at their own individual efforts (Bhargav *et al*., 2014). Other than that, Consultative, Collaborative, Collegial participation and Farmer experimentation. Farmers are consulted at each stage of the PPB process, but the breeder makes the final choice. This consultation begins when farmers determine their breeding aims and select appropriate parental materials. In a collaborative approach, breeders and farmers work together to determine selection criteria and research priorities through two-way communication. Collaborative involvement involves growing genotypes in farmers' fields and making their own plant or genotype selections. Farmers make decisions in groups or individually, but they communicate with breeders in an orderly manner. Breeders are not engaged in genotype selection or farmer research activities, which is referred to as farmer experimentation.

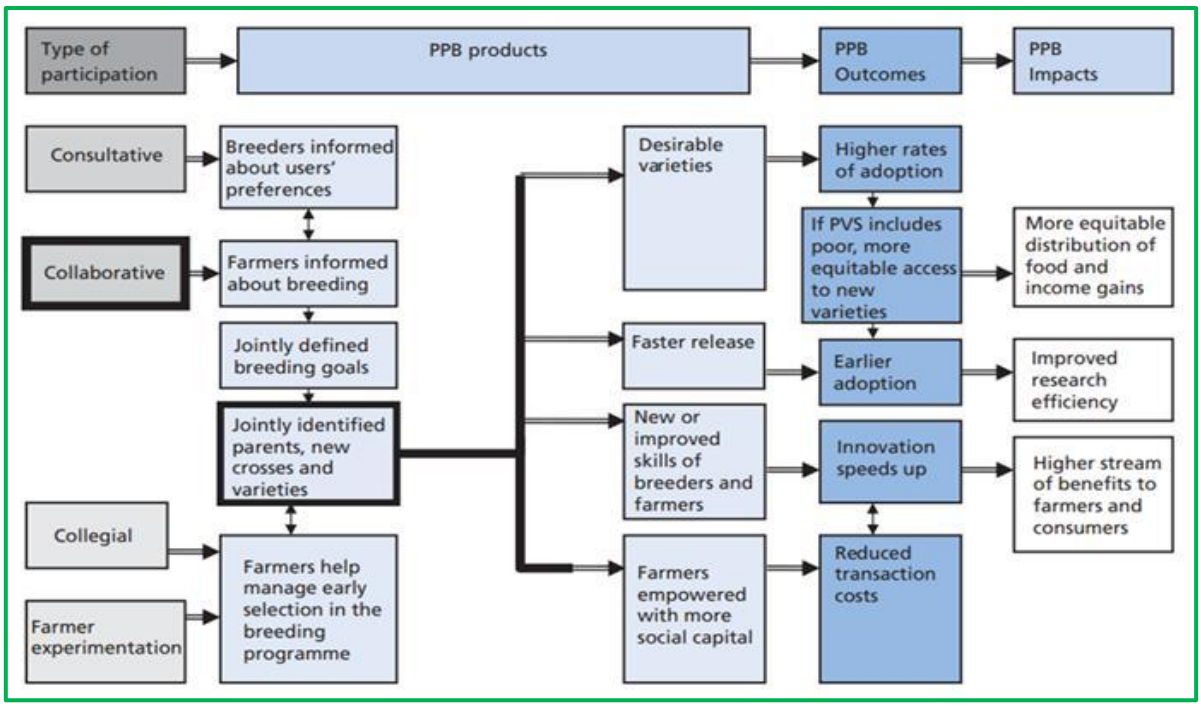

Fig. 2: Impact pathways of PPB (Image retrieved from the Ashby, 2009)

Activities of PPB

1. Identification of breeding objectives
2. Generation of genetic variability
3. Selection from variables population
4. Evaluation of experimental variety (PVS)
5. Releases of variety
6. Popularization
7. Seed production

Objectives

- Boost agricultural productivity and profitability
- Provides benefits to specific types of users
- Builds farmer skills
- Improving local adaptation and germplasm collection
- Enhancing biodiversity
- Capacity building and knowledge generation for farming communities and the formal research and development (R&D) sectors
- Creating modified germplasm for underprivileged user groups, such as women and poor farmers.
- Make breeding programmes more cost-efficient and targets more niches, especially through the decentralization of programmes

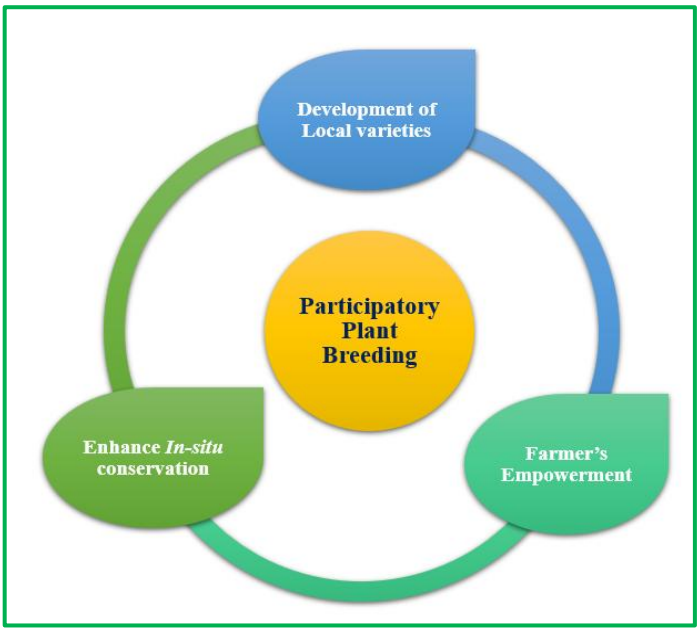

Fig. 3: Objectives of participatory plant breeding (Image created from Smolders, 2006)

Roles And Contributions of farmers in PPB Work

1. Farmers take the lead technically in evaluating cultivars for unique environmental requirements. They also share their specialities and life experiences.
2. Farmer research organizations are organized by farmers.
3. Farmers share details about preferred cultivars as well as significant characteristics that could be added to or retained in the current landraces.
4. Farmer-farmer interactions through farmers are involved skills in the building process.
5. Farmers donate their landraces or genetic resources so that future breeding efforts might utilize them.
6. Farmers provide land so that PPB genotypes can be tested.
7. Farmer participation can be valuable at certain points depending on the crop, parent materials, target region, farmer's ability to handle different types of materials, traits of interest, size of breeding program/number of materials to be screened, and researcher's ability to assimilate farmer requirements (Bhargav *et al.*, 2014).

Possible Outcomes/Benefits of PPB

- Time-saving
- Production gain
- Improving the farmer seed systems and seed provision to small-scale farmers
- Enhancement of biodiversity

- ❖ Amelioration in farmer's conditions
- ❖ Cost-efficiency and cost-effectiveness
- ❖ Research efficiency is improved
- ❖ Farmers' needs are met.
- ❖ PPB accelerates adoption
- ❖ Natural resource management

Limitations

- ❖ Often been argued about complexity of process, more time consuming and rise in cost
- ❖ Lack of suitable facilities and awareness
- ❖ Lack of appropriate laws and regulation
- ❖ The minor role of agricultural extension
- ❖ Lack of optimum situation for testing
- ❖ This raises concerns related to intellectual property rights, benefit sharing, and equitable access to improved germplasm.

Crop varieties developed in particular countries with the help of PPB

Sr. No.	Country	Place	Crop	Variety	Reference
(1)	India	Gujarat, India	Maize	GDRM-185, GDRM-186, GDRM-187	Witcombe *et al.* (2003)
		Eastern India	Rice	Ashoka 200F, Ashoka-228	Virk *et al.* (2003)
(2)	China	Guangxi, SW China	Maize	Xin Mo 1, Zhong Mo 1, Zhong Mo 2	Yiching and Jinsong lee (2011)
(3)	Uganda	Uganda	Sweet Potato	NASPOT-11	Mwanga *et al.* (2011)
			Rice	Nine varieties of rice	Kimani *et al.* (2011)
(4)	Nepal	Chhomrong and Ghandruk	Rice	M1, M2, M3, M4, M5, M6, M7	Sthapit *et al.* (1996)
		Pokhra valley	Rice	Jethobudho	Gyawali *et al.* (2010)
(5)	Brazil	Northern Brazil	French bean	Macrophomina and fusarium wilt-resistant varieties	Zimmermann (1995)
(6)	Zimbabwe	Zimbabwe	Maize	ZM-421	-
(7)	Ecuador	Ecuador	Potato	I-Frippa-99	Montesdeoca *et al.* (2006)
(8)	DR-Congo	Gandajika	Maize	AK9331-DMR-ESR-Y, QPMSRSYNTH	Mbuya *et al.* (2010)

Conclusion

PPB offers a promising approach to developing crop varieties that are not only high-yielding but also culturally appropriate, resilient to local challenges, and contribute to sustainable food security. By harnessing the collective knowledge of farmers and scientists, PPB empowers communities to take charge of their own food systems and build a more resilient future.

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