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GENETIC RESOURCES FOR VARIETAL IMPROVEMENT IN FODDER OATS

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In India, oats have been increasingly gaining importance as a good fodder and feed resource. This obviously necessitates its genetic improvement for which a wider genetic base is an essential pre-requisite. In this paper, an attempt has been made to highlight the need for new plant genetic resources and indicate the germplasm resource centres. Sources of genes for specific traits, viz., production traits, quality traits, disease resistance, drought resistance, winter hardiness, lodging resistance, photo-insensitivity, high growth rate, and high physiological efficiency have been pointed out.

Oats have recently assumed considerable importance in India for its fodder value for livestock and as animal feed particularly for calves and young stock, horses, poultry and sheep. With the advent of intensified dairy industry in the country, especially with the cross-bred animals, the oat fodder, among others, is progressively figuring for its improvement, attracting attention of plant breeders on one hand and the crop husbandry and livestock rearing workers on the other.

The success of any breeding programme depends on the available genetic base. Assemblage of a large and genetically diverse genepool including wild taxa, especially from centres of origin and the centres of the maximum diversity becomes important in isolating/developing desirable types. In this paper, an attempt has been made to project the available information on the germplasm which may prove to be very useful in the development of new varieties for various purposes and situations.

Need for new plant genetic resources

The new genepool resources are required to be exploited for particular purposes and therefore the objectives with respect to the development of specific varieties should be well defined. It is of utmost importance to know about the problems and specific needs with particular reference to varied farming systems embracing oat as a fodder component. Forage based livestock feed of good quality needs to be produced under varied situations as (i) intensified fodder production system for dairying, (ii) integration of fodder crops with food/cash crops and horticultural crops for mixed farming under irrigated and dry land conditions, (iii) forage production under specific climatic and edaphic situations.

Greater emphasis is given to high tonnage of fodder in most breeding programmes, although the importance of nutritive value of forage also caught attention of forage oat breeders in the recent past. There is an urgent need to develop forage oat varieties capable of producing high dry matter yield per unit area and time coupled with high nutritive value. Of course, breeding work related to disease resistance, wider adaptation and responsiveness to higher inputs also deserves due consideration. Under situations of excessive production during normal growing season, the surplus fodder needs to be conserved as silage or hay and the varieties must possess specific traits required for efficient conservation. Suitable plant types are needed for different cutting management systems in monoculture and for mixed cropping with leguminous fodders. Thus, the breeding strategies need to be reoriented in the above directions with particular emphasis on exploitation of new sources of genes for specific traits.

Germplasm resource centres

Sizeable oat germplasm collections are available at Plant Genetics and Germplasm Institute, U.S. Department of Agriculture, Beltsville, Maryland (U.S.A.); Research Station Ottawa, Ontario (Canada) as well as in U.S.S.R. and Israel. In India, a good oat germplasm collection is available at the Indian Grassland and Fodder Research Institute, Jhansi; G.B. Pant University of Agriculture and Technology, Pantnagar; Haryana Agircultural University, Hisar; Punjab Agricultural University, Ludhiana; Himachal Pradesh Krishi Vishwa Vidyalya, Palampur; Indian Agricultural Research Institute, New Delhi; and the National Bureau of Plant Genetic Resources, New Delhi. Free exchange of material between different agencies will help the breeders for quick development of better varieties. It may also be mentioned that Mediterranian basin is considered as the homeland of *Avena* species. An appropriate effort for further exploration in this region will provide more diverse material including species collection in future.

Sources of genes for specific traits

Besides the two important cultivated hexaploid species, *A. sativa* and *A. byzantina* grown for grain as well as fodder, many wild species have been brought under cultivation in different parts of the world due to their usefulness for forage and grain production. The important species grown for fodder are *Avena sterilis* in Mediterranian region and south-west Asia; *A. fatua* in south-west Asia; *A. abyssinica* in Ethiopia, *A. barbata* in Mediterranian region and Iran, *A. brevis* in southern Europe; *A. strigosa* in Mediterranian region, *A. wiestii* in U.A.R. and Iran and *A. ventricosa* in Algeria. The useful genes for different characters are distributed in different species. Many wild *Avena* species may serve as a useful source of germplasm for oat improvement. The new exotic germplasm of different diploid, tetraploid and hexaploid species assembled from various sources has been screened at the Indian Grassland and Fodder Research Institute, Jhansi and the new sources of useful genes have been located for their further exploitation (Bhag Mal, 1985).

1. Sources of genes for production traits

Desirable genes for specific production traits are located in different cultivars. Varieties Rapida and Montezuma, developed in U.S.A., Tarahumara in Mexico and Flamingsnova in West Germany are good sources of earliness. The variety Scott from U.S.A. has been observed to possess genes for tallness and leafiness. It produces 10-11 leaves per tiller with about 40-45 cm length and 8.00 cm breadth and may serve as a good donor for leaf number and leaf size. The varieties Houston, Norwin, Coronado and Cortez are capable of high forage production in U.S.A. The variety Saturn has been specifically bred and released for forage production in Czechoslovakia (Sebesta and Cervanka, 1979). The variety Blackbutt was released by New South Wales Deptt. of Agricultural for heavy grazing. It is a late maturing variety like Algerian.

Amongst the wild species, *A. abyssinica* and *A. canariensis* are important for earliness (Table 1). The genes for tallness are distributed in *A. sterilis*, *A. ludoviciana* and *A. strigoa* and for tiller number in *A. hirtula*, *A. prostrata* and *A. damascena*. Cultivars from *A. sterilis*, *A. nuda* and *A. chinensis* may contribute genes for high leaf number, leaf length and leaf width. The desirable genes for seed size are located in *A. magna* and for spikelet number in *A. nuda*, *A. pratensis*, *A. abyssinica* and *A. brevis*. The studies at IGFRI, Jhansi revealed that EC 130639 of *A. sterilis* possessed good tillering (11-12), plant height (150 cm), leaf number (9.0), leaf length (44 cm) and dry matter yield per plant (100 g). Likewise, EC. 108467 of *A. nuda* was observed promising for leaf length (44.2 cm), leaf width (2.3 cm), spikelet number (69.8) and seed yield per plant (30.0 g). Two accessions, viz., EC 131287 and 6409 of *A. magna* were observed to have very bold seeds with 1000 seed wt. of 61.0 g and 62.0 g, respectively. These accessicns belonging to different species may be used as the donors of genes for traits in the hybridization programme.

2. Sources of genes for forage quality traits

The most important requirement of nutritive fodder is that it should be able to supply sufficient energy and protein for animal growth (Milford, 1964). The most important and relatively simple measure of energy is provided by digestibility of dry matter. Other parameters which determine the forage quality are neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose, hemi-cellulose, lignin and silica. A number of varieties with high protein percentage *e.g.*, Dal, Goodland, Otee, Wright, Marathon and Spear have been developed and released in USA (Frey, 1979). The genes responsible for high protein % in these varieties are from *A. sativa*. Protein content of seed of *A. sterilis* has been reported from 17 to 35%. Further, studies have shown that genes for high protein content from *A. sterilis* and *A. sativa* are complementary which suggests that they can be combined to give a protein per cent higher than present in either of the species. Similar studies need to be conducted for foliage protein.

Studies conducted at Indian Grassland and Fodder Research Institute, Jhansi indicated that the genes for high foliage protein are distributed in *A. sterilis*, *A. magna*, *A. ludoviciana*. *A. maxima* and *A. abyssinica* and for dry matter digestibility in *A. maxima*, *A. ludoviciana*, *A. magna* and *A. abyssinica* (*Bhag Mal, 1985*). Likewise, genes for other quality traits are distributed in different species (Table 2).

The genotypes EC 108434 and EC 131312 of *A. abyssinica* possessed high crude protein (18-19%), high dry matter digestibility (71-73%) and comparatively

Table 1. Sources of genes for desirable production traits in *Avena* species

Species	Earli-ness	Plant ht.	Tiller No.	Leaf No.	Leaf length	Leaf bredth	Panicle length	Spikelet No.	100 seed weight
A. sterilis		x		x	x	x			
A. nuda				x	x	x		x	
A. chinensis				x				x	
A. ludoviciana		x							
A. pratensis								x	
A. vaviloviana							x		
A. barbata					x		x		
A. manga									x
A. abyssinica	x						x		
A. brevis							x		
A. strigosa		x							
A. hirtula			x						
A. prostrata			x						
A. damacena			x						
A. longiglumis						x			
A. canariensis	x								

x - indicates the presence

Table 2. Sources of genes for forage quality traits in *Avena* species

Species	Crude protein	IVDMD	NDF	ADF	Cellulose	Hemice-llulose	Lignin	Silica
A. sterilis	x				x			x
A. fatua					x			
A. maxima	x	x			x			x
A. ludoviciana	x	x						x
A. pratensis						x	x	
A. vaviloviana						x		x
A. barbata				x			x	x
A. magna	x	x						x
A. abyssinica	x	x	x	x				
A. brevis							x	
A. ventricosa				x			x	

x - indicates the presence

low NDF (50-52%), low lignin (1.6 - 2.9%) and low silica (1.1 - 1.2%). Likewise, EC 131287 of *A. magna* possessed high protein (19.10%), high digestibility (71.2%) and low lignin (0.69%). EC 130639 and EC 130640 of *A. sterilis* exhibited high crude protein (17-18%), moderately low lignin (3.0 - 3.3%) and low silica (0.73%), whereas EC 130641 and CAV 3117 possessed high crude protein (18.2 - 18.4%) alongwith high digestibility (68.6 - 69.9%) and low silica (1.67 - 1.69%). These could be used as sources of genes for specific quality traits in the fodder oat improvement programme.

3. Sources of disease resistance

Until recently, the main emphasis has been on the exploitation of race specific resistance conferred by major genes while in those cases where a pathogen has developed a race spectrum, the problem has been to find a succession of new resistance genes (Lawes, 1971). Greater attention is now directed to the use of non-specific (horizontal) resistance. New sources of genes are to be located for their effective transfer to the cultivated types. The resistant varieties for crown rust are Housten, Norwin, Coronado, Cortez, Dodge, Gerland from USA and Fidler from Canada. Other varieties possessing high degree of resistance were Fidler for stem rust, Fidler and Blackbutt for smut and Mostyn for powdery mildew.

A wealth of untapped but useful genes are available in lesser known oat species and their exploitation would be desirable. The species having cultivars possessing resistance genes for all the three important diseases, namely, stem rust, crown rust and mildew are *A. strigosa*, *A. barbata* and *A. sterilis*. Sources of genes for resistance to these important diseases have been located in many other species (Table 3). Use of *A. hybrida*, *A. sterilis*, *A. fatua* and *A. occidentalis* will be helpful in transferring resistance genes for Barley Yellow Dwarf Virus. Mildew resistance from hexaploid *A. sterilis* and *A. fatua* can be readily introduced by backcrossing. However, the transfer of genes for diploid and tetraploid species into cultivated species is more difficult due to strong sterility barriers which are required to be overcome.

Table 3. Sources of genes for disease resistance in wild *Avena* species

Species	Resistance			
	Stem rust	Crown rust	Mildew	BYDV
A. sterilis	R	R	R	R
A. fatua	R			R
A. ludoviciana			R	
A. occidentalis				R
A. barbata	R	R	R	R
A. magna		R		
A. abyssinica		R		
A. hirtula			R	
A. longiglumis	R			
A. strigosa	R	R	R	R
A. ventricosa				
A. prostrata			R	

R - indicates resistance

BYDV - Barley Yellow Dwarf Virus

A genotype of *A. barbata* collected in Algeria has been reported to be resistant to all prevalent races of mildew in U.K. (Thomas *et al.*, 1975) which may serve as a good source of resistance genes. A considerable reservoir of resistance to crown rust flora has also been reported in *A. fatua*, *A. ludovicinana* and *A. barbata* in New South Wales (Brouwer *et al.*, 1981).

4. Sources of drought resistance

Development of oat varieties tolerant to drought conditions would become necessary if oat cultivation is to be extended to areas which do not have irrigation facilities. Little work appears to have been done in this direction. The studies on chlorophyll stability index for measuring drought resistance revealed that IGFRI 3021 having the lowest index (2.0) as against (16.3) of Kent was observed to with stand high temperatures (Yadava *et al.*, 1975). Other cultivars of *A. sativa* and *A. barbata* possessing low stability index were also identified. EC 96559 showed better performance under water-stress conditions (Manchanda and Ghosh, 1978). Such sources could be utilized for transferring drought resistance genes to otherwise high yielding types.

5. Sources of winter hardiness

There is a need to develop winter hardy oat varieties in view of its cultivation gradually extending to colder regions of the country. The varieties Bronco, Mustang, Norwin and Blackbutt possess considerable winter hardiness and may be used as donors of genes for winter hardiness. *A. hybrida* a wild hexaploid oat collected from Wakhan region of Afganistan at an attitude of 2300m, possesses winter hardiness which may be incorporated into *A. sativa*. Promising cultivars of *A. fatua* and *A. sterilis* possessing winter hardiness may also be exploited.

6. Sources of lodging resistance

Under high input situations, considerable degree of damage is expected to be caused due to lodging which is primarily attributed to poor straw strength and, therefore, attention needs to be paid towards the development of lodging resistant varieties. The varieties, namely, Houston, Norwin, Coronado, Cortez, Hermes and Blackbutt possessing greater straw strength may be used as donors for developing lodging resistant varieties.

7. Genes for photo-insensitivity

In an attempt to locate genes for insensitivity to photoperiod in diploid, tetraploid and hexaploid *Avena* species, Sampson and Burrows (1972) observed that materials of northern region were very sensitive to day length, the mediterranian diploids were moderately sensitive and tetraploids (*A. abyssinica* and *A. barbata* group) were insensitive. They further reported that Rapida (*A. sativa*) and CWS (*A. byzantina*) were slightly sensitive to day length suggesting the possibility of using them as parents. Med. 147, a strain of *A. byzantina* collected in the Mediterranian area is a good source of day length insensitivity (Zillinsky, 1971).

8. Genes for high growth rate

The most significant source of genetic variability for this trait is the weedy species *A. sterilis*. Genes for high growth rate have now been introgressed from *A. sterilis* into good *A. sativa* genotypes. High growth rate is a polygenically governed trait with estimated effective 6-8 factor pairs (Frey *et al.*, 1979).

9. Breeding for high physiological efficiency

Development of suitable plant types possessing high physiological efficiency is necessary to meet the requirements of different farming systems. Erect plant type with no or low droopiness of leaves would be better for intercropping of oats with other crops, whereas cultivars with prostrate growth habit would be preferred for grazing purposes. The genotypes CAV 2699 and EC 131300 of *A. byzantina*, CAV 3117 of *A. sterilis*, 6415 B of *A. rousse* and 6416 of *A. abyssinica* exhibited erect growth habit along with almost erect leaves and could be used as donors for these traits. EC 130639 of *A. sterilis*, CAV 227 and CAV 357 of *A. barbata* possessing prostrate growth habit could be useful in developing pasture oats.

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