

GERMPLASM RESOURCES IN PLANT BREEDING

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1. INTRODUCTION

During the past two decades, several scientists have emphasised the need for collection, evaluation, conservation and mobilization of our genetic resources, and warned of the rapid extinction and/or replacement of primitive cultivars and their wild relatives which are of great value for several attributes of present and potential use. The GEU Programs (Genetic Resources Evaluation and Utilization) have been reinforced by the threat to these genetic treasures posed by the rapid spread of high yield varieties. The limited studies on the existing World collections of cereals have indicated the importance of genetic drift, nature of selective forces operating in different areas of diversity, fixation of constellation of characters in specific regions and the possible areas of concentration of desirable alleles to plan additional collections of immediate value to the breeders. A global effort under the International Biological Program and FAO has given priority to the primitive varieties of traditional agriculture. The documentation of these collections in a systematic manner and exchange of information and material for utilization by the breeders has been emphasized and a documentation system of wide application has been prepared. The International Board of Plant Genetic Resources has drafted proposals for the establishment of a network of genetic resources centres and continuation of cooperative association with national institutes in several countries. The functions

of the genetic resources centres are exploration, quarantine, conservation, utilization and documentation. Regular courses have also been started in the Department of Botany in the University of Birmingham to provide a nucleus of trained personnel. Special emphasis has been made by the Consultative Group of International Agricultural Research to give support for centres in the areas of genetic diversity and regional centres.

2. CURRENT STATUS OF GEU

Frankel and Hawkes (1975) have summarised the present status and plan of action regarding genetic variation in plant populations of World Collections, survey of genetic resources as a basis for exploration, highlighting the practical problems in such activity, particularly in seed crops and vegetatively propagated crops, current activities on exploration, evaluation problems particularly for resistance to diseases and insects and environmental stress, and quality evaluation such as protein, oils and fats, conservation and long-term storage, documentation and information management, and proposals for global network of genetic resources centres. Presently, the genetic collections are categorised into two major components - one being the base collections for long-term storage and the second, the working collections which should have medium term storage with periodical regeneration, regular multiplication and distribution, evaluation and documentation. The International Crop Research Institutes and other national institutes are proposed to be linked together for mobilizing the existing resources supplemented with a program of emergency collections of threatened genetic resources. The number of accessions in the total World collections is about 200,000 in USSR and an equal number for major crops in USDA. The estimated number of

available entries are as follows:

Rice - 35,000 (IRRI, Philippines)
Wheat - 30,000? (USDA, and CIMMYT, Mexico)
Maize - 24,000 (CIMMYT, Mexico)
Sorghum- 15,000 (ICRISAT, India)
Millet - 4,000 (ICRISAT, India)
Potato - 12,000 (CPI, Peru)
Oilseeds-11,000 (USDA)
Vegetables-14,500 (USA).

The Symposium on Crop Productivity held in 1975 by Michigan-Kettering Foundation has reiterated the urgency of exploitation for physiological improvement with emphasis on selection for photosynthetic efficiency, nitrogen fixation, resistance to environmental stress, and selective ion uptake. The genetic variability present in the World collections, particularly in the primitive cultivars for some of these attributes is to be assessed and utilized for further improvement of the existing superior cultivars. This will also involve evaluation and mobilization of nitrogen fixing microorganisms for use in supplying nitrogen to cereals and grasses in addition to legumes. There are genotypic differences in the utilization of nutrients and net photosynthesis for which rapid screening procedures are needed. The root distribution and feeding power of roots are also the characteristics of genotypes. Choice of genotypes with selective ion uptake including tolerance to toxic ions is possible by screening for these attributes. The whole gamut of plant developmental processes involving the physiological and genetic basis of response to environmental stresses will permit identification of genotypes with superior capacity for such attributes.

3. VULNERABILITY OF THE EXISTING VARIETIES

The phenomenal yield increases coupled with wide adaptation demonstrated in cereals using photoinsensitivity and dwarfing genes has resulted in the large scale cultivation of a few superior varieties. In the case of hybrids of Sorghum, maize and millets, only one source of cytoplasm has been used. Such a narrow genetic base has posed problems of large scale devastation by diseases and pests, such as bacterial leaf blight and brown plant hopper on rice, *Alternaria* and different races of rust on wheat, downy mildew on Sorghum and millet, and *Helminthosporium* on maize. The source of dwarfing genes in rice is Dee-geo-woo-gen in rice, Noriu-10 in wheat, D₂ gene in pearl millet and the four height genes in Sorghum. ~~THE~~ For example, among the presently widely cultivated rice varieties in the year 1975 in India, only 7% are resistant to blast, 4% resistant to bacterial blight and 0% to tungro-virus and gall midge (Hargrove, 1977). Even among the newly bred varieties, only 6% are resistant to tungro-virus and 0% to gall midge and 22% to blast. Among the 18 rice varieties developed during 1975 in India, 15 are derived from IR.8 and two from TN.1. Among the 57 lines of wheat in advanced tests in IARI, New Delhi, only 15 had Indian parentage, and even these involve only 3 varieties - NP.852, K.65 and NP.404. Most of the wheat breeding materials in several countries is the segregating material supplied from CIMMYT. In millet, all the five hybrids released prior to 1972 have Tift.23A as female parent and three of them have male parents derived from one variety S.350. The new hybrids resistant to downy mildew are also based on Tift. 23A cytoplasm but different sources of resistance. The same is the case with Sorghum where CK.60A derivatives are female parents in all the hybrids. Thus, in general, there is a tendency on the part of the breeders

to confine to a narrow genetic basis in spite of the availability of tens of thousand of diverse genetic stocks.

4. CONVERSION PROGRAMS OF WORLD COLLECTIONS.

of In the anxiety to quickly utilize the accessions in the World collections having some desirable attributes like disease resistance and grain quality but are photosensitive and unacceptable plant type, conversion of all such lines into photoinsensitive and dwarf types of backcrossing has been practised by USDA and Rockefeller Foundation in Sorghum and millet. Genetic erosion of several other attributes has taken place in that process due to the small sample size carried forward over generations and inadequate attention to retain the variability for other attributes originally present in the parent lines. The correlated response and genetic drift resulting from such conversion programs has altered the representativeness of the collections. The same is true of conversion programs for cytoplasmic genetic male sterility using only one cytoplasmic source readily available with the breeder.

5. EVALUATION FOR SOME ATTRIBUTES NEEDING IMMEDIATE ATTENTION

World collections are traditionally catalogued for invariant characters like colour of plant parts, while several attributes important for productivity and of relevance to the breeder are not given priority. While the former are of interest for identification, evaluation of the collections for several economic characters which are considerably influenced by environment is crucial for the utilization of the germplasm after testing them over several diverse environments. Some of the characters which need attention in addition to maturity, yield and diseases or pest resistance are survival and stability of productivity in problem soils, efficiency of uptake of micronutrients, root

activity and feeding power of roots, solubilization of nutrients in soil, efficient extraction and transfer of nutrients from applied fertilizer, competitive ability in dense stands and intercropping, photosynthetic efficiency (C_3 and C_4 pathways), symbiotic and asymbiotic association with nitrogen fixing organisms, tolerance to moisture stress and atmospheric stress, (biochemical basis to be examined), rapid transfer of nutrients to seed during stress, survival and stability of productivity under water-logging, dormancy, ability of seed to withstand weathering and rain at harvest, durable resistance and/or tolerance to diseases or pests without drastic changes in host-pathogen equilibrium (racial composition of pathogen can be drastically changed by race-specific resistance, resistance to storage pests and diseases and low seed-transmission of disease to name a few.

6. DEFICIENCIES IN MATERIAL AND BASIC INFORMATION ON THE EXISTING COLLECTIONS.

Presently, the concern is more on preserving material so that the primitive and local cultivars of potential use are not lost. However, there is little or no information which is being gathered along with the collections on the individual accessions on the cropping system in which they are presently grown, ecological conditions of their habitat, utilization by consumers sometimes for specific purposes, past history of selection and the types of environmental complexes like pests and disease which are prevalent and sometimes endemic in the area of their collection. Information is also inadequate on the range of variation of specific characters like quality and its association with yield and productivity. The available data are on highly selected material which would have been ~~xxxx~~ the result of fixation of constellation of genes, while relevant information should be based on large samples and the past history of selection.

Prof. Hutchinson (1974) stated that "the crop plants have been subjected during the past 4000 years for a farming system that only changed slowly, but during the past few years, the change has been very rapid". The impact of these changes on crop plant evolution is to be examined so that breeders may not inadvertently lose desirable alleles of low frequencies in the primitive populations. Information on the diversity of ecological conditions with rainfall pattern, farming system, such as dryland agriculture or shifting cultivation, and soil type is crucial for the mobilization of the germplasm. Little is known about the population structure in primitive cultivars. Such information is valuable on the evolution and maintenance of genetic heterogeneity without deliberate human selection, and is important on the adaptation patterns and even breeding multi-lines. Conservation on a population basis and to maintain the population structure during regeneration is important as the evaluation data will be of no use if identity of the population is not maintained (ex's cross-pollinated crops like millet). Distribution of useful alleles particularly for disease resistance is not readily available. Sometimes only one or a few lines resistant and a few with tolerance but no immunity may be available. Systematic search for disease resistance with rapid and repeatable screening techniques is necessary along with a clear understanding of the physiological and biochemical mechanisms linked up with the development of quick and simple analytical procedures.

According to Frankel (1975), the present collections are neither large nor representative let alone being recorded properly. Many collections are based on small and biased samples from a few plants and frequently depleted by subsequent selection. Many collections suffered genetic erosion as a result of outcrossing, selection, genetic drift, unsuitable growing conditions and human errors in propagation.

7. ROLE OF CYTOPLASM

Cytoplasm has a major role in several growth processes associated with productivity such as earliness, disease resistance, ageing processes, and nutritional quality. Ageing itself is determined by the cytoplasmic changes over a period of time and will determine the proneness to environmental stress and diseases. With both transcription and translation processes involved in ageing, and thereby indirectly in the proneness of the individual to diseases, more information on the biochemical processes in the cytoplasm related to the above attributes and disease resistance in particular is needed for the choice of appropriate female parents in breeding work and diversification of cytoplasmic sources. For example, a single gene substitution on the same cytoplasm as in pearl millet has a number of far reaching changes in the structure and organisation of some cytoplasmic constituents like mitochondria. There are also differences in the peroxidase activities between different cytoplasms. Low productive cytoplasms can be upgraded by backcrossing. The differences between fertile and sterile cytoplasms and age dependent effects between A and B lines and resistant vs susceptible lines in peroxidase activities indicate that biochemical characterization of cytoplasm is crucial for its utilization. The maternal parent has also a considerable role in the pattern of segregation in crosses with primitive lines as in crosses with Sikkim Primitive maize. The creation of gene pools using cytoplasmic male steriles needs a priori information on cytoplasm for the above characteristics. (Murty, 1977).

8. CAUSES FOR POOR MOBILIZATION OF AVAILABLE GERMPASM.

A very small fraction of even the existing germplasm is mobilized by the breeders. The breeders usually concentrate on the crosses which are already found successful

by others. Similarly, the competition among breeders for quick release of varieties with emphasis on yield and wide adaptation has resulted in the use of a narrow genetic base and poor mobilization. Another difficulty is that the breeder is not prepared to risk a small sacrifice in yield, even temporarily and does not want to use material which may respond better to long term selection, provided recombination is done ~~ex~~ over a ~~numk~~ number of cycles. Thus, the time factor and risk factor have made breeders over-cautious. There are also other problems such as difficulties of gene transfer ^{from} certain primitive types, lack of alternate source of resistance to the desired degree, or alternate source of cytoplasm in hybrid production or adverse association between yield and another character for which selection has become critical. These difficulties are compounded, by the lack of available effort on the breeders due to the easy availability of material from the Central Institutes and International Institutes and their excessive dependence on the same on which they concentrate with no effort towards rational utilization of the local populations.

9. NEED FOR COORDINATED EFFORT

The seed characteristics particularly the endosperm colour, texture and seed size, fat content, vitamin-A content, their effect on the keeping quality of the flour, diastatic activity, presence of micronutrients and the capacity to accumulate them in the seed and the genetic variability for low transmission of diseases can be tested rapidly in laboratory under controlled conditions and the World collection classified for these attributes. The concept of ideotype has to evolve from data ~~z~~ based on simulation studies utilizing the range of plant types in a number of advanced inbred with acceptable level of productivity derived from the World collection rather than hypothetical views. Basic studies are

needed on mutation processes in cytoplasm with particular reference to disease resistance now underway using biochemical and electron microscopic studies on pearl millet in Nuclear Research Laboratory for evaluation of specific useful genotypes from World collection. * The above mentioned investigations, although fundamental in nature are of importance in understanding the various processes of adaptation, disease resistance and physiological efficiency which are of interest in breeding for better productivity. The availability of sophisticated analytical tools and rapid screening methods has provided the breeders an excellent opportunity for rapid mobilization of the genetic resources.

10. SUGGESTED READING

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