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Inheritance and linkage relationships of qualitative characters in pearl millet (*Pennisetum glaucum*)

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ABSTRACT

In pearl millet [*Pennisetum glaucum* (Linn.) R. Br. emend. Stuntz; syn. *P. americanum* (Linn.) Leeke, *P. typhoides* (Burm. f.) Stapf & C. E. Hubb.] reciprocal crosses were made between genetic stocks having contrasting characters, and the mode of inheritance and linkage relationships were determined from the F₂ segregation data. Purple colour on stems, leaves, bristles and glumes in 'IP 8073' was controlled by a single dominant gene. Purple nodes and auricles were monogenic dominant to green nodes and auricles. Node colour showed complementary gene interaction. The *chlorina-virescens* mutant was found monogenic recessive to normal. Hairy nodes were monogenic dominant to glabrous nodes, whereas hairy leaf sheaths and blades were monogenic recessive to glabrous leaf sheaths and blades. Bristle length was intermediate in F₂ and continuous variation in F₃, indicating the additive action of more than 1 gene. The joint F₂ segregation data revealed independent assortment of purple with yellow foliage and dense long hairs on leaves.

To establish linkage maps in pearl millet [*Pennisetum glaucum* (Linn.) R. Br. emend. Stuntz; syn. *P. americanum* (Linn.) Leeke, *P. typhoides* (Burm. f.) Stapf & C. E. Hubb.], morphological variants with distinct phenotypic expression are being isolated while evaluating the world collection of its germplasm in India. These morphological variants are purified by selfing and subsequent selection. As information on inheritance and linkage relationships is very limited (Minocha *et al.*, 1980; Koduru and Krishna Rao, 1983), we studied the inheritance of purple plant colour, yellow foliage, hairiness on leaves and nodes, bristle length and linkage relationships among purple colour, yellow foliage and hairiness on leaves.

MATERIALS AND METHODS

Six different genetic stocks ('IP 8008', 'IP 8056', 'IP 8073', 'IP 8210', 'IP 8056' and 'IP 8214') having contrasting charac-

ters were used in the study. In 'IP 8073' purple pigment develops on leaf blades, leaf sheaths and internodes, approximately 3 weeks after emergence, and on bristles and glumes within 3 days after ear emergence. It is completely glabrous and has 30 mm-long bristles. As it has the d2 dwarfing gene, it grows to a height of 80 cm (Appa Rao *et al.*, 1986). 'IP 8288' has yellowish-green foliage that gradually turn light green after flowering owing to a single recessive gene (Appa Rao *et al.*, 1984). It is tall (232 cm) and has short (7 mm) bristles. In 'IP 8210' the nodes and auricles are purple, with a ring of dense long hairs on the top nodes. 'IP 8214' has green and glabrous nodes and auricles. 'IP 8056' has dense long hairs on its leaf blades and sheaths, but 'IP 8214' is glabrous. 'IP 8008' and 'IP 8214' have green nodes.

Crosses were made between genetic stocks with contrasting characters, taking advantage of protogyny (Burton, 1980) during the rainy season of 1983. The F₂s were advanced during the post-rainy

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season of 1983-84. During the rainy season of 1984, the F_2 plants were grown in boxes filled with sand. Seedlings at the age of 20 days were classified yellow or green and were transplanted in 2 groups. The frequency of purple and green plants, node colour and bristle length were recorded at anthesis. Chi-square test was used to test the data for goodness-of-fit. Linkage relationships were estimated based on joint segregation in F_2 and was calculated by the product method of Immer and Henderson (1943).

RESULTS AND DISCUSSION

Purple foliage

Purple pigmentation developed on all the plant parts in the F_1 , indicating its dominance over green plant colour. The F_2 plants segregated into purple and green in a 3:1 ratio (Table 1), showing a single-gene difference. In the F_3 all the green F_2 plants were homozygous recessive. Among the 10 purple F_2 plants tested, 4 bred true but 6 segregated for purple and green. No recombinants were observed between purple colouration of leaf sheaths, leaf blades, internodes, bristles and glumes, and the pigmentation of the 5 parts was inherited en bloc as a single unit, indicating the pleiotropic effect of the single gene. Gill (1969) reported that purple pigmentation is controlled by a single dominant gene, whereas Gill and Athwal (1970) and Minocha *et al.* (1980) reported that it is controlled by 2 complementary genes. The gene symbol PP is proposed for purple pigmentation in 'IP 8073'.

Purple nodes and auricles

Purple nodes and auricles were dominant to green, and the F_2 plants segregated into purple and green in a 3:1 ratio (Table 1), indicating a single-gene difference. In F_3 all the 5 plants with green nodes bred true. Of the 10 purple-noded F_2 plants tested, 3 bred true but 7 segregated. No recombinants for node and auricle colour were observed, indicating that pigmentation of nodes and auricles is governed by a single gene. Purple node colour is controlled by 2 dominant genes with comple-

entary interaction (Gill, 1969) or by a single dominant gene Rn (Koduru and Krishna Rao, 1979). Purple auricle colour is controlled by a single dominant gene (Singh *et al.*, 1967). Hence the gene controlling the colour of nodes and auricles in 'IP 8210' is different from those reported previously. The gene symbol Pna is proposed for the gene controlling purple nodes and auricles.

When 'IP 8008' and 'IP 8214' (both have green nodes) were crossed, the F_1 plants had purple nodes, whereas F_2 plants segregated into purple and green noded in a 9:7 ratio (Table 1), indicating complementary interaction for 2 genes. Gene symbols Pn₁ and Pn₂ are proposed for 'IP 8008' and 'IP 8214' respectively. Appa Rao *et al.* (1986) also observed similar results in dwarf plants. All the tall plants had purple nodes, whereas the dwarfs had green nodes. The internode length was more than the leaf-sheath length in tall plants, and hence the nodes were exposed to light resulting in the development of purple colour, but in the dwarfs these are covered by leaf sheaths.

Bristle length

Burton and Powell (1968) reported that a single gene is responsible for long bristles, but in our study the crosses between long- and short-bristled plants showed an intermediate bristle length in F_1 . In F_2 bristle length varied, indicating the action of more than 1 gene. The F_2 plants were classified into long- (like parent), intermediate- and short-bristled plants. The F_3 plants with short bristles bred true, but those with intermediate and long bristles segregated.

Hairs on leaves and nodes

Crosses between plants with hairy and non-hairy leaf blades and sheaths resulted in non-hairy leaf blades and sheaths in F_1 , indicating that hairiness is recessive. The F_2 plants segregated into non-hairy and hairy in a 3:1 ratio (Table 1), suggesting the action of a single recessive gene. It confirms the observations of Singh *et al.* (1967) and Krishna Rao and

Table 1. Inheritance of plant colour, node colour, and hairiness in pearl millet

| Character | Cross | F ₁ | F ₂ plants (No.) | | Ratio | χ ² | P value |
|----------------|-------------------|----------------|-----------------------------|-----|-------|----------------|---------|
| | | | a | b | | | |
| Foliage colour | Purple × green | Purple | 333 | 129 | 3 : 1 | 2.10 | 0.1-0.2 |
| Foliage colour | Green × yellow | Green | 361 | 101 | 3 : 1 | 2.43 | 0.1-0.2 |
| Node colour | Purple × green | Purple | 432 | 138 | 3 : 1 | 0.19 | 0.5-0.7 |
| Node colour | Green × green | Purple | 262 | 189 | 9 : 7 | 0.62 | 0.3-0.5 |
| Leaf hairs | Hairy × non-hairy | Non-hairy | 511 | 178 | 3 : 1 | 0.26 | 0.5-0.7 |
| Node hairs | Hairy × non-hairy | Hairy | 416 | 122 | 3 : 1 | 1.55 | 0.2-0.3 |

a, Frequency for dominant phenotype; b, frequency for recessive phenotype

Table 2. Joint segregation and linkage relationships of genes governing purple plant colour, yellow foliage and hairy leaves in pearl millet

| Cross* | F ₂ plants (No.)† | | | | χ ² (9 : 3 : 3 : 1) | P value | Recombination % and SE |
|-----------------|------------------------------|-----|-----|----|-----------------------------------|----------|------------------------------|
| | a | b | c | d | | | |
| PPYY × ppyy | 267 | 66 | 94 | 35 | 7.03 | 0.05-0.1 | 44.30 ± 3.26 |
| ppyy × PPYY | 493 | 172 | 141 | 53 | 3.45 | 0.3-0.5 | 44.95 ± 2.53 |
| PPHIHl × pphlhl | 470 | 148 | 138 | 46 | 2.19 | 0.5-0.7 | 49.20 ± 2.62 |
| pphlhl × PPHIHl | 624 | 217 | 185 | 66 | 2.87 | 0.3-0.5 | 49.64 ± 2.26 |

*PP, purple; yy, yellow; hlhl, long hairs

†No. of individuals carrying at least 1 dominant allele at both loci (A-B-) = a; at A locus (A-bb) = b; at B locus (aaB-) = c and double recessive (aabb) = d

Koduru (1979), but differs from that of Lal and Singh (1971). Hairy node was found to be monogenic dominant to glabrous node, confirming the observations of Krishna Rao and Koduru (1979).

Linkage

When purple plants were crossed with yellow plants, the F₁ plants were purple, and the F₂ plants segregated into purple, green and yellow in a 12 : 3 : 1 ratio (Table 2), indicating a modified dihybrid ratio. However, when the seedlings were classified into green and yellow and transplanted separately, yellow plants that developed purple colouration were assumed as a separate phenotypic class and a dihybrid ratio of 9 : 3 : 3 : 1 was

observed (Table 2). It showed an independent assortment of purple plant with yellow foliage. When purple plants with glabrous leaves ('IP 8073') were crossed with green hairy leaves ('IP 8056'), F₁ plants were purple non-hairy, and the joint segregation pattern in the F₂ generation corresponded to 9 : 3 : 3 : 1 ratio, showing independent assortment (Table 2).

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in an increased branch length for the treatment combination Black soil:Red soil = 1:3 and vermiculite.

The data suggest that for the growth of the two *Cicer* species in plastic pots the soil type and composition, within the described limits, are not so important, but by using white instead of black pots and white polypropylene granules on the soil surface, the branching and biomass

production are greatly increased and the yield can be doubled, probably through the protection of the rooting area against excessively high temperatures. These findings may possibly be applicable to places of comparable climate. It is possible that by increased effective protection a further improvement of plant growth can be achieved.

Biochemical evaluation of chickpea genotypes showing varied reactions to *Fusarium oxysporum ciceri*

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Three chickpea genotypes (WR-315, Pant G-114 and JG-62) were screened for resistance against *Fusarium oxysporum ciceri*, the causal agent of wilt by growing them in wilt sick plots and by the water culture technique wherein (Table 1) they gave resistant, tolerant and susceptible reactions, respectively. It was then desired to differentiate among these genotypes in terms of some biochemical parameters. The general observation that plants showing enhanced peroxidase activity and total phenol content after

inoculation with pathogenic microorganisms are resistant to the disease prompted us to determine the changes in these parameters in the three varieties during their life cycles.

Accordingly, the seeds of WR-315, Pant G-114 and JG-62 were sown in the field in November, 1983. Five healthy plants were taken from each of the three genotypes. The leaves of each plant were pooled together and analysed separately for total phenol content and peroxidase activity at various stages of

Table 1. Screening of chickpea genotypes against wilt resistance

| Genotype | Water culture technique | | | Sowing in wilt sick plots | | |
|------------|-------------------------|----|----|---------------------------|----|----|
| | Total number of plants | R | S | Total number of plants | R | S |
| WR-315 | 65 | 65 | 0 | 44 | 41 | 3 |
| Pant G-114 | 65 | 58 | 7 | 53 | 39 | 14 |
| JG-62 | 65 | 0 | 65 | 45 | 0 | 45 |

R = Resistant : S = Susceptible