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ABSTRACT

To adapt new varieties to a wide spectrum of environments breeders and farmers have emphasized the need for broadening the current narrow genetic base of modern varieties of important cereal crops such as wheat and barley. In response to this need, several thousand samples of indigenously cultivated Triticeae species and their wild relatives have been collected from the centers of diversity. However, gene bank collections are of little use if they are not evaluated and the information disseminated widely. Evaluation is essentially the link between conservation and use. Some of the collected material has been evaluated at the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria. In the past cereal breeders were averse to using germplasm that after years of work yielded uncertain results. However, in recent years they have begun to successfully utilize non-conventional germplasm (wild/alien and obsolete forms) in their crossing blocks. The substantial progress at ICARDA in the evaluation and utilization of Triticeae germplasm for crop improvement in the low rainfall areas of West Asia and North Africa is described.

INTRODUCTION

As a result of considerable rise in collection and conservation activity of Triticeae genetic resources during the last two decades a very large quantity of accessions of wild, cultivated and obsolete (primitive) forms have been assembled at various genetic resources conservation centers around the world. However, genetic resources merely kept safely in storage can be of little value to plant breeders for utilization in their crop improvement programs unless these are evaluated and the resulting information made available through communication and exchange. Evaluation is essentially the link between conservation and use.

A population structure of a species is defined as the totality of ecological and genetical relationships among individual members which may co-evolve as a result of gene exchange but may also diverge under localized forces of evolutionary change (Jain, 1975). Landraces and obsolete cultivars are as a rule products of several years of crop evolution and it is vital to preserve their genetic composition during and after evaluation. Instances have been reported where polymorphic cereal populations have undergone radical changes in their genetic composition in one growing cycle (Shevchuk, 1973). However, in the case of samples collected from village markets or those which are subjected to biased sampling methods in the farmer's field, it is sufficient to safeguard and maintain their genes and not necessarily their gene frequencies within populations (Porceddu and Damania, 1992).

It is now generally agreed that the gene bank curator must be regarded as being responsible for characterization of new incoming material whereas the evaluation of the same should be the task of a germplasm scientist, other than a breeder, attached to a crop improvement program (Jana, 1987). In fact, Frankel (1987) categorically states that genetic resources have been utilized without elaborate characterization but never without evaluation mostly by, or in close interaction with plant breeders. The aspects of evaluation and documentation of cereal genetic resources has been reviewed recently by Damania (1990).

EVALUATION OF GENETIC RESOURCES COLLECTIONS

Cultivated genetic resources which survive evaluation for biotic and abiotic stresses are normally suitable as potential crossing material for one or two specific traits, hence it would be useful as a donor of these traits rather than as lines for release as commercial cultivars.

Many wheat evaluation studies have used ranking as a method of describing results. This ranking may change from one site to another for some quantitative characters such as plant height and days to heading (Damania, 1983). Such unstable characters cannot be adequately described when studied at a single location. Thus the concept of multi-location testing has gained importance in evaluation projects in recent years.

However, there are traits such as resistance to diseases and tolerances to certain types of soils (such as saline) for which variability can only be observed at particular sites where the incidence of that particular stress is the greatest, the so called "hot spots". For example, for screening against resistance to *Septoria tritici* (leaf blotch) ICARDA uses a humid and relatively high rainfall site located near Lattakia on the Mediterranean coast in Syria. Experiments on tolerance to salinity and drought are conducted at a site on the shores of salt lake Jabboul in northern Syria. Jana *et al.* (1983) first used this site to evaluate 3000 durum wheat accessions from various countries and out of these only ten lines were found to be highly tolerant to combined stresses of salinity and drought. In recent years screening for salt tolerance is being carried out with more accurate results with the use of hydroponics or sand culture because past experience has shown that soil salinity in a field is highly variable (Damania *et al.* 1994).

A total of 662 accessions of twenty-four *Aegilops* spp. were planted at Tel Hadya, the principal experimental station of ICARDA. In the subsequent three seasons, which were highly variable for temperatures and precipitation, a number of these accessions were dropped from the study due to their poor tolerance to one or more biotic and abiotic stresses prevalent at that site. Accessions with poor viability and growth vigor were also eliminated. Hence, in the subsequent season only 206 elite accessions were isolated as more or less pure lines selections. The number of species were reduced to just twelve with only 4 species being dominant among these as the most tolerant and hence useful for providing donor genes for wheat improvement in wide crossing programs (Table 1).

Unlike *Aegilops* spp., the wild progenitors of wheat belonging to the genus *Triticum* are commonly sympatric with their cultivated forms. They differ in phenotype and adaptation but remain sufficiently related genetically to cross and produce fertile hybrids with exchange of genes particularly in the direction of the cultivated forms. The ecological environment of growth for the purposes of preliminary evaluation should be made as identical as possible to that of the original habitat of the germplasm. However, this is not always possible in a collection where samples originate from all corners of the areas of their distribution. Therefore, no single evaluation location can be entirely suitable for all accessions or Triticeae species. Darlington (1969) states that barley and emmer wheat (*Triticum dicoccum*) originated in Syria. ICARDA is fortunate in being located within the center of diversity for cultivated and wild Triticeae and, as such, is as near to an ideal site for evaluation as can possibly be found (Srivastava and Damania, 1989). Evaluation carried out at near ideal sites minimize the effect of natural selection on the accessions' genetic make-up and also ensures an adequate harvest of seed quantity for distribution or further evaluation.

Recombinant DNA technology has a great potential for elucidating the biochemical and molecular bases of the complex processes underlying agronomically interesting traits and also for making otherwise unattainable changes in plant genotypes. However, for monocotyledon species such as wheat, practical achievements are not expected in the immediate future. On the other hand, chromosome engineering, i.e. sexual transfer of chromosomal segments between related Triticeae species through manipulation of the homoeologous pairing process allows successful introduction of useful genes of alien origin into cultivated wheat due to the availability of molecular techniques as analytical and selection tools.

Table 1. List of species of *Aegilops* which were tolerant to frost, drought and heat stress over four seasons at Tel Hadya.

Species	Ploidy	Genome	No. of lines
Aegilops biuncialis	4X	UM	50
Aegilops caudata	2X	C	8
Aegilops columnaris	4X	UM	27
Aegilops kotschyi	4X	US	1
Aegilops ovata	4X	UM	53
Aegilops peregrina	4X	US	4
Aegilops speltoides	2X	S	2
Aegilops squarrosa	2X	D	2
Aegilops triaristata	6X	UMUn	6
Aegilops triuncialis	4X	UC	39
Aegilops umbellulata	2X	U	5
Aegilops vavilovii	6X	DMS	8
		Total	205

UTILIZATION OF GENETIC RESOURCES COLLECTIONS

For the purpose of utilization systematic analysis and description of samples is useful in distinguishing between populations, identifying duplicates, as well as providing information on the extent of variation for desirable traits within a given genetic resources collection. It is axiomatic that the more evaluation information on a collection is available the greater the chances of its rational utilization. Collection site information is extremely important. For instance, at ICARDA newly received germplasm which is described as having a short maturity period and collected from heat stress prone areas receives immediate attention of the breeders as these traits are essential for evading periods of drought and high temperatures during grain filling in the dry areas of West Asia.

There are three ways in which obsolete forms and wild relatives of our cultivated cereal crops can be utilized (Frankel, 1970): i) Introductions for direct use as crops, ii) introductions which can confer particular traits to the adapted cultivars such as, disease resistance, protein content, etc. (this type of utilization is the most prominent way in which obsolete forms and wild relatives of Triticeae have been utilized), and iii) introductions to increase yield *per se*, irrespective of the effect of physical or biotic stresses present in the environment. The extent of evaluation and initial usage among the three categories of germplasms are almost proportional to the degree of their utilization. However, wild Triticeae species, especially those from the secondary gene pool, remain one of the least collected, conserved and exploited categories of germplasm.

Varietal improvement and the incorporation of yield stability in the improved cultivars for the low rainfall areas through the use of landraces has been impressive in wheat. For example, Duwayri *et al.* (1987) crossed Stork, a semi-dwarf high yielding durum wheat cultivar under optimum conditions with Haurani, the local well adapted durum landrace in Jordan and Syria which produces reasonable yields under stress conditions. A number of lines which resulted from these crosses appear promising in low as well as moderate rainfall zones of West Asia and North Africa (WANA).

It becomes obvious that if greater use of obsolete and wild Triticeae material has to be made it is essential to remove (or at least suppress) the close linkage between desirable traits and unfavorable alles. This may be done through transporting the germplasm to areas similar to the native habitats where evaluation and selection can be carried out under favorable conditions of soil, photo-periods and temperatures. For wild species, particularly the putative progenitors, either a naturally introgressed population or an artificially directed back-crossing program would improve their chances of inclusion in a breeding program. This preparatory activity is often referred to as germplasm enhancement or pre-breeding (Chang, 1985).

Sears (1956) gave a good example of pre-breeding efforts involving a wild relative of wheat. In that early report *Aegilops umbellulata* was initially crossed with *Triticum dicoccoides* to produce an amphidiploid progeny. This was crossed with a *T. aestivum* cultivar but the F_1 was male sterile and had to be back-crossed to *aestivum* twice. The progenies of this back-cross were tested for leaf-rust resistance which was present in the wild species. A resistant plant was isolated carrying 21 bivalents. This plant was then crossed with Chinese Spring to produce Transfer which was widely used in North America as a leaf-rust resistant cultivar. Since then, other wild species of wheat have been utilized by Canadian and U.S. breeders as gene sources for improving winter-hardiness, short stature and cytoplasmic male sterility in wheat (Stalker, 1980).

The utilization of wild relatives has also yielded promising results in producing lines of wheat with disease resistance as well as tolerance to drought and salinity. An experiment to assess tolerance to artificially created salinity and its effect on morphological traits in some lines of *Triticum boeoticum* and *Triticum dicoccoides* was carried out at ICARDA using sand culture techniques in a controlled environment with eight replicates. In general, *T. dicoccoides* was found to be more tolerant to salinity than *T. boeoticum* (Damania *et al.* 1994).

The real bottle neck in the utilization of wild and obsolete/rare (primitive) forms in wheat crop improvement has been the lack of genetically pure lines with stabilized desirable characters incorporated therein. Breeders are averse to utilizing germplasm which may retard progress on their improved lines and/or that which may require years of back crossing to eliminate undesirable traits which are very often inherited when wild or obsolete/rare (primitive) material is used. For example, in a simple *Triticum durum* x *T. dicoccoides* cross characters such as, brittle rachis, glume hairiness, profuse unsynchronized tillering, hybrid necrosis, grass clumping and loose crown persist in subsequent generations but rapid progress can be made by making a top cross of this material with durum wheat.

To alleviate this problem an extensive program of pre-breeding was established. Crosses between wild progenitors (mainly *Triticum dicoccoides*) and durum wheat, and between durum wheat and obsolete forms with disease resistance (such as *T. dicoccum*), were made during 1989-90 in order to develop genetic stocks with stable desirable characters which the breeders could use directly in their crossing programs. Also, Haurani was crossed with *T. dicoccoides* using the latter as the male parent because lower fertility has been reported when *T. dicoccoides* was used as a female parent (M. Tahir, pers. comm.). Selections were made in 1991-92 season and subsequent seasons and the first segregates were tested in 1992-93 for inheritance of desirable traits with encouraging results.

The *T. durum* x *T. dicoccoides* cross also transfers certain disease resistance, high protein content as well as improved yield to the cultivated form. The 1000-kernel weight of the durum varieties used as female parents was much higher than that of the *T. dicoccoides*. Nevertheless, in selected progenies high 1000-kernel weight from the female parent and high protein content from the male is retained (Srivastava and Damania, 1989).

A number of obsolete forms such as, *T. polonicum*, *T. turgidum* and *T. carthlicum* (which are tolerant to drought and possess resistant to yellow rust) were also crossed with accessions of *T. dicoccum* to improve gene combinations in the latter. Progenies of these crosses were planted in plastic house and their characteristics studied. The number of crosses and seeds obtained are given in Table 2.

The utilization strategies for Triticeae genetic resources at ICARDA are as follows: a) large-scale screening for tolerance to biotic and abiotic stresses; b) evaluation of the extent of variability within the species for agronomic traits; c) selection of a small number of accessions with stable desirable traits to initiate a crossing program with cultivated wheat; and d) evaluation of a number of early generation progenies with non-brittle rachis. At present the early generations of the hybrid material are being grown at several sites representing the actual crop growing environments in the WANA region.

Table 2.List of crosses between cultivated, wild and obsolete species of wheat and number of seeds obtained after harvest.

Female parent		Male parent		No. of seeds
T. durum Haurani	x	*T. dicoccoides*	600340	1
T. durum Haurani	x	*T. dicoccoides*	600548	1
T. durum Haurani	x	*T. dicoccoides*	600474	1
T. durum Haurani	x	*T. dicoccoides*	600455	13
T. durum Haurani	x	*T. dicoccoides*	600874	3
T. durum Cham 1	x	*T. dicoccoides*	600340	8
T. durum Cham 1	x	*T. dicoccoides*	600340	2
T. durum Cham 1	x	*T. dicoccoides*	600415	6
T. durum Cham 1	x	*T. dicoccoides*	600415	2
T. durum Cham 1	x	*T. dicoccoides*	600392	2
T. durum Cham 1	x	*T. dicoccoides*	600392	12
T. durum Cham 1	x	*T. dicoccoides*	600392	12
T. durum Cham 1	x	*T. dicoccoides*	600435	1
T. dicoccum 600780	x	*T. turgidum*	09805	5
T. dicoccum 600768	x	*T. turgidum*	09805	6
T. dicoccum 600770	x	*T. turanicum*	22276	5
T. dicoccum 600768	x	*T. dicoccum*	14253	3
T. dicoccum 600765	x	*T. polonicum*	12197	1
T. dicoccum 600765	x	*T. dicoccum*	14215	1
T. dicoccum 600774	x	*T. dicoccum*	14215	7
T. dicoccum 600767	x	*T. turanicum*	12276	3
T. dicoccum 600767	x	*T. turanicum*	12276	6
T. polonicum 12194	x	*T. dicoccum*	600771	5
T. polonicum 12194	x	*T. turgidum*	136071	3
T. spelta 08861	x	*T. compactum*	37367	2

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