Conservation and Utilization of Plant Genetic Resources

K. E. Prasada Rao[1] and Ratikanta Maiti[2*]

[1]Genetic Resources Division, International Crop Research Institute for the Semi-arid Tropics, Patancheru, Andhra Pradesh (502 324), India
[2]Vibha Seeds, Vibha Agrotech Ltd, Inspire, Plot no. 21, Sector 1, Huda Techno Enclave, High Tech City Road, Madhapur, Hyderabad, Andhra Pradesh (500 081), India

Article History

Manuscript No. 219
Received in 30th October, 2011
Received in revised form 3rd November, 2011
Accepted in final form 16th November, 2011

Correspondence to

*E-mail: ratikanta.maiti@gmail.com

Keywords

Germplasm, genetic resources, conservation, utilization

Abstract

Germplasm and genetic resources are synonymous. Germplasm implies the sum total of hereditary material in a crop species along with its wild and weedy relatives. Land races are primitive varieties, which had evolved without any systematic selection effort. Obsolete varieties are those developed mostly by pure line and mass selection from the local cultivars of past but are no more grown. Various activities involved in the conservation of germplasm are described in this paper along with the trends in utilization of germplasm of some major crops and their significant achievement in plant breeding.

1. Introduction

Germplasm and genetic resources can be used as synonyms. It can be defined as the sum total of hereditary material in a crop species and its wild and weedy relatives. For plant breeders, in their endeavor directed towards increased agricultural production, there is a pressing need for more genetic diversity to work upon to cater to varied kinds of problems and needs. The wider the range of choice a breeder will have in selecting appropriate kind of diversity, the better will be chances for his success for any particular goal. A wider genetic base, thus, assumes priority in plant breeding research aimed at developing new varieties and hybrids for increased crop production. The diversity comprises of land races, obsolete varieties, varieties in cultivation, breeding lines and wild and weedy relatives.

Land races are primitive varieties, which had evolved without any systematic selection effort by men. They are store houses of genetic variability and, ordinarily, are adapted to the local soil type and climatic conditions. They are the sources of many valuable genes, including those for adaptation.

Obsolete varieties are those developed mostly by pure line and mass selection from the local cultivars of past but are no more grown. They, however, have some desirable features for example NP series of Wheat, BAM, MTU, SLO series of rice etc. GEB 24 (Kichidi samba) although a variety of late 50's has contributed for the development of samba masuri a most popular present day rice variety. Some of the obsolete varieties are still available in the gene banks of international institutes. The varieties in cultivation are the most important base material used in breeding programs. They are good sources of genes for yield and quality etc. They can be introduced in a new area, and directly released for cultivation. Breeding lines are lines/populations developed in the breeding programs. They often contain valuable gene combinations. This group includes: nearly homozygous lines, inbreds, A lines, R lines and lines derived from Biotechnology programs and non transgenic lines.

Wild forms are the wild species from which the crop species were directly derived. They are easily crossable with the concerned crop species, thereby causing recombination of diverse genes in the populations. Weedy forms are the natural cross derivatives between wild and cultivated available in the place of origin. Usually these forms will be hardy with cultivated grain characters and high grain shattering habit.

If properly handled these weedy forms provide good source material in breeding programs especially resistance to biotic and abiotic stresses.

The collection and conservation of this diversity in a systematic manner is the primary responsibility of the plant genetic resource units weather public or private. In fact the extent of diversity in the germplasm is the strength of the institute or organization. The scientists, planners and policy makers have a challenge as to how best to assemble the germplasm, preserve it and utilize for increasing the production. Plant genetic resources are thus on heritage and new conservation for posterity.

2. Activities in Germplasm Conservation

The various activities in germplasm conservation can be grouped into the following categories:

2.1. Germplasm collection

The germplasm collection of any crop consists of diverse types of collection such as:

2.1.1. Those derived from centers of diversity

- Landraces
- Natural hybrids between cultigens and wild relatives (weedy races)
- Wild relatives
- Related species and genera

2.1.2. Those derived from areas of cultivation

- Commercial types
- Obsolete varieties
- Primitive cultivars
- Special purpose types

2.1.3. Those derived from breeding programs

- Pure lines derived from farmers' varieties
- Elite varieties or hybrids
- A, B, and R lines
- Breeding lines attained uniformity/inbreds/populations
- Mutants
- Polyploids
- Intergeneric and interspecific hybrids

2.2. Germplasm regeneration

Germplasm collections have to be regenerated every few years since seeds of most species lost viability with the storage duration (Rao, et al., 2004). Germplasm regeneration consists of growing seeds of the various entries in field and harvesting fresh seeds for further storage. Generally about 50-100 plants should be grown accession^{-1}, but in some cases it may be a smaller number depending on the availability of source seed. Regeneration should be done under climatic conditions similar, if not identical, to those from which an accession was collected.

The above precautions are essential to prevent genetic drift and natural selection. Random drift represents changes in genes and genotype frequencies of a small due to sampling error (because of small sample size). Periodical regeneration is essential for the maintenance of germplasm collections in their original constitution and in a healthy state.

In addition to reduction in viability, the genotypic constitution of the entries may change, especially if they are grown in environments considerably different from those from which they were originally collected. This is particularly true in case of cross-pollinated crops and for old local varieties or land races.

2.3. Characterization and evaluation

2.3.1. Characterization

Characterization consists of recording those characters which are highly heritable, can be seen by the eye and are expressed in all environments. Characterization should provide a standardized record of readily assessable plant characters which, together with pass port data, go a long way to identify an accession. In order to have a uniform language of descriptive and descriptor states for each crop internationally, the International Board for Plant Genetic Resources (IBPGR), now called IPGRI (International Plant Genetic Resource Institute) Rome, published descriptors and descriptor states for all most all crops (IBPGR/ICRISAT, 1993). Since these descriptors are too many and exhaustive the National Bureau of plant Genetic Resources has published 'Minimal Descriptors' for crop plants limiting to most important descriptors often required by plant breeders (NBPGR, 2001). Characterization descriptors include spike/panicle shape, seed shape and colour, and other characters which are generally more of taxonomic type. Their recording along with the passport data provides an overall picture of the range of diversity in the collections, which are very much useful to the plant breeders and other crop scientists.

2.3.2. Evaluation

Evaluation only confines to preliminary evaluation since no much statistical design and analysis are used. Preliminary 1collections for ready access and use (Prasada Rao et al., 1989). In addition a sorghum core collection was established, which represents the genetic spectrum of the whole collection for utilization in crop improvements (Prasada Rao and Ramanatha Rao, 1995).

2.4. Germplasm cataloguing (data storage and retrieval)

Each germplasm accession is given an accession number either by public or private gene banks. The number is strictly controlled in India, by NBPGR with either IC (indigenous collection), EC (exotic collection) or IW (indigenous wild). Information on the accession is recorded using the standard descriptors and descriptor states. The usefulness of an accession or entire germplasm collection either in part or full, becomes known to the plant breeders only when the information about the features of the accession becomes available to them. Therefore, catalogues of the germplasm collection for various crops are published by the gene banks. The amount of data recorded during the evaluation is huge. Its complication and storage and retrieval is now done by using special computer programs.

2.5. Germplasm conservation and maintenance

Seeds of several crops show orthodox storage behavior; hence the germplasm is conserved ex-situ as seeds in the gene bank under controlled conditions. Ex-situ conservation is cost efficient, and also makes it easier for scientists to access, study, distribute and use plant genetic resources. In many gene banks including ICRISAT (Rao et al., 2004) the National Bureau of Plant Genetic Resources (NBPGR, New Delhi), all the germplasm is stored as active collection under medium-term storage conditions (4^{o}C-20% RH). The germplasm is also conserved as base collection at -20^{o}C for long-term storage. Viability is maintained by germination tests at 5-year intervals in medium-term storage and 10-year intervals in long-term storage. Any sample having less than 75% viability is identified for rejuvenation.

Diversification, genetic studies and germplasm enhancement through conversion and introgression resulted in the development of trait specific germplasm pools at over years at ICRISAT. These along with the germplasm accessions possessing some valuable traits, are maintained as subsets or working collections for ready access and use (Prasada Rao et al., 1989). In addition a sorghum core collection was established, which represents the genetic spectrum of the whole collection for utilization in crop improvements (Prasada Rao and Ramanatha Rao, 1995).

2.6. Germplasm utilization

The plant breeder is the principal users of germplasm collections and, therefore, it is pertinent to consider the kind of information that the breeders will want about each accession. Though, the potential of a germplasm sample is largely known at the time of its collection, it has been observed that a number of desirable characters are identified whenever a diverse group of germplasm samples are evaluated and screened. The breeder is interested in a small fraction of the entire collection for its immediate objectives. His working collections will consist of superior genotypes for yield and yield components and for resistance to diseases, pests and abiotic stress conditions and also for some of the important quality components. The sources of resistances to various biotic and abiotic stress factors should be harnessed for their introgressions in crops for adaptation under various stress factors and sustainable agriculture. In this respect glossy sorghum lines are found to be tolerant to shoot-fly and drought (Maiti et al., 1984).

Germplasm can be used in the breeding program in the following 3 ways:

Direct release as variety
It may be subjected to selection for developing a variety
It may be used as parents in hybridization programs

The trends in the utilization of germplasm of some major crops and their significant achievement in plant breeding are discussed below.

2.6.1. Rice

Utilization of semi-dwarf genes from a local Tiawaneese Indica Dee-geo-woo-gen and another local variety Tsai-Yuan-Chung, for the production of semi dwarf varieties Taichung Native 1 (TN-1) and IR8 and other varieties developed using these as base material. These have caused threefold increase in rice production and responsible for green revolution.

2.6.2. Wheat

Norin (dwarf) wheat germplasm lines from Japan were used in the development of a wide range of dwarf wheat varieties through breeding. From this breeding program, outstanding wheat varieties were selected and released. These are Sona 227, Sonalika, Safed lerma, Choti lerma, Sharabati sonara which are also responsible for green revolution.

2.6.3. Maize

Through systemic mobilization of elite Indian materials and germplasm introduced from Central and South America and the USA, high yielding double cross hybrids were developed in 1961. Later, a number of additional hybrids were developed using the improved inbreds and recommended for commercial cultivation.

2.6.4. Sorghum

Interaction of Kafir genes and Milo cytoplasm for the development of cytoplasmic-genetic-male sterility in sorghum les the way for the production of hybrids. Kafir genes are from Southern Africa and Milo cytoplasm is from Sudan landraces. Zera-zera landrace from Ethiopia (Prasada Rao and Mengesha, 1987) has been extensively used in the Indian sorghum hybrid program as restorer.

2.6.5. Pearl-millet

Indian landraces provided excellent sources of early maturity, better tillering and shorter height. In contrast, African sources particularly from West African region provided excellent sources of head volume and seed size, higher degrees of resistance to diseases and better seed quality.

Utilizing the cytoplasmic-genetic-male sterility these germplasm sources have contributed substantially in the diversification of genetic base of the parents in the production of several potential hybrids. Likewise the germplasm has contributed substantially in the development of improved varieties in pulses, oil seeds and fiber (cotton) crops. The wealth of germplasm which farmers grew earlier, are gradually disappearing.

3. Conclusion

A collection and study of these landraces and primitive cultivars revealed that these have contributed to a great deal in the crop production. Similarly, many wild relatives of the crop plant can contribute high degree of resistance sources. One can thus understand the dire need for conservation of plant genetic diversity. Its value in the future will be much more than what can be imagined at present, considering the diversified crop improvement programs, technologies and human needs.

3. References

Rao, K.N., Bramel, P.J., Gopal Reddy, V., Deb, U.K., 2004. Conservation, utilization and distribution of sorghum germplasm. In: Bantilan, M.C.S., Deb, U.K., Gowda, C.C.L., Reddy, B.V.S., Obilana, A.B., Evenson, R.E. (Eds.), Sorghum Genetic Enhancement: Research Process, Dissemination and Impacts. International Crop Research Institute for the Semi-Arid Tropics, Patancheru, 43-62.

IBPGR/ICRISAT, 1993. Descriptors for sorghum [*Sorghum bicolor* (L.) Monech]. International Board for Plant Genetic Resources, Rome, Italy, 38.

Maiti, R.K., Prasada Rao, K.E., Raju, P.S., House, L.R., 1984. The glossy trait in sorghum: its characteristics and significance in crop improvement. Field Crops Research 9, 279-289.

NBPGR, 2001. Minimal Descriptors of Agri-horticultural Crops. National Bureau of Plant Genetic Resources, Pusa, New Delhi,

Prasada Rao, K.E., Mengesha, M.H., Gopal Reddy, V.G., 1989. International use of sorghum germplasm collection. In: Brown, A.H.D., Frankel, O.H., Marshall, D.R., Williams, J.T. (Eds.), Use of Plant Genetic Resources, Cambridge University Press, Cambridge, 49-67.

Prasada Rao, K.E., Ramantha Rao, V., 1995. The use of characterization data in developing a core collection. In: Hodkin, T., Brown, A.H.D., Hinthum, T.J.L., Morales, E.V.A. (Eds.), Core Collection of Plant Genetic Resources, John Wiley and Sons, London, 109-115.

Prasada Rao, K.E., Mengesha, M.H., 1987. Morphology and distribution of Zera-zera sorghum. Journal d'Agriculture Traditionellle et de Botanique Appliquee 34, 51-55.