
Importance of Participatory Variety Selection and Participatory Plant Breeding in Variety Development and Adoption

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Abstract: Participatory varietal selection and participatory plant breeding are two new terminologies that include both old and new concepts and procedures. The degree and timing of farmer involvement in plant breeding determines the difference between participatory varietal selection and participatory plant breeding. The main difference between participatory plant breeding and participatory varietal selection is the degree of farmer involvement in the various stages of the breeding program. Participatory varietal selection involves farmers testing and selecting new varieties generated by the institutional system in their fields and at local research stations in a range of environments, as well as comparing these varieties to local farmer varieties while in a participatory plant breeding, farmers are often involved in decision-making throughout the breeding process, not just in the final testing of advanced breeding lines. Farmers are the primary beneficiaries of a participatory variety selection program because they are the end-users of agricultural technologies. The participatory variety selection method provides researchers valuable feedback that allows them to focus their research program to properly meet the demands of farmers. The poorest farmers should to profit from new varieties by promoting collaboration between plant breeders and farmers. However, poor farmers in marginal areas continue to produce obsolete crop varieties that are low yielding, susceptible to pests and disease and are less fitted to farmers' actual challenges and opportunities. These farmers have little exposure to new varieties, and those that have been released are frequently unsuitable for marginal areas. Therefore, participatory variety selection is very critical to introducing improved crop varieties to new growing environments based on farmers preferred traits and selected improved crop varieties. In order to enhance improved crop varieties, farmers' preferences must be taken into account across regions and growing seasons that farmers will accept. Generally, participatory varietal selection and participatory plant breeding are the way to overcome the issue of local adaptation and demand driven improved technologies. Participatory Varietal Selection and client-oriented breeding are two methods used to achieve farmers' profitability with improved crop varieties.

Keywords: Participatory Varietal Selection, Participatory Plant Breeding, Selection Criteria, Farmers Preferences

1. Introduction

Participatory variety selection is a broad term that refers to approaches in plant breeding that engage a number of actors (including scientists, breeders, farmers, and other stakeholders) whereas participatory plant breeding is a method of plant genetic development that brings together a variety of stakeholders, such as researchers, farmers, facilitators, and others [1]. Participatory plant breeding is a strategy that fosters the development of agro-ecology by

taking an approach that goes beyond the conventional scientific framework and considering the economic, social, and environmental potentials of a region. Indeed, it encourages financial autonomy for farmers, promotes a system that contributes to knowledge transfer and sharing, and works to preserve and sustain biological diversity [2]. Participatory varietal selection was proposed by Witcombe *et al.* [3] as a method for identifying acceptable novel varieties and eliminating the constraints that force farmers to grow landraces or obsolete cultivars.

Farmers' participation improved variety selection in their own production situations guarantees that improved varieties are accepted and eventually adopted [3]. According to Ashby [4], participatory varietal selection causes more farmers to adopt improved crop varieties over a larger area, resulting in increased food and income benefits. Farmers are routinely involved in selecting improved crop varieties to prefer desirable traits in order to boost the adoption rate of superior and stable varieties through participatory variety selection. Farmers are invited to take part in the selection of the best performing varieties based on the primary criteria of their desirable traits in participatory variety selection. Farmers' engagement in participatory variety selection has a number of benefits, including defining breeding goals and priorities, selecting the best varieties on their farm for further improvement, designing and planning subsequent activities through discussions with scientists, suggesting methodological changes, and multiplying seed of preferred improved varieties.

When it comes to launching improved crop varieties to a new growing environment, participatory variety selection is critical. Participatory varietal selection implies that better varieties exist than those currently grown, but that farmers do not have the opportunity to test or adopt them. Farmers are given varieties to test in their own fields as part of participatory varietal selection. Researchers used seeds from cultivars that have already been released, not only in the target region but also in other regions or countries, and which have the potential to be useful in other regions. The most important breeding program, participatory variety selection, increased the popularity of better varieties by raising awareness based on smallholder farmers' selection criteria.

In general, participatory variety selection refers to the higher and more complex involvement of farming communities in making decisions at the early and fundamental stages of the variety development chain [5]. Understanding farmers' preferences across agro-ecologies and growing seasons is a crucial first step for breeding programs aiming to develop farmer-acceptable varieties [6]. Breeders, farmers, scientists, and other stakeholders in variety development participate in participatory variety selection [7]. Participatory variety selection helps in the improvement of local landraces through best-practice agronomy and evaluates final breeding materials on farmers' farms [8]. Farmers' preferences are neglected when new improved varieties are released, and the process is typically supply-driven rather than demand-driven. However, because supply-driven developed varieties are not adopted, participatory variety selection has shifted the processes to demand-driven [9].

Participatory variety selection helps promote the adoption of appropriate improved varieties to meet farmers' increasing demands for better varieties and to increase skills in variety development processes with desirable traits [6]. Participatory varietal selection is playing a key role in identifying farmers' preferred improved varieties and is providing a long-term solution to the constraints that compel farmers to grow low-

yielding, biotic, and abiotic stress-prone land-races [10]. Participatory variety selection gives communities a lot of power over evaluating and choosing the best-performing varieties with desirable traits in their own fields. Participatory variety selection improves farmers' access to improved varieties, ensures food security, increases genetic diversity, helps in the extension of released varieties and increases adoption rates on a large scale, selects varieties that are cost-effective, and generates and scales up at the community level [11]. Farmers on their own farms select finished or near-finished crops from plant breeding programs through participatory varietal selection. This category includes newly released varieties, varieties in advanced phases of development, and well-characterized material such as advanced non-segregating lines in inbreeding crops or advanced populations in outbreeding crops.

Breeders, farmers, marketers, processors, consumers, and policy-makers work together to design a participatory plant breeding program. It allows farmers to take part in the development of new varieties or populations that are more adapted to marginal environments and organic farming practices. It is founded on the premise that both farmers and professional plant breeders have valuable knowledge and skills that can be integrated. Farmers choose genotypes from genetically variable, segregating material in participatory plant breeding, which often entails farmers actively participating in breeding programs and selecting genotypes from genetically variable, segregating material. The distinction between participation variety selection and participatory plant breeding may not appear to be significant at first glance. Participatory plant breeding, on the other hand, requires more resources and time than participatory variety selection, while participatory variety selection identifies material that the formal seed sector can give more promptly [12].

Participatory plant breeding (food security, health and nutrition, employment) is the development of a plant breeding program in collaboration involving breeders and farmers, marketers, processors, consumers, and policy-makers [13]. Plant breeding in the poor world is referred to as participatory plant breeding, and it comprises close collaboration by farmers and researchers to improve plant genetics within a species. Participatory plant breeding is a plant breeding method with its own set of methodologies that can be used when the demand for specific varietal characteristics among producers, traders, industries, and consumers is unknown and difficult to detect using conventional research methods [7]. Participatory Plant Breeding is based on the assumption that both farmers and professional plant breeders have valuable knowledge and abilities to contribute. It refers to approaches that include a variety of actors at various phases of the plant breeding process [7].

As an alternative to centralized breeding, farmer engagement procedures such as participatory varietal selection and participatory plant breeding can be used. Participatory plant breeding, which is an extension of

participatory varietal selection, utilizes the outcomes of participatory varietal selection by using recognized cultivars as parents of crosses. Farmers participate in participatory variety selection, which involves choosing lines from a population of fixed (stable) lines that are being field-tested that they consider are the most appropriate and applicable. As a result, participatory plant breeding has a higher empowering effect than participatory varietal selection since farmers are participating in decision-making at earlier and more fundamental stages of the variety generation chain. [5]. The objective of the review was to understand the role of participatory varietal selection and participatory plant breeding in variety enhancement and adoption.

2. Participatory Approaches

Farmers are becoming more active in agricultural research as scientists and development workers become more aware of the ideology of "farmer first" and its success [14]. A range of farmer participatory approaches are possible in farmer participatory research for improved crop cultivars. Farmers' participatory varietal selection (FPVS) and farmer participatory plant breeding (FPPB) are two types of participatory approaches (PPB). Because these two approaches are so dissimilar, they are likely to provide extremely different results. In participatory varietal selection and participatory plant breeding procedures, several levels of farmer participation and researcher input are used. Depending on the situation, participation varietal selection or participatory plant breeding may be the best option. A successful collaborative cultivar identification process typically leads to participatory plant breeding [14].

Participatory approaches to agricultural research and regional development, such as participation plant breeding and participatory varietal selection, have become a driving force. In previous decades, these methods were developed as an alternative to centrally controlled breeding methods in order to better incorporate end users' perspectives into the varietal development process and to more effectively address agriculturalists' desires for increased food security and improved farmer livelihoods, particularly in resource-poor areas. In participatory plant breeding, farmers are actively involved in the breeding process, from setting activity goals to selecting variable, early generation material.

2.1. Participatory Varietal Selection

Participatory variety selection is a way of field testing a small number of finished or almost finished varieties with the help of partners [13]. The most crucial activity in every breeding program is selection, which occurs at every stage of the process [10]. As a result, participatory plant breeding generally includes participatory variety selection [13]. According to Rahman et al. [10], participatory varietal selection can be used to identify farmer-acceptable variants and thereby eliminate the constraints that lead farmers to grow old or obsolete varieties. of trial run, to help partners who are underestimating the amount of land and time

required for a full-fledged participatory plant breeding program [15].

Thus, farmer-acceptable variations that are superior to old and obsolete varieties that farmers have been using for a long time can be selected through participatory variety selections [16]. In participatory varietal choices, farmers-centered varietal selections are confined to testing of finished varieties. Farmers assess a wide range of traits that are important to them, assisting in the increase of on-farm varietal diversity, faster varietal replacement, and rapid scale-up. Furthermore, participatory variety selections can assess quality traits such as milling percent, cooking and keeping quality, taste, and market price, which are difficult or costly to assess in conventional trials.

Participatory varietal selection is becoming increasingly popular as a means of choosing which materials should be included in breeding projects and which characteristics should be targeted, as well as for testing materials in farming environments before release [16]. The three processes of participatory varietal selection to find preferred cultivars are identifying farmers' needs, searching for appropriate material to test with farmers, and experimenting on farmers' fields. Farmers must be provided with seeds of farmer-preferred cultivars in a timely and cost-effective manner once they have been identified.

According to Joshi and Witcombe [14], despite their wealth of knowledge and skills in selecting varieties that match their demands, fit in local environments, and satisfy consumers' satisfaction, farmers' participation in technical advancement is limited by the current breeding system. Without the participation and involvement of smallholder farmers' indigenous knowledge in variety selection, better varieties may not be adaptable to various agro-ecologies due to climate variability [17]. Breeders' selection criteria and techniques of judging cultivar performance, which are largely quantitative and statistically driven, differ greatly from the methods used by farmers in the past, according to studies on participatory variety selection [18].

As a result, several scientists consider participatory variety selection as a way to get around the limitations of conventional breeding by incorporating farmers' knowledge and selection criteria into the plant development process [19]. It has showed success in identifying more preferred cultivars by farmers in less time, boosting cultivar diversity, and speeding up their dissemination. Farmers' participation in variety testing and selection can lower research expenditures while increasing adoption rates [20]. Participatory plant breeding or selection also harnesses the potential gains of breeding for specific adaptation through decentralized selection in the target environment [21].

Participatory approaches have significantly improved varietal diversity, which can serve the interests of different stakeholders, because they incorporate research and development-oriented procedures for organizing genetic materials at on-farm experiments. "Some of the benefits of participatory research approach include improving farmers' indigenous knowledge available within local communities for

optimal planning and empowerment," as well as raising farmer awareness, enhancing varietal diversity, and mobilizing farmers, according to the research. It is common practice, according to several authors, to include farmers in the selection and testing of novel cultivars that are designed to match the

needs, cropping methods, and existing environments. As a result, participatory approaches in research and development programs are crucial for viable advancement and benefit specific to the desires and conditions of farmers, especially for small-scale and resource-poor farmers.

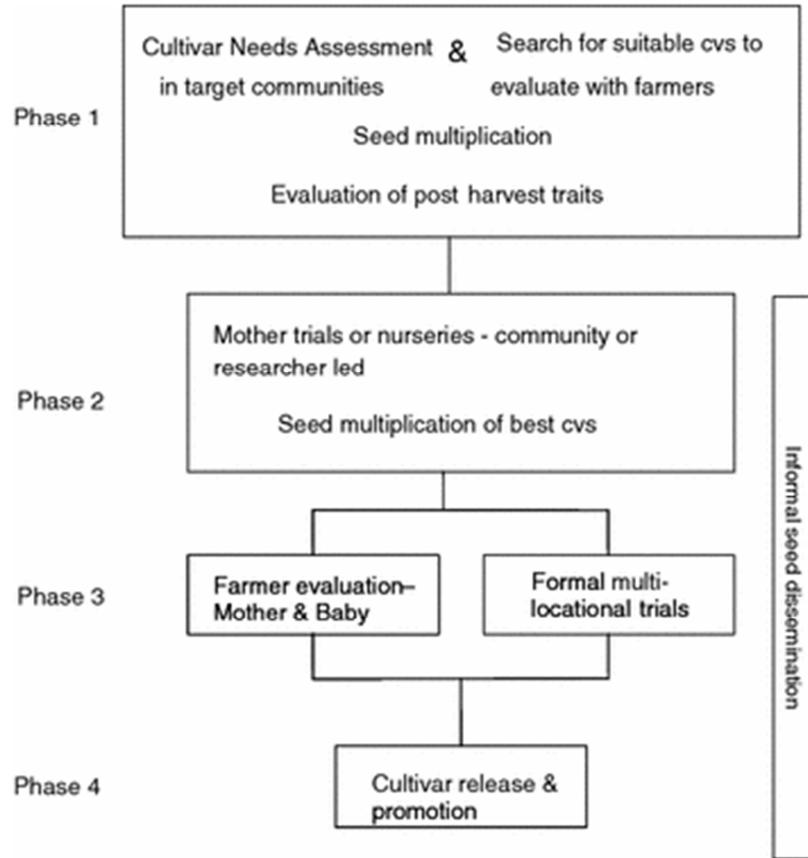


Figure 1. Participatory variety selection and scaling up.

2.2. Participatory Plant Breeding

Farmers and formally trained breeders collaborate at various stages of the breeding process, generally by placing breeding plots in farmers' fields rather than on agricultural research stations and selecting for agronomic and quality traits that are suited to the farmers' needs. Beginning in the 1950s, there were complaints of the lack of effectiveness of development initiatives aimed at bringing modern agriculture practices to places lacking these resources and participatory plant breeding was developed out of these criticisms.

Plant breeding goes back to the dawn of agriculture, with people domesticating crops like barley and emmer wheat some 10,000 years ago [22]. Plant breeding as a scientific field goes all the way back to Mendel's early 1900s findings on the inheritance of genetic traits. Plant breeding is a "science-based method" focused on providing farmers with better cultivars by choosing from genetically different plant populations [23]. Participatory plant breeding, according to Witcombe et al. [3], is "a logical extension of participatory varietal selection," in which farmers are involved in the early stages of selection from segregating populations.

Participatory plant breeding methodologies are well described in the scientific literature, and they vary greatly depending on the resources and project goals. They're all committed to meaningfully involving farmers in the breeding process. Farmers can participate in different stages of varietal development, such as setting breeding goals, making initial crosses, selecting among diverse progeny, evaluating experimental varieties, and disseminating seeds [24]. Participatory plant breeding is sometimes presented as a continuous process in which farmers can participate at different stages of varietal development, such as setting breeding goals, making initial crosses, selecting among diverse progeny, evaluating experimental varieties, and disseminating seeds. Furthermore, a distinction is frequently made between "formal-led participatory plant breeding," which is overseen by scientists from public research institutes, and "farmer-led participatory plant breeding," in which scientists play a more supportive role in the farmer's action plan [25].

With centralized participatory plant breeding efforts taking place on formal research stations and decentralized participatory plant breeding initiatives taking place in

farmers' fields, the selection environment can differ. Participatory plant breeding efforts aim to achieve a range of goals, such as developing varieties for marginalized areas, conserving biodiversity, empowering disadvantaged groups (especially women), and/or reducing breeding costs and timeframes [25]. Users can now follow step-by-step instructions to set up a participatory plant breeding program like Ceccarelli's [13] comprehensive plant breeding with farmers.

2.3. Relevance of Participatory Plant Breeding

Participatory plant breeding is known as collaborative plant breeding (CPB) [26], farmer participatory breeding (FPB) [27], and participatory crop improvement (PCI) [13], arose from the "Farmer-Back-to-Farmer" model developed by Rhoades and Booth [28]. Farmers, researchers, extension agents, and other plant breeding beneficiaries have all worked together to generate new crop varieties via participatory plant breeding [29]. Farmer selection of finished or nearly-finished varieties is known as participatory varietal selection, whereas farmer selection of segregating materials with a high degree of genetic variability is known as participatory plant breeding [13]. Ceccarelli et al. [17] defined decentralized breeding as testing and selecting at several sites representative of the target-breeding environment.

Decentralized breeding can be done without farmer input [24], and participatory plant breeding and participatory varietal selections are not necessarily done in various environments. Depending on the strategy and purpose, participatory breeding can be considered either researcher-led

or farmer-led [30]. Depending on the breeding process's goals and expected outcomes, either the farmer or the researcher takes the lead. Biggs [31] also identified four distinct categories of participation: a. "Signed contract," in which farmers exclusively supply scientists with land and services; b. "Consultative," in which scientists consult farmers about their difficulties before developing solutions; c. "Collaborative," in which scientists and farmers engage together as research partners; and d. "Collegial," in which scientists help farmers strengthen their informal research and development system.

Many poor countries have used participatory plant breeding or participatory varietal selection to evaluate and boost crop output over the last two decades [20]. Using participatory plant breeding, breeders can provide farmers with a wide range of genetic variability. As a result, participatory plant breeding has the potential to increase the breeding performance of complex farming systems in a variety of settings, including marginal ones [32]. By integrating farmers early in the selection process, the issue of adjusting the crop to a variety of target locations and user preferences can be overcome [33]. Farmers are asked to collaborate in order to improve the efficiency and effectiveness of the breeding program, and farmer engagement is also encouraged on the basis of equity. Participatory plant breeding provides a stronger emphasis on boosting yield in marginal areas, lowering production costs, and addressing the many farmers throughout the world who have not adopted modern varieties yet whose landraces are producing insufficient yields [29].



Figure 2. Development of improved and relevant crop varieties with farmers.

3. Farmers' Selection Criteria

Depending on their circumstances, individual farmers may have distinct selection concerns that demand the availability of several cultivars within each community to meet different requirements [34]. A farmer will need to plant more landraces to satisfy all of his or her requirements the more selection criteria he or she uses [35]. Farmers' selection criteria are frequently based on a variety of characteristics, such as active participation in technology development, cropping system, and family uses of crop and market; however, they may differ depending on gender and age of farmers, as well as socioeconomic conditions (access to credit).

Farmers commonly use crop traits such as large size, shape, and color of harvested component, absence of insect damage, and maturity duration [36]. Different cultivars are selected and planted as backups in the event that one fails due to environmental stress. Farmers can profit from a variety of markets by choosing cultivars that are in great demand.

3.1. Stage of Farmers Participation and Roles of Farmers in Participatory Plant Breeding

Farmer participation can be advantageous at different times depending on the crop, parent materials, target region, researcher capacity to assimilate farmer criteria, farmer capacity to handle different types of materials, traits of interest, and scale of the breeding program/number of materials to be screened [37]. Technical leadership, key social organizational leadership, information dissemination, trainer/skill-building, field worker, input supply, and landrace or farmer material for further breeding are all roles that farmers might play in participatory plant breeding [37].

3.2. Impact of Participatory Approaches

Farmers and scientists collaborate on plant breeding with the primary goal of effectively meeting the needs of farmers in developing countries' marginal areas [24, 16]. Participatory crop improvement is a set of strategies in which farmers and scientists collaborate on plant breeding with the primary goal of effectively meeting the needs of farmers in developing countries' marginal areas. Participatory approaches, such as participation plant breeding and participatory varietal selection, have become a driving force in agricultural research and rural development. Rather than simply telling smallholders what to do, an increasing desire to improve responsiveness to the rural poor has prompted development techniques that include communities in problem identification, project planning, and planning and implementation. Agricultural development routes are influenced by extrinsic and intrinsic location-based factors, which benefit from inclusive and locally adapted strategies [38]. Participatory approaches were developed with this in mind to allow communities to identify and prioritize development challenges, as well as to enhance the origin and adoption of solutions.

Participatory approaches represent a shift in strategy toward enhancing human resources and empowering

communities across the agricultural research and development agenda. Participatory approaches and tools used in agriculture include farmer field schools, farmer-to-farmer extension, agro-ecosystems analysis (AA), participatory rural appraisal (PRA), and a rapid rural appraisal (RRA). Participatory approaches, which use a variety of strategies and technology, aim to implement community-based farmer-to-farmer extension and collaborative learning within a defined framework. These programs, such as PREA [39], can effectively convey scientific information to farmers, enhance technological adoption, and empower local ownership.

According to Joshi and Witcombe [15], higher farmer participation enhances cultivar adoption rates, and poor farmers adopting participatory variety selection, adopt new varieties as quickly as richer farmers. Participatory variety selection has proven to be a superior concept to the traditional one once again. Participatory variety selection was a more rapid and cost-effective technique of selecting farmers' preferred cultivars when a good selection of cultivars was provided to evaluate [3].

3.3. Advantages of Participatory Over Conventional Plant Breeding Methods

At least one parent in every cross is well adapted to the local environment. Genotypes x environment interactions are effectively used since breeding is done in the intended environment. The impact of genotype x year interaction is expected to be diminished because local parental materials have adapted to local year-to-year variations. Because only a few crossings are made, large F2 and F3 populations can be generated, increasing the probability of selecting suitable sergeants. Most breeding experiments fail because the major stakeholders are not involved in the selection and development of the varieties in conventional breeding. According to Osiru *et al.* [40], this scenario leads to low adoption and diffusion of developing technology.

As a result, farmers who stand to benefit the most from improved agricultural technology must be engaged or participate. Farmers are now required to participate in agricultural activities. Participatory procedures developed from what was perceived as inappropriate varieties, practices, or extensions that did not meet local environmental conditions or special social demands, according to Joshi, A., and Witcombe [3].

New varieties are released through conventional plant breeding (CPB) before farmers have a chance to decide whether or not they like them, and the process is strongly influenced by supply. Because the process is demand-driven and is driven by the initial adoption by farmers at the completion of a full cycle of selection, the delivery phase in participatory plant breeding is turned upside down [9, 37]. As a result, many people now think of participation research as a way to solve most agricultural research programmers' challenges, because participatory plant breeding is expected to yield focused, relevant, and appropriate varieties [41].

As a result, the objectives of participatory plant breeding are to boost agricultural production and profitability by developing and increasing adoption of acceptable, usually better varieties. To benefit a certain sort of user or to respond to the needs of a larger set of users. Increase farmer abilities to improve farmer selection and seed production efforts [37]. Participatory plant breeding includes identifying breeding objectives, generating genetic variability, selecting within variable populations to develop experimental varieties, evaluating experimental varieties, variety release, popularization of release varieties, and seed production [37].

Table 1. Differences and similarities of conventional breeding and participatory plant breeding.

Conventional plant breeding	Participatory plant breeding
Supply driven	Demand driven
Selection of new varieties	Selection of new varieties
Variety release	Adoption
Production of certified seed	Variety release
Adoption	Production of certified seed

4. Conclusion

Farmers use participatory approaches to evaluate advanced, finished, or near-finished products from plant breeding programs on their own farms. Farmers' adoption of new crop varieties happened during and after the introduction of participatory plant breeding and participatory variety selection, as indicated by the fact that participating farmers adopted new crop varieties at a higher rate than non-participating farmers. It's likely that the link between Research & development activities and adoption is that collaborating farmers gain greater information, making it easier for them to see advantages of new crop varieties. As a result, the findings emphasize the importance of a collaborative approach to technology transfer in various countries. On various crops, research from participatory plant breeding and participatory variety selection have shown the potential for increasing on-farm varietal diversity and adoption rates.

The strategy allows for the evaluation of new crop varieties under a variety of biological and socioeconomic conditions, boosting their chances of success and offering access to new genetic resources five to six years before formal research begins. Many constraints associated with farmer participation are addressed through developed participatory approaches, which include establishing parameters, selecting superior varieties, evaluating the performance of better varieties, identifying better varieties, and speed up the dissemination of farmer-selected varieties in target areas. Suitable choice cultivar seed must be rapidly multiplied and delivered to farmers at a low cost after they have been identified.

Farmers who have had the chance to evaluate and select new varieties have a significant advantage in terms of maximizing their potential knowledge of choosing adapted

varieties that best meet their demands, which can then be included in their varietal portfolio for seed production. Most farmers recognized that improved cultivars will perform better when used in conjunction with recommended cultural practices. As a result, collaboration between researchers and farmers will aid in the development of research objectives aimed at overcoming rejection of varieties developed only by researchers, improving variety acceptability, and lowering variety production costs. Women play a crucial role in postharvest quality assessment and propagating new genetic materials, therefore biological yield and indigenous knowledge systems are important concerns when developing new crop varieties to boost varietal adoption and diversification.

Plant breeding has an impact on individuals and civilizations since it impacts the direction of our agricultural future. Farmers can't succeed unless they have varieties that are adapted to their farming practices, and consumers suffer from price increases, a lack of food availability, or both. Participatory plant breeding is an important method that has helped farmers and breeders in poor countries generate varieties that are suited to the harsh conditions seen on many subsistence farms. Participatory plant breeding does this by exploiting genotype by environmental interaction and selecting varieties directly in the area in which they will be used. Farmers are suitable to recognize the agronomic and qualitative traits that will allow the variety to be productive in their system, thus their participation in the methodology is essential.

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