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# ISOLATION OF DOWNY MILDEW RESISTANT LINES FROM A HIGHLY SUSCEPTIBLE CULTIVAR OF PEARL MILLET

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**Abstract** : Inbred progenies with high levels of downy mildew (DM)-resistance were developed from a highly DM-susceptible pearl millet landrace cultivar 7042 (IP-2696) by pedigree selection for five generations. Extensive variability for plant height, tillering, leaf and earhead type, anther colour and rust resistance was also observed between the progenies. Six of the 18 most DM-resistant progenies were phenotypically similar to the original 7042. The results suggest the possibility of utilizing hidden residual variability for resistance to renovate commercially useful but DM-susceptible cultivars which would otherwise be discarded because of their susceptibility.

**Keywords** : Downy mildew, *Sclerospora graminicola*, Pearl millet resistance

Downy mildew (DM) caused by *Sclerospora graminicola* (Sacc.) Schroet., is the most important disease of pearl millet (*Pennisetum americanum* (L.) Leeke) in India and Africa. In 1971, the disease appeared in an epiphytotic form in the Indian sub-continent resulting in the withdrawal of the most popular high yielding hybrid HB-3 (23 $D_2$ A × J-104) which had contributed to a record harvest of 8 million tonnes of grain in 1970 (Anonymous, 1971; Murty, 1974; Safeeulla, 1977). HB-3 was replaced by BJ-104 (5141A × J-104), a hybrid with the same male parent but a more DM-resistant seed parent. BJ-104 is now showing an increased level of susceptibility in farmers fields and recorded a mean incidence of 21.3 per cent (range of 0 to 82 per cent) over 14 locations in the All India Coordinated Millet Improvement Program Pathology trials for 1983, compared to an average of 10.6 per cent (range 8 to 15 per cent) for 1977 to 1983 (Anonymous, 1977-83). As a consequence, it is not being recommended for cultivation beyond 1984 by the All India Coordinated Millet Improvement Project (AICMIP) (G. Harinarayana, personal communication). Tests of the two parent lines of this hybrid under heavy inoculum pressure in the ICRISAT downy mildew nursery indicate that both are presently showing levels of susceptibility equal to the standard susceptible lines 7042 and NHB-3 (Table 1). Intensive efforts are underway to identify newer sources of DM resistance and incorporate these into agronomically elite genotypes. Though there is no dearth of DM resistance sources (Safeeulla, 1976; Williams *et al.*, 1982; Singh *et al.*, unpublished), these sources as such lack agronomic eliteness, and transferring such resistance into elite genotypes requires a long period. It could be highly advantageous if there were more rapid ways of raising resistance levels to extend the useful life of leading

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cultivars. In cross-pollinated crops, particularly pearl millet, residual variability often exists even in apparently phenotypically uniform inbreds.

This paper presents evidence to show that it is possible to greatly reduce DM susceptibility of pearl millet cultivars by a pedigree selection process in a relatively short period.

## MATERIALS AND METHODS

### Test cultivar

Cultivar 7042 (IP-2696), a dwarf landrace cultivar from Chad that flowers between 30 and 35 days, and develops more than 90 per cent DM at ICRISAT in breeders fields without assistance from infector-rows was chosen. It grows 100-125 cm tall, has broad succulent leaves and short compact earheads with bold, pearly white grain.

### Screening procedure

The DM infector-row system (Williams *et al.*, 1981), modified by spacing infector-rows at every ninth row instead of every fifth was used. Cultivar 7042 or NHB-3, both highly DM-susceptible, were planted as an indicator of DM pressure after every 10 test rows. Rows were 75 cm apart and plants within rows were spaced at 5-10 cm. Plot size varied depending upon the seed availability.

DM incidence records were taken twice in S1 and S2 and thrice in S3, S4 and S5 progenies. The first and second records were taken between 15 and 30, 45 and 57, and third between 72 and 83 days after planting (DAP).

### Progeny advancement and selection

Bulk seed of cultivar 7042 was planted in forty, 4-m rows in the DM nursery in 1979 rainy-season. Of the 2064 plants grown, 97 per cent developed DM and 20 DM-free plants that closely resembled 7042, were selfed and their seeds harvested separately. The resultant progenies grown head-to-row, were tested in the DM nursery and the resistant plants were advanced by selfing for five generations (S1 to S5). Major selection criteria were DM resistance and trueness to types normal in the parent variety. Seeds were collected from only DM-free plants. Details regarding the number of progenies selected and evaluated for their DM reactions in each generation are shown in Fig. 1.

### Measurement of other characters

Detailed data of rust (*Puccinia penniseti* Zimm.), plant height and tillering were recorded in the S5 generation. Rust was dependent on natural infection and reaction was assessed using Cobb's modified scale (Melchers and Parker, 1922). For plant height, progenies were classified into four visually distinct groups; five progenies per group were randomly selected and heights of 20 random plants per progeny were measured. Tillering ability was measured on the basis of 20 random plants per progeny. Visual records on leaf and earhead type and anther colour were also made.

## RESULTS

### Variability for DM

A large variation for DM-resistance was observed in the progenies among and between generations (Fig. 1). DM incidence in 20 S1's (grown from seed from DM-free plants) ranged from 0 to 100 per cent. The reactions of the progenies derived and advanced (up to S5) from 10 of these S1's were not consistent from one generation to the next. None of the progenies advanced from three S1's (7042-5, 7042-7 and 7042-15) showed improved DM resistance; and the DM resistance in the progenies from five S1's (7042-9, 7042-12, 7042-13, 7042-14 and 7042-18) were inconsistent across generations (S2-S5). However, high levels of DM resistance were stabilized (<10 per cent). DM incidence in S3, S4 and S5 generations in 18 progenies advanced from two S1's (7042-3, 7042-11) (Table 2). Six of the progenies (entries 1 and 6 to 10) resembled the original 7042, while others segregated for plant height.

### Variability for other characters

*Rust* : Of the 148 progenies evaluated, 16 did not develop rust, 66 had 5-10 per cent rust, and the rest had 25-40 per cent, in contrast to 65-100 per cent rust on the rust susceptible checks.

### Tillering

Only 122 progenies were evaluated for tillering. Tiller number ranged from 3-7, but most progenies had 4-5 tillers/plant.

### Plant height

The S5 progenies showed considerable variability for plant height (35 to 198 cm) and were classified into four height-groups. The means (and ranges for plants within progenies) for heights, and the number of progenies falling in each of the four height-groups were: (a) 56 cm (35-80 cm), 12; (b) 80 cm (58-100 cm), 26; and (c) 122 cm (82-158

TABLE 1 : Downy mildew reactions of 5141A, J-104, NHB-3 and 7042 from 1981-83 rainy season in the DM-nursery at the ICRISAT Centre

| Cultivars | Per cent downy mildew incidence | | | | | |
|---|---|---|---|---|---|---|
| | 1981 | | 1982 | | 1983 | |
| 5141A | 2.4 (723) | ± 0.6* | 69.6 (1060) | ± 1.4* | 94.5 (110) | ± 2.2* |
| J-104 | 24.7 (178) | ± 3.2 | 86.6 (455) | ± 1.6* | 98.0 (41) | ± 2.4 |
| 7042 | 77.8 (27) | ± 7.9 | 87.4 (246) | ± 2.1 | 81.6 (71) | ± 5.6 |
| NHB-3 | 89.0 (667) | ± 1.2 | 88.0 (1165) | ± 1.0 | 91.0 (893) | ± 1.0 |

Figures in parentheses are total number of plants.
*S. E.—Standard Error

TABLE 2 : Downy mildew incidence in the 18 best performing 7042 progenies and check during 1979-1982 rainy and post-rainy seasons

| Entry no. | Pedigree | Downy mildew incidence (per cent) | | | | |
|---|---|---|---|---|---|---|
| | | S1 | S2 | S3 | S4 | S5 |
| 1. | 7042-3-1-2-2-1 | 46 | 10 | 6 | 1 | 0 |
| 2. | 7042-3-1-2-2-2 | 46 | 10 | 6 | 1 | 0 |
| 3. | 7042-3-1-2-6-1 | 46 | 10 | 6 | 0 | 4 |
| 4. | 7042-3-1-2-6-2 | 46 | 10 | 6 | 0 | 0 |
| 5. | 7042-3-1-2-6-3 | 46 | 10 | 6 | 0 | 1 |
| 6. | 7042-11-1-2-2-1 | 33 | 38 | 9 | 9 | 5 |
| 7. | 7042-11-1-2-2-3 | 33 | 38 | 9 | 9 | 9 |
| 8. | 7042-11-1-2-13-1 | 33 | 38 | 9 | 8 | 4 |
| 9. | 7042-11-1-2-13-2 | 33 | 38 | 9 | 8 | 1 |
| 10. | 7042-11-1-2-13-3 | 33 | 38 | 9 | 8 | 1 |
| 11. | 7042-11-1-2-13-4 | 33 | 38 | 9 | 8 | 0 |
| 12. | 7042-11-1-2-13-5 | 33 | 38 | 9 | 8 | 7 |
| 13. | 7042-11-1-2-13-6 | 33 | 38 | 9 | 8 | 5 |
| 14. | 7042-11-1-12-4-1 | 33 | 38 | 8 | 0 | 0 |
| 15. | 7042-11-1-12-4-2 | 33 | 38 | 8 | 0 | 0 |
| 16. | 7042-11-1-12-4-3 | 33 | 38 | 8 | 0 | 0 |
| 17. | 7042-11-1-12-4-4 | 33 | 38 | 8 | 0 | 0 |
| 18. | 7042-11-1-12-4-5 | 33 | 38 | 8 | 0 | 5 |
| | Susceptible check* | 62 (55-78) | 37 (29-49) | 53 (46-65) | 84 (75-90) | 72 (67-86) |

*Mean of all indicator-rows (figures in parentheses are ranges).

cm), 98; and (d) 154 cm (120-198 cm), 12. Thus the majority of the progenies were in the height range of the original population which averaged 122 cm.

### Leaves, earheads and pollen colour

Leaves were generally broad, thick and succulent, but plants with narrow, pointed, upright leaves were also produced. Tillers in most of the progenies (93 per cent) flowered synchronously. Earheads were of 7042 type in 50 per cent of the progenies while tapering earheads with sterile tips were the most common in the remainder. Anther colour varied from violet to brown to yellow.

## DISCUSSION

The results show that if a useful cultivar, which is not a total inbred, develops or is found to contain increased DM susceptibility, then quite possibly it can be renovated by reselection of residual resistance using stringent selection under the high pressure of a disease nursery. However, the success of this operation depends mainly upon two factors: (a) there must be adequate residual variability for DM resistance in the cultivar, this should not be uncommon because neither 100 per cent resistance nor susceptibility are usual, and (b) the existence of an effective and reliable screening technique that

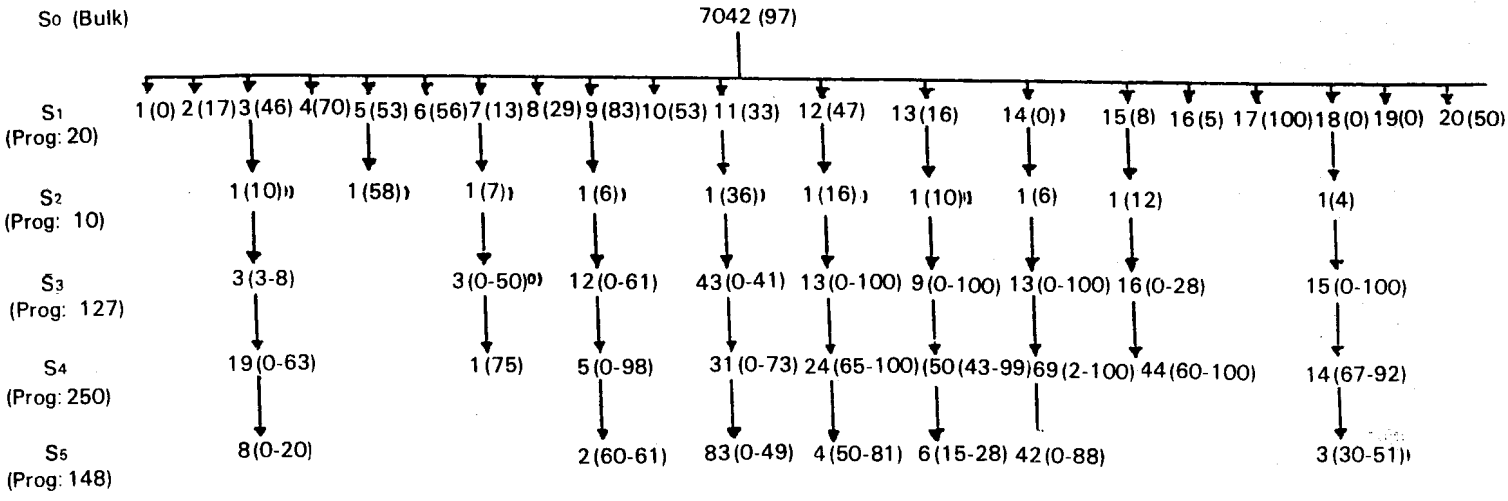


Fig. 1 : Details of progenies evaluated and their downy mildew reactions in five generations in DM-nursery.
(Figures in parentheses are percent downy mildew incidence values.)

minimizes escapes. With the availaibility of these two, it then becomes a matter of detecting the variability which in pearl millet, being highly cross-pollinated, exists as a rule. This is exemplified in the present work where variability not only for DM resistance but also for several plant characters and even for resistance to another disease (rust) was observed.

For resistance developed in this way to remain effective at many locations, it is advisable that the selection for resistance is done at the location where the greatest degree of virulence is known to occur. Support for this concept comes from our multilocational testing program in which it was discovered that the DM resistance which is effective in Northern Nigeria (where the pathogen is the most aggressive) remained effective at the majority of the locations but not vice-versa (Singh *et al.*, 1982).

The development of a DM-resistant cultivar (or disease resistant cultivars, in general) through normal breeding course requires a long period and involves necessarily three steps: (a) identification of stable disease resistance sources; (b) transfer of the identified resistance into agronomically acceptable genotypes; and (c) multilocational tests for yield, adaptability and resistance. By this route, many years are required before a disease-resistant cultivar is released for cultivation to farmers. If a useful pearl millet cultivar is put out of cultivation only because of its DM susceptibility, then the approach found useful here will be valuable. The only problem one may face following this approach is the possible loss of some useful traits, particularly when the residual variability for DM resistance is low. However, there will be little shift in the variety/population characteristics provided large enough numbers are screened (depending on the degree of inbreeding) and sufficient number of resistant plants identified.

The concept demonstrated by the work on cultivar 7042 can be extended in other ways. If a new or introduced variety is found to be high yielding but susceptible to downy mildew, its potential may still be realised by reconstructing a DM-resistant version. The basic breeding behaviour of pearl millet would also permit the application of this process to reduce susceptibility to other diseases, provided a powerful screening technique is available and resistance is sufficiently heritable.

The necessity to partially inbreed to isolate DM resistance also provides an opportunity to capitalize on variability for any other useful recessive traits which may be concurrently exposed. Utilization of many DM-resistant selections of cultivar 7042 in several of our breeding projects to produce synthetics (in several height groups) for low rainfall zones, to induce dwarfness, earliness and large seeded characters, and also to study the inheritance of DM resistance, are examples of the usefulness of this work. The results particularly show that the conventional resistance breeding approaches such as mutation and use of new resistance from "unadapted" germplasm sources, which are always associated with their own disadvantages—are not always required in relation to DM resistance in pearl millet. In the present case, 7042 was a landrace cultivar, but the approach is giving encouraging results in parental lines of particular value of pearl millet (Singh, unpublished) which have proved to be not true inbreds.

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