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CHARACTERISTICS AND POTENTIAL USES OF SOME GENETIC STOCKS OF PEARL MILLET IN THE WORLD COLLECTION

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The world germplasm collection of pearl millet [Pennisetum glaucum (L) R. Br.] *consisting of 21, 772 accessions from 44 countries is being maintained at ICRISAT Centre, Patancheru, India. Most of the material has been evaluated and characterised to identify traits of economic importance for present and future utilisation. Promising accessions identified as sources of disease resistance are 1220 to downy mildew, 151 to ergot, 161 to smut and 392 to rust. Other genetic stocks and seedling markers identified are 145 dwarfs, 3 midribless, 8 glossy and many viable chlorophyll deficient mutants. New male sterile lines identified from Ghana and Botswana germplasm are early-maturing and produce large grains. Sweet stalk types with high sugar content are useful to develop fodder types. Early-flowering stocks are useful to develop early-maturing high-yielding cultivars. Germplasm from West Africa is a good source for disease resistance, high head volume and large grain size.*

Pearl millet [*Pennisetum glaucum* (L) R. Br.] had originated in a diffuse belt from Sudan to Senegal most probably around Mali-Mauritania (Brunken *et al.*, 1977) and spread to other countries where considerable diversity had accumulated. The world collection of pearl millet comprising of 21,772 accessions from 44 countries is being maintained at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. As and when the germplasm material is collected or acquired, they are evaluated as per the standard pearl millet descriptors (IBPGR/ICRISAT, 1981) and traits of economic importance are identified. Enormous variation was observed for several morpho-agronomic characters (Murty *et al.*, 1967; Mengesha, 1984; Mengesha and Appa Rao, 1986; Harinarayana *et al.*, 1988). Accessions possessing these economic traits are maintained as genetic stocks collection and the results of evaluation and screening data are summarised in this paper.

GENETIC STOCKS OF ECONOMIC IMPORTANCE

Source of economically useful traits are identified through systematic screening of world germplasm (Table 1) with a view to incorporate them in the improved cultivars.

Early flowering and maturity

Days to flowering and maturity assume special significance as pearl millet is grown under relatively dry conditions. In the world collection, flowering ranged from 33 to 140 days offering wide scope for tailoring the genotypes to suit different

Table 1. Sources of resistance idenitfied in pearl millet germplasm

Screened for	Number of accessions	
	Screened	Resistant
1. *Disesase Resistance*		
Downy mildew	3163	1220
Ergot	2554	151
Smut	941	161
Rust	2670	392
2. *Insect Resistance*		
Mythimna spp.	100	0
Shoot fly	424	45
Aphids	100	14
Shoot bugs	100	8
Thrips	29	3
Spider mites	234	31
3. *Other characters*		
Drought Resistance	509	2
Early	16968	8
High protein	3523	100
High sugars	3008	4
Male sterility	16968	7
Glossy leaf	16968	8
Dwarf lines	15388	145
Midribless	17000	3
Chlorophyll mutants	16968	150

environmental conditions and farming systems. Early flowering appears to be controlled by two genes e_1 and e_2 (Hanna and Burton, 1985) and plants having e_1e_1 flowered in 49 days and e_2e_2 genotype in 38 days as compared to the control (76 days) when grown at Tifton, Georgia. After screening the world collection of 18,148 accessions, 7 genotypes that flowered earlier than Tift 23BE having e_1e_1 gene were identified. Among them, IP 4021 (*Bhilodi*) collected from Gujarat which flowered in 33 days was the earliest. A comparison of the phenology of parents and F_1s revealed that late flowering is partially dominant, dominant or overdominant. The differences in flowering time between Tift 23BE and Bhilodi were controlled by 1 or 2 genes (Appa Rao *et al.*, 1988a). ICRISAT constituted a medium maturity composite by random mating 197 geographically diverse Indian and African lines, all flowering in 45-55 days.

Dwarfs

The inheritance of five dwarfs was studied (Burton and Fortson, 1966) and two stocks were identified in which dwarfing was conditioned by a single recessive gene, d_1 or d_2. The d_2 gene has been incorporated into male sterile (ms) lines like Tift $23A_1$, Tift $239A_2$, $126A_1$ and $81A_1$. Seven diverse tall composites have also been converted into d_2 background providing a broad dwarf genetic base for breeding dwarf parents and dwarf open pollinated varieties (Andrews *et al.*, 1985). Subsequently, over 40 dwarf stocks were identified and mode of inheritance of 13 stocks was studied. When these 13 dwarfs were crossed to Tift $23d_2B$ (d_2 dwarfing stock), 8 were found to be allelic and 5 were found to be non-allelic to d_2. Of these five, one was allelic to d_1, two showed continuous variation for plant height, and two stocks were found to be non-allelic to d_1 and d_2. These simply inherited dwarfs, which are non-allelic to each other, were assigned new gene symbols d_3 and d_4. These dwarfs possess several agronomically desirable characters besides reduced height (Appa Rao *et al.*, 1986). They can be used in millet improvement to produce cultivars with reduced height.

Sweet stalk types

The search for alternate uses of pearl millet revealed the occurrence of genotypes with high sugar content in their stems. Among sweet stalk pearl millet cultivars, considerable variation for juiciness and sweetness of the stalks was observed. Comparative studies at ICRISAT indicated 5 to 20 per cent sugar in 8 accessions, 4 of which are from Tamil Nadu (Appa Rao *et al.*, 1982). Sweet stalk types from Tamil Nadu flower late and grow very tall when compared to normal genotypes. They appeared to be good fodder types.

Sugar content in 68 genotypes studied at Coimbatore ranged from 3 to 16 per cent (Harinarayana *et al.*, 1988). The genotype FD 832 recorded the highest sugar content of 16.2 per cent followed by NEP 18-5023-2 (15 %) and Giant Bajra (13.8 %). Popularisation of sweet pearl millet for extraction of jaggery like in sweet sorghums may be beneficial in pearl millet growing areas of the semi-arid tropics.

Large spikes

Most of the accessions from India and southern Africa produced shorter spikes compared to those from West Africa. The accessions from Nigeria and Niger produced the largest spikes where the Gero, Zongo and Maiwa forms produce more than 1m long spikes. Those with longer spikes produced fewer tillers, mature later, and are often strongly photoperiod sensitive.

Seed characters

The seed size in pearl millet varied from very small (2.39 g/1000 grains as in IP 3100) to very bold (23 g/1000 grains as in IP 10437) with different grades of sizes. Bold seeded collections predominantly occurred in accessions from Benin, Ghana, Togo and Uganda. Light pigmented pearl millet grains which vary from white to yellow were identified in germplasm from Chad, Central African Republic, Ghana and Sudan (Appa Rao *et al.*, 1985). These pearly pearl millets are also sweeter and contain higher protein (more than 15 %) and may have good scope in improving nutritional quality and appearance of bakery products (Harinarayana *et al.*, 1988). These may also find a place in irrigated farming and acceptability by the elite segment of the society.

High seed protein

Seed protein content in 3523 samples was analysed and 100 accessions with the high protein content were selected. The protein content ranged from 15.5 to 20.2 per cent and the 1000 seed weight ranged from 3.2 to 12.8 g in the selected accessions. There are several lines having more than 15 per cent protein and seed weight more than 7 g, which are useful in millet improvement. Such lines are mainly from West Africa.

Cytoplasmic male-sterility

Several new male-sterile lines were identified from Ghana and Botswana germplasm (Appa Rao *et al.*, 1989). These male-sterile lines flower earlier than all the existing CMS lines and they have larger grain size. It is hoped that commercial hybrids with early maturity, large grain size, wide adaptability and higher grain yield can be produced after identifying suitable restorer lines.

USEFUL GENETIC STOCKS

Glossy types

After screening the world collection of 16,968 accessions from 31 countries, glossy trait was observed in eight accessions (Appa Rao *et al.*, 1987). The glossy characteristic was distinguishable at seedling emergence and persisted for 28 days. Mist accumulated as droplets on glossy leaves. Glossiness was due to a single *recessive gene in each case and three different non-allelic genes,* gl_1, gl_2 and gl_3, governed this trait. Glossiness appeared to be associated with seedling drought tolerance.

Midribless mutants

Three spontaneous midribless mutants identified were characterised by leaf blades that tend to droop because of the absence of a keel in the midrib portion of the leaf lamina. Androecium and gynoecium were affected in both the mutants. A single recessive gene controlled midribless trait in each of the three mutants. Two different genes $mr1_1$ and $mr1_2$ were identified. These mutants are useful to study the structure and function of the midrib (Appa Rao *et al.*, 1988 b).

Chlorophyll deficient mutants

Several lethal and non-lethal chlorophyll deficient mutants have been reported in pearl millet. Naturally occurring non-lethal chlorophyll deficient mutants, not reported so far, were studied. All the leaves of the 'bright-yellow' mutant were shiny and deep yellow from emergence to maturity. The 'chlorina-virescent' mutant produced yellow leaves, which turned pale green after flowering. The 'greenish-yellow' mutant retained its pale-yellow colour from emergence to grain filling. All the mutants, could be identified in the seedling stage. In all the mutants, flowering was delayed compared to the corresponding normal genotypes. It was established that in each case the mutant condition was governed by a single recessive gene (Appa Rao *et al.*, 1984). As most of the mutants can be identified soon after germination, they can be used as seedling markers for mapping chromosomes.

Stripe mutants

Stripe plants show longitudinal yellow or white stripe, alternating with varying shades of green, on leaf blades, leaf sheaths, internodes, peduncles, inflorescences, and spikelets. Several stripe mutants were found which differ in number, size, and colour of the stripes. Segregation data indicated that the yellow spikelet colour was monogenic recessive to the green colour and stripe plants are considered to be chimeras (Appa Rao and Mengesha, 1984).

The plastids from green tissue of fully expanded stripe leaves were normal, and those from yellow tissue of fully expanded leaf were enclosed by a typical double membrane envelope. They were irregular in shape and relatively smaller than the normal plastids but equal in number. Majority of the cells in pure yellow stripes contain no normal plastids. In the overlapping regions of yellow and green stripes, however, occasional cells with normal and aberrant plastids were found (Reddy *et al.*, 1988). These mutants are of considerable academic interest.

DISEASE RESISTANCE

Downy mildew, ergot, smut, and rust are the important diseases of pearl millet. Downy mildew, in particular, devastated the single cross hybrids in India (Rai and Singh, 1987). Ergot and smut occur in favourable seasons and may be less widespread and less threatening. Rust occurs sporadically. Nevertheless, all these diseases deserve effective control to reduce losses in productivity and to eliminate the toxic principles in the food grains and in the stover. The incorporation of host plant resistance offers the best choice for effectively checking the occurrence and spread of these diseases.

Downy mildew resistance

Ex-Bornu, from Nigeria, 3/4 Ex-Bornu and 3/4 Hainei Kirei from Niger contributed to downy mildew resistance (Andrews *et al.*, 1985). Of the 3,163 accessions screened for downy mildew resistance, 1220 were found to be resistant, of which 428 flowered in 45-60 days (Singh *et al.*, 1987). Sources of resistance were found in West Africa, mainly in Mali, Niger, Nigeria and Senegal. This is mainly because the host plant also appeared to have evolved alongwith the pathogens and resistance was found along the centre of origin.

Ergot resistance

More than 2,500 germplasm accessions were screened to identify sources of resistance to ergot in pearl millet. Ergot resistance lines were developed by intermating relatively less-susceptible plants by pedigree selection (Thakur and Chahal, 1987).

Smut resistance

More than 1,500 accessions from germplasm working collection and 6,200 advanced breeding lines were screened to identify resistance to smut in pearl millet (Thakur and Chahal, 1987). All the advanced breeding lines were susceptible, but resistance was detected in several germplasm accessions originating from Nigeria, Senegal, Mali, Cameroon, Uganda, Lebanon and India. Selections from six germplasm accessions and four newly developed smut-resistant, agronomically elite lines showed consistently high levels of smut resistance for 1-6 years at six or seven locations in India and West Africa. These lines had across-location mean smut severities of less than 5% compared with 35% or more in the susceptible checks. These lines also were found to possess resistance to downy mildew in India.

Rust resistance

A dominant gene for rust resistance was found in 2696-14, a selection from the germplasm originating from Chad (Hanna *et al.*,1985). A number of traits of economic importance were identified in the world collection of pearl millet. The seeds are available to any one who wants to use them. These should be more extensively used to broaden the genetic base to confer stability in high-yielding cultivars.

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