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# SOME NEWLY IDENTIFIED GENETIC TRAITS IN PEARL MILLET*

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## SUMMARY

During the course of maintaining and evaluating the 16480 accessions of the world collection of pearl millet *Pennisetum americanum* (L.) Leeke, some naturally occurring mutants were identified, and the inheritance of these new traits was studied. Pearl millet cultivars with 'sweet-stalks' were identified from Tamil Nadu, India and Cameroon. Of the 13 dwarfs studied, only 2 have new genes designated $d_3$ and $d_4$. Light-green shiny leaves of the 'glossy' seedlings were due to a single recessive gene in each of the 8 lines, and this is due to either of the three non-allelic genes designated $gl_1$, $gl_2$ and $gl_3$. 'Midribless'' mutants are characterized by leaf blades that tend to droop because of the absence of keel. Two different midribless genes $mrl_1$ and $mrl_2$ were found. A number of non-lethal chlorophyll deficient mutants were identified. In the 'zebra' mutant, transverse lemon yellow streaks alternating with green were found to be temperature dependent. In the 'zebra-virescent' mutant, transverse yellow bands disappear after the 6th leaf. 'Bright-yellow', 'chlorina-virescent', and 'greenish-yellow', were due to a single recessive gene in each case and are good seedling markers. The 'stripe' mutant, in which green, yellow and variegated spikelets occur, was found to be a chimera. The newly identified cytoplasmic male-sterile lines developed from Ghana and Botswana germplasm flower early and have large grain size, making them potential seed parents for the commercial production of pearl millet hybrids.

## INTRODUCTION

Pearl millet [*Pennisetum americanum* (L.) Leeke] is grown over an estimated area of 42 million hectares, producing over 30 million tonnes of grain annually (FAO, 1985). Though it is an important food crop in Asia and Africa, information on the inheritance of characters is limited. Burton and Powell (1968), Rachie and Majmudar (1980) and Jauhar (1981) reviewed the inheritance of some characters. Koduru and Krishna Rao (1983) tabulated information on the inheritance of more than 100 characters, which are relatively few compared to maize (Neuffer *et al.*, 1968) or any other cereal crop.

Minocha *et al.* (1980) reported several genetic stocks in pearl millet. Though 7 linkage maps are possible, only 2 linkage groups were reported

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(Hanna *et al.*, 1978; Krishna Rao and Koduru, 1978a). Though linkage between purple glume, hairy leaf, bristle ear and yellow striping, hairy node and purple foliage, purple node and basal branching, tip branching and purple glume were reported (Minocha *et al.*, 1980; Minocha and Sidhu, 1979), the recombination values were not given. With a view to establishing linkage maps, some new traits are identified and the respective genetic stocks are being maintained at the Genetic Resources Unit (GRU), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). This paper summarizes the salient features and the mode of inheritance of new traits/genes identified in pearl millet at ICRISAT during the last one decade.

## MATERIALS AND METHODS

During the course of evaluation and maintenance of 16480 germplasm accessions of pearl millet from 31 countries by GRU at ICRISAT Center, Patancheru, naturally occurring mutants were identified and are maintained by selfing. Those mutants which lack some floral organs and do not set seed by selfing are maintained in a heterozygous condition.

The mode of inheritance is studied by crossing the mutants to genetic stocks having contrasting characters and studying the $F_2$ segregation data. Crossing is done without emasculation by making use of protogyny as described by Burton (1980).

## RESULTS AND DISCUSSION

*Sweet stalks.* Sweet stalk sorghums are very common and are used for chewing like sugarcane, and in making syrup or jaggery (Prasada Rao and Murty, 1982). Among sweet stalk pearl millet cultivars, considerable variation for juiciness and sweetness of the stalks was observed. We identified sweet stalk pearl millet in germplasm collected from Pollachi, Aruppukkottai and Pudukkottai in Tamil Nadu (Appa Rao *et al.*, 1982). Several accessions from Cameroon also were found to have sweet stalks. Sweet stalk types from Tamil Nadu flower late and grow very tall when compared to normal genotypes. In both sweet and normal types, sweetness increased upto a few days after flowering, which occurred in 65-80 days. At flowering time, soluble sugars were similar in both types. At maturity, however, the levels of the normal types reduced abruptly, whereas only a slight drop was observed in the sweet stalk types (Appa Rao *et al.*, 1982). The sweet stalk forms appear to be good fodder types. Inheritance studies of this sweet stalk mutant are in progress.

*Dwarfs.* Dwarfing genes in cereals often provide lodging resistance and responsiveness to fertilisers. In pearl millet, 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, $d_1$ and $d_2$. We identified over 40 dwarf stocks, and the mode of inheritance of 13 stocks was studied (Appa Rao *et al.*, 1986). When these 13 dwarfs were crossed to Tift 23$d_2$B ($d_2$ dwarfing stock), 8 were found to be allelic and 5 were

found to be non- allelic to $d_2$ (Appa Rao *et al.*, 1986). Of these, 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 $d_3$ (Fig. 1), and $d_4$ (Fig. 2). These dwarfs possess several agrono-

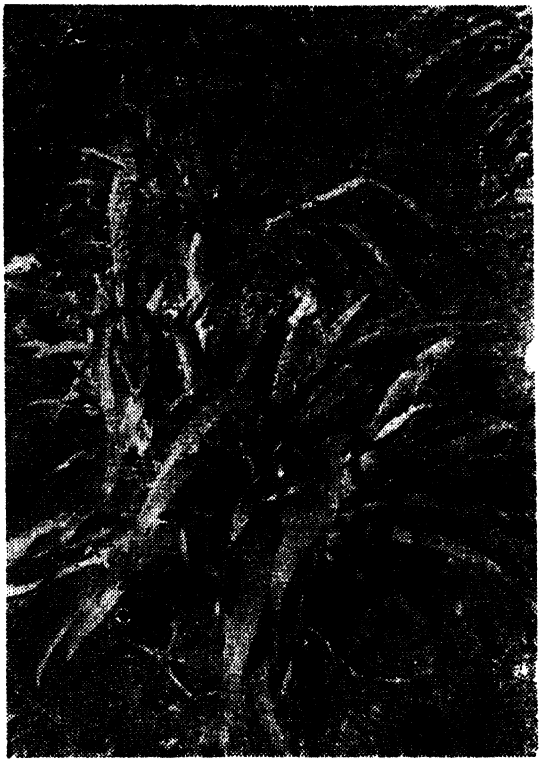

FIG. 1. $d_3$ dwarf : IP 10401 with condensed internodes and poor spike exsertion.

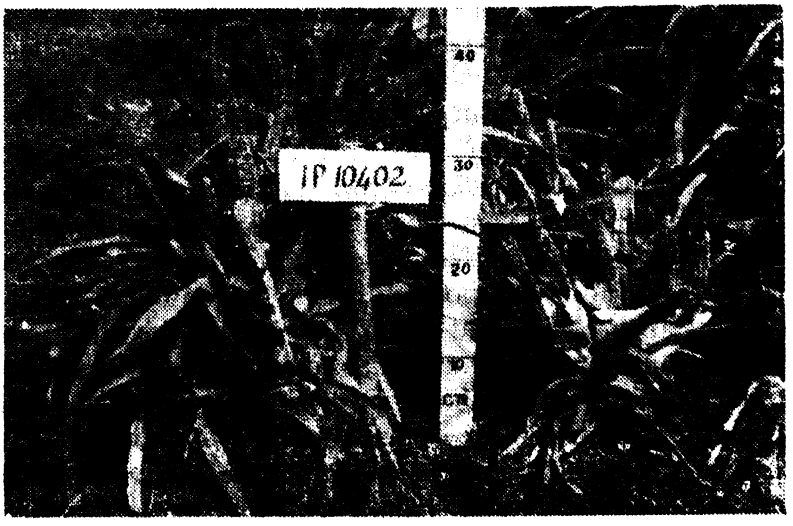


FIG. 2. $d_4$ dwarf : IP 10402 with tufted growth habit and good spike exsertion.

mically desirable characters besides reduced height (Appa Rao *et al.*, 1986). They can be used in millet improvement to produce cultivars with reduced height.

*Glossy.* In pearl millet, after screening a world collection of 16480 accessions from 31 countries (Appa Rao *et al.*, 1987), we found glossy trait in eight different accessions. The glossy characteristic was distinguishable at seedling emergence and persisted for 28 days. Similar to sorghum and maize, mist accumulated as droplets on glossy leaves of pearl millet (Fig. ). Studies of $F_2$ segregation in reciprocal crosses between the glossy and non-glossy plants showed a segregation ratio of 3:1 and no reciprocal differences. Intercrosses among the eight glossy lines indicated that three different non-allelic genes control glossiness. The gene symbols assigned were $gl_1$, $gl_2$, and $gl_3$ (Appa Rao *et al.*, 1987). An easily identifiable seedling marker 'glossy' was found to be associated with shoot fly resistance

FIG. 3. Water accumulates as droplets on glossy leaves (right) while on non-glossy leaves (left) such droplets are not formed.

and seedling drought tolerance in sorghum (Maiti *et al.*, 1984).

*Midribless.* After screening the world collection of over 17000 germplasm accessions (Appa Rao *et al.*, 1988), three spontaneous midribless mutants in pearl millet were identified. The midribless mutants are characterized by leaf blades that tend to droop (Fig. 4) because of the absence of a keel in the midrib portion of the leaf lamina. Seed set was drastically reduced in J 561 and IP 6534 midribless mutants as the gynoecium and androecium were abnormal. In one of the midribless mutants (IP 10154), the gynoecium was absent or rudimentary but the androecium was more prominent with prolific pollen shedding. Studies of $F_2$ segregation in reciprocal crosses between normal and their corresponding midribless mutants indicated that a single recessive gene controlled the midribless trait in each of the three mutants. Tests for complementation among the midribless mutants indicated that J 561 from India and IP

FIG. 4. Plant with normal midrib (right) and midribless mutant (left).

6534 from Mali have the same gene designated *mrl*$_1$, while IP 10154 from Mali has a different gene designated *mrl*$_2$ (Appa Rao *et al.*, 1988).

The anatomy and histochemistry of leaf, ligule and stem of midribbed and midribless plants were investigated. The leaf in midribbed plant has a distinct keel and thus is erect, whereas in the midribless mutant it is devoid of a keel and hence droops. In both types of leaves, the vascular bundles are surrounded by double parenchymatous sheaths.

*Chlorophyll deficient mutants.* Several lethal and non-lethal chlorophyll deficient mutants have been reported in pearl millet (Harinarayana *et al.*, 1969; Hanna *et al.*, 1978; Burton and Powell, 1965; Krishna Rao and Koduru, 1978b; Appa Rao *et al.*, 1984).

Naturally occurring non-lethal chlorophyll deficient mutants, not reported so far, were studied. In 'zebra' (z) mutant, yellow streaks were found only at low temperature and the bands persist till maturity. The 'zebra-virescent' (zv) mutant was characterized by transverse yellow bands alternating with green bands on the third to seventh leaf blades, which disappear subsequently. All the leaves of the 'bright-yellow' (by) mutant were shiny and deep yellow from emergence to maturity. The 'chlorina-virescent' (chv) mutant produced yellow leaves, which turned pale green after flowering. The 'greenish-yellow' (gy) mutant retained its pale-yellow color from emergence to grain filling. In the 'albino-terminalis' (at) mutant, the terminal 3-5 leaves remained ivory-white till maturity, while the basal leaves were green throughout. All the mutants, except 'albino-terminalis', could be identified in the seedling stage. In all the mutants, flowering was delayed, compared to the corresponding normal genotypes,

except in the 'chlorina-virescent'. From the reciprocal crosses between the normal and mutant 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 from germination, they can be used as seedling markers, mapping chromosomes.

*Stripe.* Stripe plants show longitudinal yellow or white stripes, alternating with varying shades of green, on leaf blades, leaf sheaths, internodes, peduncles, inflorescences and spikelets. This mutant condition was reported to be controlled by three genes (Gill *et al.*, 1969), bi-parental with a suggestion of dominating maternal influence (Krishna Rao and Koduru, 1978b) or only maternal (Subrahmanyam *et al.*, 1986).

We found several stripe mutants which differ in the number, size and color of the stripes. The stripe plants segregated into white, stripe and green, depending on the number and size of the stripes on the leaves of the parent. The $F_2$ segregation data from crosses of green and stripe plants did not fit a definite Mendelian ratio similar to those reported by Gill *et al.* (1969), Krishna Rao and Koduru (1978b) and Subrahmanyam *et al.* (1986). The spikes of the stripe plants have yellow and green spikelets and when yellow spikelets were crossed with green spikelets, segregation data indicated that the yellow spikelet color was monogenic recessive to the green color. Since the yellow and green sectors, which are genetically different from each other, lie adjacent to each other, the stripe plants are considered to be chimeras (Appa Rao and Mengesha, 1984).

Electron microscopic studies revealed ultrastructural differences between the plastids of green and yellow areas of stripe leaves (Reddy *et al.*, 1988) 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.

*Male-sterile lines.* The discovery of cytoplasmic male sterility in pearl millet (Burton, 1958) led to the development of commercial hybrids. Three sources of sterile cytoplasm viz., $A_1$ (Tift 23, 5141A, 5054A, 111A), $A_2$ (239D2A, 18D2A, L66A), and $A_3$ (L67A) were described by Burton and Athwal (1967). As the male-sterile lines became susceptible to downy mildew, downy mildew resistant male-sterile lines were developed (Pokhriyal *et al.*, 1976; Anand Kumar and Andrews, 1984). All these workers used the existing sterile cytoplasm and hence there is a need to identify new sources.

We identified male-sterile lines from Ghana and Botswana germplasm (Appa Rao and Mengesha, 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.

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# Effect of Water Deficit at Different Growth Phases of Peanut. I. Yield Responses

**R. C. Nageswara Rao, Sardar Singh, M. V. K. Sivakumar, K. L. Srivastava, and J. H. Williams**