



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 difference between participation varietal selection and participatory plant breeding is determined by the degree and timing of farmer involvement in plant breeding. The degree of farmer involvement in various stages of the breeding program is the fundamental difference between participatory plant breeding and participatory varietal selection. Farmers test and select new varieties generated by the institutional system in their fields and at local research centres in a variety of environments, as well as comparing these varieties to local farmer varieties, while farmers are often involved in decision-making throughout the breeding process, not just in the final testing of advanced breeding lines, in participatory plant breeding. 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

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 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 (Voss J, 1996). Participatory varietal selection was proposed [2] 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, participatory varietal selection causes more farmers to adopt improved crop varieties over a larger area, resulting in increased food and income benefits [4]. 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

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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 [10]. 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 landraces [11]. 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 [12]. Farmers on their own farms select finished or near-finished crops from plant breeding programs through participatory varietal selection. This category includes newly released cultivars, varieties in advanced stages of development, and well-characterized material such as advanced non-segregating lines in inbreeding crops or advanced populations in out-breeding crops.

Breeders, farmers, marketers, processors, consumers, and policymakers 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 ideally adapted to marginal environments and organic methods of cultivation. 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 typically involves 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 a first impression. Participatory plant breeding, on the other hand, requires more resources and time than participatory variety selection, while participatory variety selection identifies the material that the formal seed industry can give more rapidly [13].

The development of a plant breeding program in partnership with breeders and farmers, marketers, processors, consumers, and policymakers (food security, health, nutrition, and employment) is known as participatory plant breeding [14]. Plant breeding in the developing 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 strategy with its own methodology that can be utilized when the demand for specific varietal traits among farmers, merchants,

industries, and consumers is unknown and difficult to identify using conventional research methods [15]. 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 [16].

As an alternative to centralized breeding, farmer engagement approaches 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 results of participatory varietal selection by employing recognized cultivars as parents of crosses. Farmers participate in participatory variety selection, which entails choosing lines from a population of fixed (stable) lines that are being field-tested that they believe are the most appropriate and applicable. Because farmers are involved in decision-making at earlier and more fundamental stages of the variety creation chain, participatory plant breeding typically involves a higher and more sophisticated level of farmer involvement than participatory varietal selection. As a result, participatory plant breeding has a greater empowering effect than participatory varietal selection [17]. The objective of the review was to understand the role of participatory varietal selection and participatory plant breeding in variety enhancement and adoption.

Participatory Approaches

Farmers are becoming more involved in agricultural research as scientists and development workers become more aware of the ideology of "farmer first" and its effectiveness [18]. 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. Because these two approaches are so different, they are likely to provide extremely different results. In the participatory varietal selection and participatory plant breeding procedures, several levels of farmer participation and researcher involvement are used. Depending on the situation, participatory varietal selection or participatory plant breeding may be the best option. Participatory plant breeding is frequently the result of a successful collaborative cultivar identification process [19].

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 regions. In participatory plant breeding, farmers are actively involved in the breeding process, from setting activity goals to selecting variable, early generation germplasm.

Participatory Varietal Selection

Participatory variety selection is a method in which a small number of finished or almost finished varieties are field-tested with the participation of the partners [20]. Selection is the most important activity in any breeding program, and it happens at every stage of the process [21]. As a result, participatory variety selection is always an element of participatory plant breeding [22]. Found that participatory varietal selection can be utilized effectively to identify farmer-acceptable varieties and so overcome the constraints that cause farmers to grow old or obsolete varieties [23]. Participatory variety selection can also

be utilized as a jumping-off point, a sort of trial run, to assist partners inappropriately appraising the amount of land and time commitment that a fully-fledged participatory plant breeding program necessitates [24].

Thus, participatory variety selections can be used effectively to select farmer-acceptable varieties that are superior to old and obsolete varieties that farmers have been using for a long time [25]. Farmers-centered varietal selections are limited to testing of finished varieties in participatory varietal selections. Farmers evaluate a variety of traits that are essential to them, assisting in the expansion of on-farm varietal diversity, faster varietal replacement, and rapid scaling up. Furthermore, participatory variety selections can analyze quality traits such as milling %, cooking and keeping quality, taste, and market price, which are difficult or expensive to evaluate in conventional trials.

Participatory varietal selection is becoming a popular method for determining which materials should be included in breeding programs and which traits should be targeted, as well as for testing materials in farming environments prior to release [26]. Identifying farmers' needs, searching for relevant material to test with farmers, and experimenting on farmers' fields are the three phases of participatory varietal selection to identify preferred cultivars. Farmers must be promptly and cost-effectively supplied with seeds of farmer-preferred cultivars once they have been identified.

Farmers' involvement in technological development is restricted by the current breeding system, according to Joshi and Witcombe [27], despite their wealth of knowledge and skills in selecting varieties that meet their needs, fit in local environments, and satisfy consumers' satisfaction. Due to climate variability, better varieties may not be adaptive to varied agro-ecologies without the participation and involvement of smallholder farmers' indigenous knowledge in variety development [28]. According to studies on participatory variety selection, breeders' selection criteria and methods of assessing cultivar performance, which are mostly quantitative and statistically based, differ significantly from the methods used by farmers in the past.

As a result, several scientists consider participatory variety selection as a solution to overcome the constraints of conventional breeding by integrating farmers' knowledge and selection criteria into a plant development effort [29]. It has demonstrated success in identifying more preferred varieties by farmers in less time, speeding up their spread, and increasing cultivar diversity. If farmers are allowed

to participate in variety testing and selection, research costs can be decreased and adoption rates can [30]. Through decentralized selection in the target environment, participatory plant breeding or selection also harnesses the potential gains of breeding for specialized adaptation [31].

Because participatory approaches involve research and development-oriented procedures for organizing genetic materials at on-farm experiments, the variety generated through participatory approaches has significantly improved varietal diversity, which can suit the needs of various stakeholders. It could be concluded that "some of the benefits of participatory research approach include improvement of farmers' indigenous knowledge available within local communities for proper planning and empowerment," as well as increasing the degree of farmers' awareness, increasing varietal diversity, and mobilization of farmers. Several authors have said that including farmers in the selection and testing of novel cultivars that are designed to meet the needs, cropping methods, and existing environments is a common practice. As a result, the implementation of participatory approaches in research and development programs is critical, especially for small-scale and resource-poor farmers, for viable progress and benefit specific to the desires and conditions of farmers (Figure 1).

Participatory Plant Breeding

Participatory plant breeding is a process in which farmers and formally trained breeders collaborate at various stages of the breeding process, often by putting breeding plots in farmers' fields rather than on agricultural research stations and selecting for agronomic and quality traits that are suited to the farmers' specific needs. Participatory plant breeding arose from criticisms of the ineffectiveness of development initiatives aiming at delivering modern agriculture methods to areas without these resources, which began in the 1950s.

Plant breeding as a practice goes back to the dawn of agriculture, with crops like barley and emmer wheat being domesticated by humans around 10,000 years ago [31]. Plant breeding as a scientific field can be traced back to Mendel's discoveries on the inheritance of genetic traits in the early 1900s. Plant breeding is a "science-based technology" that strives to provide farmers with improved cultivars by selecting among genetically diverse plant populations [32] defined participatory plant breeding as "a logical extension of participatory varietal selection," in which farmers are participating in the first stages of selection from segregating populations [33].

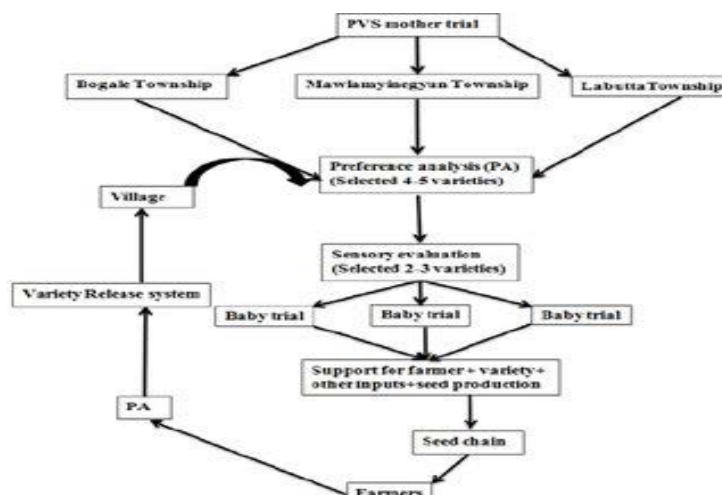


Figure 1: Participatory variety selection and scaling up.

Participatory plant breeding methodologies are well in the scientific literature, and they vary greatly depending on the project's resources and objectives. All of them are committed to include farmers in the breeding process in a meaningful way. 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 [25]. Furthermore, a distinction is sometimes drawn between "formal participatory plant breeding," in which scientists from public research institutes oversee the project, and "farmer-led participatory plant breeding," in which scientists play a more supportive role in the farmer's action plan [34].

The selection environment can differ, with centralized participatory plant breeding projects taking place on formal research stations and decentralized participatory plant breeding initiatives occurring in farmers' fields. Participatory plant breeding projects strive to achieve a variety of objectives, including improving varieties for marginalized places, preserving biodiversity, empowering disadvantaged populations (particularly women), and/or reducing breeding costs and time-frames [18]. Users can now follow step-by-step directions to establishing a participatory plant breeding program, such as Ceccarelli's (2012) comprehensive plant breeding with farmers.

Relevance of Participatory Plant Breeding: Participatory plant breeding is known as collaborative plant breeding (CPB) [16]. Farmer participatory breeding (FPB) [8], and participatory crop improvement (PCI) [12], arose from the "Farmer-Back-to-Farmer" model developed by Rhoades and Booth (1982). Participatory plant breeding has since been used to bring together farmers, researchers, extension agents, and other plant breeding beneficiaries in the development of new crop varieties [35]. Participatory varietal selection refers to farmer selection of finished or nearly-finished varieties, whereas participatory plant breeding refers to farmer selection of segregating materials with a high degree of genetic variability [32]. Decentralized breeding was also characterized, as testing and selecting in several sites typical of the target-breeding environment [27].

Participatory breeding and participatory varietal selections are

not always done in diverse contexts, and decentralized breeding can be done without farmer input [10]. The method of participatory breeding could be regarded as either researcher-led or farmer-led, depending on the approach and goal [5]. Depending on the objectives and expected outcome of the breeding process, either the farmer or the researcher takes the lead position. In addition, Biggs [19] identified four different types of participation: a. "Signed contract," in which farmers only provide land and services to scientists; b. "Consultative," in which scientists consult farmers about their problems and then develop solutions; c. "Collaborative," in which scientists and farmers collaborate as partners in the research process; and d. "Collegial," in which scientists work to strengthen farmers' informal research and development system.

Over the last two decades, many poor countries have adopted participatory plant breeding or participatory varietal selection to evaluate and increase crop productivity [28]. Breeders can give a wide range of genetic variability to farmers using participatory plant breeding. As a result, participatory plant breeding may improve the success of breeding for complex farming systems in a variety of habitats, including marginal ones [20]. The difficulty of adapting the crop to a variety of target environments and user preferences can be solved by involving farmers early in the selection process [32]. Farmers are expected to be partners in order to improve the breeding program's efficiency and efficacy, while farmer participation 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 [25] (Figure 2).

Farmers' selection criteria

Individual farmers may have different selection concerns that require the availability of several cultivars within each community to meet different requirements, depending on their circumstances [33]. The more selection criteria a farmer uses, the more landraces he or she will need to plant in order to meet all of his or her requirements [34]. Farmers' selection criteria are often based on a number of characteristics such as active participation in technology development,

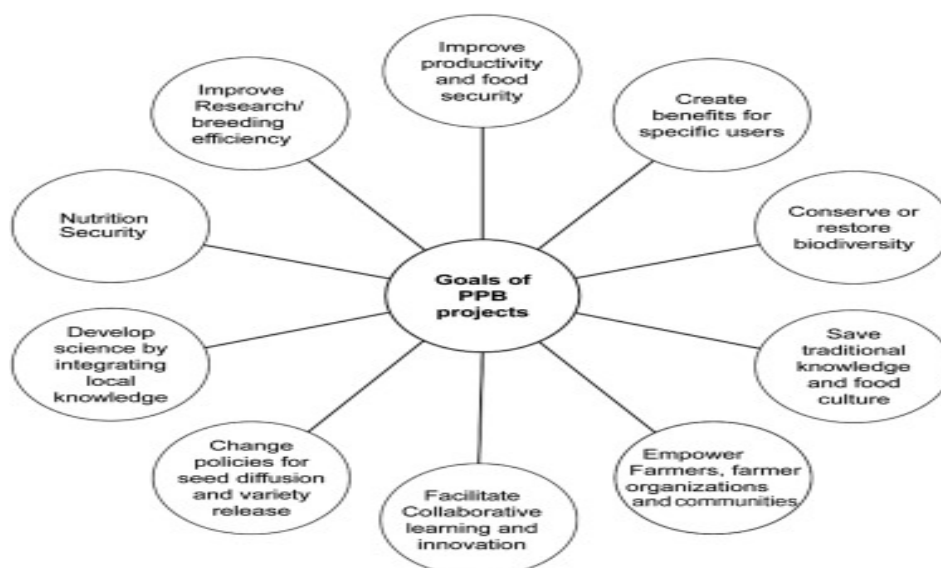


Figure 2: Development of improved and relevant crop varieties with farmers.

cropping system, and family uses of crop and market; however, they might differ depending on gender and age of farmers, as well as socioeconomic situations (access to credit).

Large size, shape, and color of harvested component, absence of insect damage, and maturity duration are all common crop characteristics employed by farmers [35]. Different cultivars are also chosen and planted as backups in case one fails due to environmental stress. Farmers may take advantage of different markets by selecting cultivars that are in high demand.

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

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, farmer participation can be advantageous at various times [36]. Farmers can play many different roles in participatory plant breeding, including technical leadership, important social organizational leadership, information dissemination, trainer/skill-building, field laborer, input supply, and landrace or farmer material for further breeding [37].

Impact of participatory approaches

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 [21, 8]. Participatory approaches have become a motivating force for agricultural investigation and rural development for example participatory plant breeding and participatory varietal selection. Instead of just telling smallholders what to do, a growing desire to increase responsiveness to the rural poor has encouraged development approaches that involve communities in problem identification, project planning, and planning and implementation. Extrinsic and intrinsic characteristics that are location-based influence agricultural development routes, which benefit from inclusive and locally adapted strategies [19]. With this in mind, participatory approaches were developed to empower communities to identify and prioritize development concerns, as well as to increase the genesis and adoption of solutions.

Throughout the agricultural research and development agenda, participatory approaches represent a shift in strategy toward strengthening human resources and empowering communities. Farmer field schools, farmer-to-farmer extension, agro-ecosystems analysis (AA), participatory rural appraisal (PRA), and a quick rural appraisal are examples of participatory methodologies and tools used in agriculture (RRA). Participatory approaches, which use a variety of strategies and technologies, are designed to put community-based farmer-to-farmer extension and collaborative learning into practice within a defined framework. These initiatives, such as PREA [14], can successfully disseminate scientific research to farmers, empower local ownership, and increase technological adoption.

According to Joshi and Witcombe [13], higher farmer participation improves cultivar adoption rates, and poor farmers adopt new varieties as quickly as richer farmers using participatory variety selection. Participatory variety selection has once again demonstrated that it is a superior concept to the traditional one. If a good selection of cultivars is provided to evaluate, participatory variety selection was a more rapid and cost-effective method of selecting farmers' preferred cultivars [15].

Advantages of Participatory Over Conventional Plant Breeding Methods

In every cross, at least one parent is well adapted to the local environment. Because breeding is done in the desired environment, genotypes x environment interactions are used effectively. Because local parental materials have adapted to local year-to-year variations, the impact of genotype x year interaction is likely to be diminished. Because only a few crossings are made, extensive F₂ and F₃ populations can be developed, increasing the chances of selecting desirable sergents. In conventional breeding, the primary stakeholders are not involved in the selection and development of the varieties, which is why most breeding experiments failed. This scenario, [38] results in low adoption and diffusion of the emerging technology. As a result, farmers who are the primary beneficiaries of better agricultural technology must be involved or participate. Farmers' participation in agricultural activities is now essential. Participatory processes, according to Joshi, A. and Witcombe, J.R [39], arose from what was perceived as inappropriate varieties, practices, or extensions that did not meet local environmental conditions or special social demands.

New varieties are released through conventional plant breeding (CPB) before farmers have an opportunity to decide whether they like them or not, and the process is largely supply-driven. The delivery phase in participatory plant breeding is turned upside down because the process is demand-driven and is driven by the initial adoption by farmers at the end of a full cycle of selection [22,26]. As a result, many people now consider participatory research as a means to solve most agricultural research programmers' problems, because participatory plant breeding is expected to produce varieties that are targeted, relevant, and appropriate [9]. As a result, participatory plant breeding's objectives are to increase agricultural productivity and profitability through the development and increased acceptance of acceptable, usually improved varieties. To provide benefits to a specific type of user, or to address the demands of a larger group of users. To improve farmer selection and seed production efforts through improving farmer skills [26]. Identifying breeding objectives, producing genetic variability, selecting within variable populations to generate experimental varieties, evaluating experimental varieties, variety release, popularization of release varieties, and seed production are all examples of participatory plant breeding [40] (Table 1).

Conclusion

Farmers use participatory approaches to evaluate advanced,

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

finished, or near-finished products from plant breeding programs on their own farms. Farmers' adoption of new crop varieties occurred during and after the introduction of PPB and PVS, as indicated by the fact that participating farmers adopted new crop varieties at a higher rate than non-participating farmers. It's possible that R&D and adoption are linked since collaborating farmers gain greater information, making it easier for them to grasp the 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, findings from participatory plant breeding and participatory variety selection have shown the potential for increasing on-farm varietal diversity and adoption rates.

The strategy allows new crop varieties to be evaluated under a variety of biological and socioeconomic situations, improving the likelihood 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 speeding the dissemination of farmer-selected varieties in target areas. Grower cultivar seeds must be rapidly replicated and delivered to farmers at a low cost after they have been found.

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 combination with recommended cultural practices. As a result, the interaction between researchers and farmers will aid in the development of research objectives aimed at overcoming the rejection of varieties developed only by researchers, improving variety acceptability, and lowering variety production costs. Biological yield and indigenous knowledge systems are important concerns when creating new crop varieties to boost varietal adoption and diversification.

Plant breeding has an impact on people and societies 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 G x E interaction and selecting varieties directly in the area in which they will be employed. Farmers are best suited to recognize the agronomic and qualitative characteristics that will allow the variety to thrive in their system; therefore their participation is crucial to the methodology.

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