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23. Participatory Breeding

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Abstract

Participatory breeding is a collaborative approach where farmers, researchers, and breeders work together to develop new crop varieties tailored to local conditions and preferences. It emphasizes farmers' active involvement in selecting and breeding plants, ensuring that the resulting varieties meet their needs and enhance agricultural sustainability. By integrating traditional knowledge with scientific expertise, participatory breeding fosters resilient and adaptable crops, mitigating risks posed by climate change and increasing agricultural productivity. This approach not only empowers farmers but also promotes genetic diversity, fosters community resilience, and strengthens food security in diverse agroecological systems.

Keywords:

Food Security, Crop Variety, Climate Resilience, Adaptability, Genetic Diversity.

23.1 Definition

Breeding of crop varieties through involvement of farmers/ officials from dept of agriculture/Policy makers/ various stakeholders like processing industries during selection

processes to effectively identify the crop genotypes suited to local conditions, improved quality, tolerance to biotic and abiotic stresses. The concept of participatory plant breeding (PPB) was introduced in Canada's International Research Development Centre (IRDC) during a workshop conducted in 1992. In the year 2000, PPB had become mandatory for CGIAR crop improvement initiatives. Modern plant breeding aimed to develop crop varieties with wider adaptations and stability. Wider adaptations lead to loss in agro diversity resulting in narrow genetic diversity. Stability of modern varieties not the same over period of time. Participatory plant breeding aims to enrich the agro diversity addressed to diverse growing regions.

23.2 Introduction

Crop varieties development and popularization are routine processes in agrarian societies like India. Crop varieties are developed using various breeding methods viz., Introduction, selection, hybridization, mutation and innovative methods like marker assisted selection, transgenic development followed by genome edited lines. Homozygous lines are developed by continuous selection of genotypes based on traits of interest. Stabilized homozygous lines are evaluated for the traits of interest like yield, quality, duration and tolerance to biotic and abiotic stresses. After preliminary analysis in the research stations, the promising entries are proposed for conducting trials in multi locations as MLT (Multi Location trials).

The entries performing better in MLT using a check variety (popular variety with a negative trait or few drawbacks) will be analyzed for further entry into adaptive research trials (ART). Selected promising entries will be sent for ART by coordination with officials of the state dept of agriculture. ARTs are usually conducted at selected farmers' fields of the particular region from the district. It is usually for the evaluation of yield under particular conditions or tolerance levels to biotic and abiotic factors.

The entries performing better under ART than the check varieties are proposed for variety release through the State Variety Release committee (SVRC). SVRC consists of the Head of the institution, Director of Agriculture, Agricultural production commissioner, Officials from Department of agriculture, technical experts, progressive farmers of the state and stakeholders of the food processing industries. After careful evaluation of the proposed entry by the committee, the crop variety will be designated with a name and released for the cultivation in the state or particular region of the state. The variety will be popularized by front line demonstrations (FLD), on farm trials (OFT)in farmers field and through field days by analyzing the yield performance of the released variety The variety will be simultaneously notified by the Central Subcommittee on Crop Standards Notification and Release of Varieties of Agricultural Crops, Govt of India. Notified varieties will be entering into the seed production chain from Breeder seeds to foundation seeds to certified seeds for larger multiplication and cultivation in farmer's field.

The Central Variety Release Committee recommends variety release for many states of the nation. Evaluation processes are being conducted through All India CoOrdinated Research Programmes on various crops. Both SVRC and CVRC mode of variety release involves popularization of released varieties in farmers' fields through seed production chain. In this regular method of variety release and popularization, many varieties are not preferred by

farmers on a long-term basis. Soon they are withdrawn from the seed production chains and eventually from cultivation. Only a few varieties are well adapted to the agro ecological conditions and continuing in seed production chain and cultivation. Breeding programmes in India and many other countries follow different breeding methods, evaluation procedures and varietal release which usually takes min of 6-12 years based on pollination mode and seed multiplication ratios. It involves lot of manual and other inputs incurring larger costs. After spending several years and money on varietal development and release, it is futile if the variety is not accepted by the farmers. There are various reasons for the non-acceptance of crop varieties by farmers. There are many critical reasons for non-acceptance of recently released varieties by the farmers community. Due to climate change, alterations in existing cropping patterns, market driven demands, the preferences for well adapted varieties for particular geographical regions is very much limited. Yields of major crops like rice, wheat, maize, cotton and sugarcane are declining every year due to climate change, reduction in soil fertility, increased incidences of pests and diseases and abiotic stresses like drought, high and low temperatures, salinity and nutrient deficiencies. The varieties evolved with keen management practices under research farms fail to adapt to the local conditions existing in farmer's holdings on a long-term basis. Quality aspects of crop produce are also changing narrowly from regions to regions at a greater level of speed. Crop varieties are evolved by the research community without involvement of stakeholders during the initial evolving period.

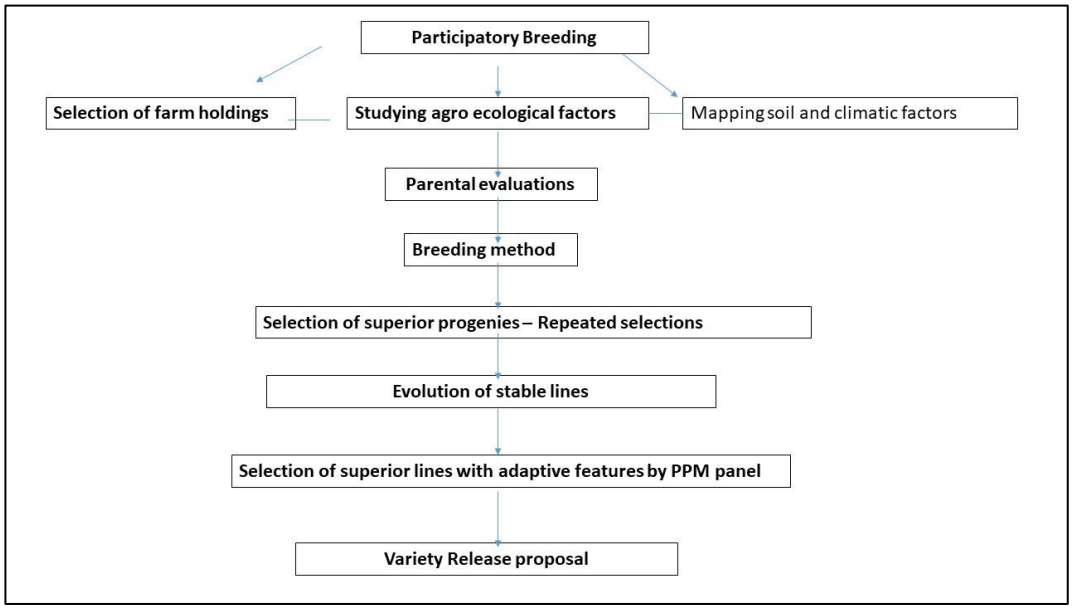

Figure 23.1: Schematic Description of Steps involved in Systematic Participatory Breeding procedures

23.3 Scientific Basis of Participatory Breeding:

During early domestications and prior to green revolution, the varieties were the products of purely natural selection by the farmers which were highly adapted to the particular geographical regions in a localized area in smaller scales.

The soil fertility was mainly attributed through application of bulky organic manures which promoted the activity of native microbes. Every environment had unique crop varieties which are mixtures of purelines with greater genetic and agro diversity. Their yield performances were low, but they were tolerant to biotic and abiotic stresses. They were the geographical indicators for the particular region. The varieties evolved from that region through natural selection having stronger associations with native microbiomes at different levels viz., rhizosphere, endophytic, phyllosphere and seeds. The microbes essentially involved in nutrients mobilization, acquisition, translocation, and accumulation in produces. They were also involved tolerance to biotic stress tolerances through induced systemic acquired resistance.

The stronger association of microbiome in produces involved in prebiotic and probiotic principles of food produces involved in gut health. Each and every geographical location were enriched with greater agro diversity and typical food habits. Modern crop varieties are being evolved through artificial selection under controlled environments of research institutes under the normalized fertilizer application conditions.

The varieties evolved are fertilizer responsive and don't have stronger association with native microbes from research institute itself. The microbiome network was broken due to unidirectional selection towards high input responses correlated with higher yields. It resulted in disruption of microbiome network associated in crop variety fitness. Necessarily, the crop varieties dependent upon higher doses of chemical inputs like fertilizers, weedicides, pesticides and fungicides. Farmers usually apply the chemical inputs in higher doses which resulted in disruption of native microbiome network in farm holdings also. Lack of microbiome association with crop varieties resulted in poor fitness of variety due to susceptibilities to biotic and abiotic stresses and also lacked the pre and probiotic associations.

Participatory breeding essentially aims to promote the agro diversity to utilize the local land races/ germplasm lines of the particular regions under low input conditions. The variety evolved through participatory breeding under low input response conditions from the farmer's holdings will have stronger associations with microbiomes. Association is genetically mediated. Hence, the performance of that particular variety to the region is stable over period of time. It is the indicator of soil health also. Selection efficiency will be higher and precise. Selection in participatory breeding is achieved by the members of the panel from different backgrounds viz., farmers, professionals, Private seed sector and processing industry.

23.3.1 Concepts of Participatory Breeding:

A. Selection of farm holdings for the evolution and evaluation of crop genotypes:

Selection of representative farm holding to conduct participatory breeding trials is a crucial and foremost step. Data on soil fertility, climatic conditions, crop yield responses under different input levels, irrigation sources, cropping pattern, preferences of crops, preferences of varieties, local needs of the farmers are to be collected.

Farmer's skills, knowledge on the cropping system, his experiences in the value-added products and food processing industries, existing cropping and market issues of that particular area should be taken into account while selecting the farmer and farm holdings to conduct participatory breeding programmes. Climate change is affecting crop production and productivity throughout the world. The magnitude of changes varies with the locations.

B. Studying the agro ecological conditions of the particular geographical regions and mapping the regions with similar conditions:

Identifying soil and environmental factors, climatic conditions, cropping pattern of the particular area chosen under participatory breeding programme should be compared with other regions of the country or state for exploring the adaptive trials suitable for other regions.

Mapped climate and soil conditions should be used for comparison. Regions with similar climatic and soil factors will likely to be responding with the proposed breeding lines developed from the proposed region of participatory breeding.

C. Strategic Plant Breeding approaches for Participatory Breeding:

Parental selections and donors will be screened under existing farmer's field conditions. Evaluation of parents should be done as yield and other parameters for selection. Extreme types can be identified and crossing should be performed in research institutes.

F_1s can be produced at the research institute and large-scale screening of F_2 segregating populations in farmers' holdings. Segregating populations can be subjected to screening under ecosystems and selection parameters should be applied for the identification of superior segregant with required adaptive features. Selected lines will be subjected to continuous selection and generation advancement in each generation in farmer's field and research institute as shuttle breeding.

After attaining homozygosity only better performing lines will be subjected to further evaluation for yield, biotic and abiotic stress tolerances and quality aspects. Better performing lines will be evaluated by the team as participatory mode. For cross pollinated crops/ vegetatively propagated crops, initial evaluation of lines can be done in farmers holdings. Inbreeding and inbreds development can be done at research institutes. Hybrids can be evaluated in farmers field and promising lines can be subjected to scoring and evaluating by the team as participatory mode.

D. Constituting panel members for participatory varietal Selection

The panel will be constituted with objective of selection of better promising lines developed in farmers' field. Farmers with experience on yield evaluation, quality aspects and market preferences, field level officials of Dept of agriculture, Assistant Director of Agriculture, Policy makers, Representatives from Private Seed Sectors, and experts from food processing industries. Based on the objectives of the breeding lines, the panel will evaluate the lines and based on the evaluation's lines will be identified.

E. Selection Procedures:

a. Estimation of yield:

Yield estimation can be done by visual scoring by counting the grains/ produces. Yield can also be estimated by routine crop cutting experiments. Comparison with existing check varieties with the improved variety developed through participatory breeding under low input response conditions and specific cultivation practices like relay cropping, double cropping and intercropping etc on yield can also be done.

b. Tolerance to biotic stresses:

Susceptible check with the tolerant/ resistant variety identified in participatory breeding can be scored visually under natural epiphytotic conditions viz., conducive climate for the outbreaks of particular pest and disease. Resistance/ tolerance levels can be compared with the susceptible check. Hotspots for particular pest and disease can be identified and utilized for participatory breeding for tolerance to biotic stresses.

c. Tolerance to abiotic stresses:

Yield performance, crop stand, uniformity of abiotic tolerant variety can be compared with the sensitive variety. Abiotic stresses like drought, salinity, high temperature and low temperature stresses can be evaluated.

d. Quality:

Taste, flavor, aroma of produces unprocessed and processed can be done by sensory evaluation based on different ratings. Members from traders and processing industry can be involved for the processing parameters incorporated in the variety.

F. Crop variety will serve as Geographical Indicator (GI):

The variety developed through participatory breeding will definitely serve as a geographical indicator as the specific adaptive processes involving local conditions during evolution of the varieties. The contributing parameters of crop variety performances viz., yield, tolerance to biotic and abiotic stresses, quality parameters like taste, flavour, nutritional value and cooking quality will be stable and identical with the local conditions. Though it is a rapid unidirectional selection in farmers holdings, the outcome of the variety as adaptability will be identical with the locally adapted land races or traditional varieties of the region.

G. Evaluation parameters are based on the local conditions and farmers' requirements

Critical evaluation of parameters by scoring the expected traits expression levels and identifying the better performing entries will be done in farmers holdings. Hence, performance as desired outcome of the variety by participatory breeding is assured.

H. Variety Release Proposal

The identified variety will be proposed for variety release, without going through the time-consuming process like Multi location trials, adaptive research trials, and on farm trials. Seed multiplication in larger scale and popularization during evaluation will be sufficient to propose a distinct variety for release.

23.3.2 Merits of Participatory Breeding:

- Increased selection efficiency, as the selection parameters are stringent
- Performance and outcome of the variety through participatory breeding is positively assured on long term basis by entering into organized seed production and supply chain
- Evolution and evaluation of better performing lines are relatively faster and it avoids the evaluation trials viz., station trials, multi-location trials, adaptive research trials and on farm trials
- Popularization of newly evolved variety through participatory breeding is a simultaneous process. variety is popularized during evolution and evaluation phases itself. Hence there is no need to conduct large scale trials, Front line Demonstrations and Field days which are the routine and time-consuming methods to popularize the newly released varieties
- Utilization of local land races for creating genetic variability which are well adapted to the existing conditions. Genetic improvement of local land races/ traditional varieties will provide a novel genetic resource as improved variety
- Conservation of valuable genetic resources developed through participatory breeding. The varieties can be maintained by farmers for a long time without depending upon institutions for supply of quality seeds. It empowers the farmers on their rights to seeds.
- Genetic restoration of improved genetic resources which are adapted to the particular region which will increase the genetic diversity/ agro diversity. Instead of mega varieties over a larger area with wider adaptability
- Health and nutritive value benefited by the native microbiome involved fortifications, pre and probiotic properties enhanced in the variety selected in the farmers holdings in food products like rice and urd bean batter, millets drink and green leafy vegetables
- Increased and stable income through participatory seed production and supply. The seeds will be in high demand from the farmers of the region due to the stable performance and popularity. Hence timely supply of seeds to the farmers will fetch high and stable income.
- Due to stable performance and low input requirements for the cultivation, the cost of production will be relatively low. Market preferences combined with higher yield will generate stable income for the farmers who are cultivating the crop varieties developed through participatory breeding.

23.3.3 Demerits of the Participatory Breeding:

- Difficulties in selection of farm holdings
- Difficulties in mapping of regions

- Difficulties to conduct trials at farmers holdings subjected to natural calamities and accessibilities
- Products will be essentially having narrow adaptability to a particular environment or geographical region.
- Relatively high-cost involvement for mobilizing resources and cultivation in farmers holdings on hiring basis than research institutes.

23.3.4 Future Scope of Participatory Breeding:

Farm productivity and stable income should be improved from the unit area without destroying the natural resources and without creating environmental pollutions. Due to urbanization and increased population growth, farm holdings are in continuous decline over period of time. Average productivity of major crops is in decreasing trends which is mainly attributed by the climatic changes. To feed the expected 9.7 billion people during 2050, the farm productivity should be improved by developing resilient varieties with specific adaptabilities with low input response for sustainable productivity and stable income.

Crop breeding should be intensified and area coverage should be minimized for better adaptability. Entire cultivation area should be made into grids with identical/ differential ecological factors should be promoted with specific varieties developed through participatory breeding.

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