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Resistance to downy mildew (*Sclerospora graminicola*) in forage pearl millet (*Pennisetum glaucum*)

C R RAMESH[1] and D H SUKANYA[3]

Regional Research Station, Indian Grassland and Fodder Research Institute, Dharwad, Karnataka 580 008

and

R P THAKUR[2] and *V P RAO*[4]

International Crop Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh 502 324

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ABSTRACT

Eleven forage composites and their parents were evaluated during 2001 against 6 diverse pathotypes of *Sclerospora graminicola* (Sacc.) Shroet. (3 from Patancheru, and 1 each from Mysore, Jalna and Jodhpur) at the International Crop Research Institute for Semi Arid Tropics, Patancheru, and the Indian Grassland and Fodder Research Institute, Dharwad, in greenhouse conditions, and also in field nursery, using infector row system at Patancheru. Three genotypes ('DRSB 3', 'DRSB 7' and 'IP 14305') of pearl millet [*Pennisetum glaucum* (L.) R. Br. emend. Stuntz] were resistant with < 5% mean downy mildew incidence. Seven genotypes, ('DRSB 6', 'DRSB 7', 'DRSB 10', 'Giant Bajra', 'IP 9294', 'IP 14188' and 'IP 14305') had < 10% downy mildew incidence at Dharwad. Average linkage cluster analysis using Euclidian distances of mean downy mildew incidence across the pathotypes from both locations broadly classified the 17 genotypes into 3 groups — resistant, moderately resistant and susceptible.

Keywords: Crop protection, Pearl millet fodder, *Pennisetum glaucum*, Downy mildew, *Sclerospora graminicola*, Resistance

Pearl millet [*Pennisetum glaucum* (L.) R.Br. emend. Stuntz] is grown in drier tracts, marginal lands, low fertile soils, where it is preferred over maize (*Zea mays* L.) and sorghum [*Sorghum bicolor* (L.) Moench]. In India, it is widely grown as a fodder crop in around 0.9 million ha (Hazra *et al.* 1998). It is excellent forage with high fat, albuminoides, protein, calcium, phosphorus and mineral content (Gupta *et al.* 1980). There have been several attempts in India to identify agronomic potential of pearl millet for forage production. One such attempt at the Regional Research Station, IGFRI, Dharwad, developed 11 composites through selections in inbreds and half-sib segregating populations. Many of these were superior to national and state checks, viz 'UUJ IV M' and 'DFB 1', respectively, for forage yield and associated attributes.

Though pearl millet is a very hardy crop, it suffers from biotic stresses, of which downy mildew, caused by *Sclerospora graminicola* (Sacc.) Shroet, is the most destructive and widespread, causing 10–70% losses in grain yield (Singh *et al.* 1993). The disease at vegetative stage affects the green fodder yield and quality, and its appearance at dough-stage affects fodder seed production, which is very important in annual crops established by seeds. In India, downy mildew epidemics in pearl millet have been frequent resulting in heavy losses to single-cross hybrids compared to open-pollinated varieties (Singh *et al.* 1993). Currently, developing high-yielding cultivars have been based on utilization of resistance in breeding (Andrews *et al.* 1985). Pathogenic and genetic variability exists in *S. graminicola* that result in breakdown of resistance (Sasrty *et al.* 1995, Thakur *et al.* 1999). Hence realizing the importance of the disease, some of the recently developed fodder pearl millet composites and their parental lines were evaluated for resistance against diverse pathotypes of *S. graminicola*. The greenhouse and field screenings were taken up at the International Crop Research Institute for Semi-Arid Tropics, Patancheru, and the Regional Research Station, Indian Grassland and Fodder Research Institute, Dharwad.

MATERIALS AND METHODS

Eleven fodder pearl millet composites ('DRSB 1' to 'DRSB 11') developed during 1996–99 at the Regional Research Station of the Indian Grassland and Fodder Research Institute (IGFRI), Dharwad, and their parents from diverse origin

[1]Principal Scientist and OIC, [3]Senior Scientist,Regional Research Station, Indian Grassland and Fodder Research Institute, Dharwad, Karnataka 580 008; [2]Senior Scientist, [4]Senior Scientific Officer, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh 502 324

['IP 9294' (Togo), 'IP 5549' (Niger), ' IP 14188' and 'IP 14305' (Cameroon), ' IP 17395' Central African Republic) and 'Giant Bajra' (India)] were the material for the study. Composites were derived from selection in inbreds and half-sib segregating populations. All these composites are early flowering (50–55 days to bloom), with early vigour, medium height, high tillering potential and synchrony, good leaf : stem ratio, high green and dry-matter yield, good crude protein (up to 9.7%) and palatability (up to 77%) (Sukanya *et al.* 2003).

Greenhouse evaluation

At the ICRISAT, Patancheru, 3 pathotypes of *S. graminicola*, Sg 153 from Patancheru, Sg 150 from Jalna, and Sg 139 from Jodhpur, maintained on pearl millet cultivars '7042 S', 'MBH 110' and 'Nokha Local', respectively, were used. These isolates were maintained on the respective host cultivars in separate chambers at the ICRISAT, Patancheru, and were purified through asexual sporangia through several generations on the respective hosts (Thakur *et al.* 2001).

At RRS, IGFRI, Dharwad, 5 pathotypes viz Sg 008, Sg 013 and Sg 153 from Patancheru; Sg 048 from Mysore and Sg 150 from Jalna, maintained on 'NHB 3', '7042 S', '843 B', '852 B' and '834 B', respectively, at the ICRISAT, Patancheru, were used in 2001.

Seeds of 11 composites, 6 parents and 3 susceptible controls (Table 2) were surface-sterilized with 1% chlorine (NaOCl) for 5 min, washed thoroughly with sterilized distilled water, dried at room temperature (approximately 25°C) prior to sowing. The experiment was conducted in greenhouse at the ICRISAT, Patancheru, during July–August 2000, in randomized complete-block design with 2 replications of 2 pots/replication with 35–40 seedlings each.

Infected leaves of pearl millet cultivars were sporulated for 6 hr in humid chambers at 20° C (Singh *et al.* 1993). Sporangia were collected in ice-cold water and sporangial suspension was filtered through 2-layered muslin cloth. The inoculum concentration was adjusted to 1×10^5 (10 000) sporangia per mili-litre. This inoculum was sprayed at the 2-leaf stage, incubated at 20° C for 24 hr. The inoculated seedlings of the genotypes were transferred to 25° C in a greenhouse, and maintained for 14 days and after 14 days disease incidence was calculated.

Field evaluation

Field screening was done at the ICRISAT, Patancheru. Twenty cultivars (11 forage composites, 6 parents and 3 susceptible controls) were planted in randomized complete-block design with 2 replications in downy mildew nursery. Screening was done using infector row system (Singh *et al.* 1993) during the rainy season 2000. Each entry was in 2 rows of 4 m long in each replication with 40 seedlings/row. Total and diseased plants were counted at pre-tillering (30 days after seedling emergence) and at soft-dough stages.

Statistical analysis

Percentage disease incidence data were arc-sin transformed before subjecting to analysis of variance (ANOVA) using GENSTAT statistical package. Since there was increase in the number of diseased plant at soft-dough stage in the field evaluation at the ICRISAT, Patancheru, data from soft-dough stage were considered for estimating the disease incidence. And since the analysis on both scales was similar, the mean incidence data were presented on the original scale. Least square differences were computed for comparing pathotypes, host genotypes and their interaction means for downy mildew incidence. Downy mildew incidence data sets from both field and greenhouse of both Patancheru and Dharwad were subjected to an average linkage cluster analysis using Euclidian distance measures of mean downy mildew incidence to classify the fodder lines into resistant and susceptible groups and hierarchical dendrogram of downy mildew incidence was made using Sigma Plot 2001 (Statistical solutions, 8 South Bank, Crosse's Green, Cork, Ireland).

RESULTS AND DISCUSSION

Greenhouse evaluation

At the ICRISAT, Patancheru, the mean downy mildew incidence ranged from 3% on 'DRSB 7' to 22% on 'DRSB 9' compared to 96% on a susceptible control ' 7042 S' across the 3 pathotypes. The mean downy mildew incidence ranged from 6 to 44% for Patancheru pathotype (Sg 153), 3 to 24% for

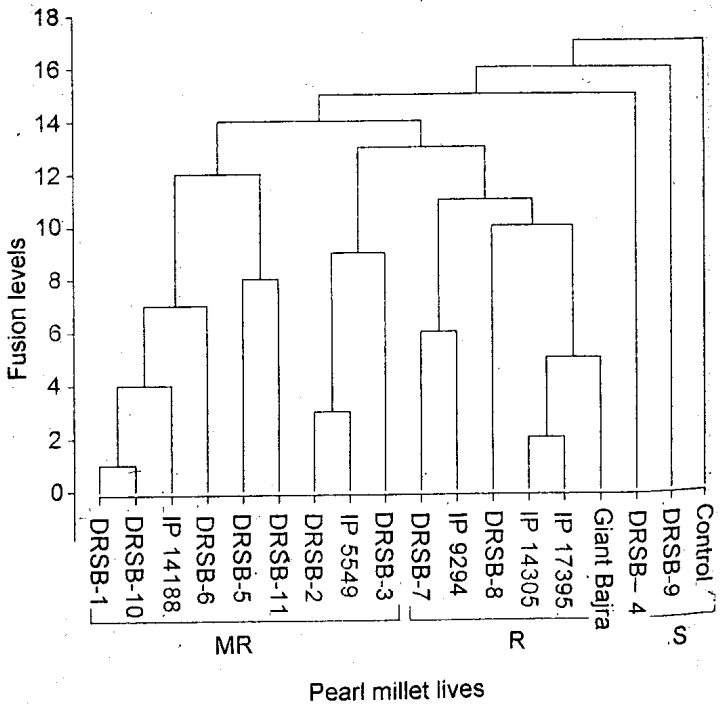

Fig 1 Classification of 17 fodder pearl millet lines based on average linkage cluster analysis using Euclidian distances of similarity measures of mean downy mildew incidence (%) across diverse pathotypes of *S. graminicola* into 3 groups: R, Resistant; MR, moderatily resistant; S, susceptible

Table 1 Downy mildew incidence of 11 composites and their parents of forage pearl millet caused by 3 pathotypes of *Sclerospora graminicola*, greenhouse and field conditions, during 2000 at the ICRISAT, Patancheru and the IGFRI, Dharwad

Identity	Downy mildew incidence (%)[a]											
	Greenhouse								Field[b]	Mean		
	Patancheru (Sg 153)		Jalna (Sg 150)		Jodhpur (Sg 139)	Patancheru (Sg 008)	Patancheru (Sg 013)	Mysore (Sg 048)		Green house	Greenhouse + field	Green house
	ICRISAT	IGFRI	ICRISAT	IGFRI	ICRISAT	IGFRI	IGFRI	IGFRI	ICRISAT	ICRISAT	ICRISAT	IGFRI
'DRSB 1'	17 (24)[c]	16	7 (15)	9	19 (26)	7	15	13	17 (24)	14 (22)	15	12
'DRSB 2'	14 (22)	8	5 (13)	11	12 (20)	17	13	23	11 (19)	10 (18)	10	14
'DRSB 3'	13 (21)	11	0 (0)	3	6 (14)	21	11	23	1 (3)	6 (12)	5	14
'DRSB 4'	11 (20)	9	4 (11)	4	16 (23)	12	44	26	19 (26)	10 (18)	13	19
'DRSB 5'	23 (28)	24	6 (14)	9	23 (29)	16	12	17	10 (18)	17 (24)	15	16
'DRSB 6'	26 (31)	12	0 (0)	0	13 (21)	13	9	15	17 (24)	13 (17)	14	10
'DRSB 7'	6 (14)	16	0 (0)	0	3 (10)	4	16	13	6 (14)	3 (8)	4	10
'DRSB 8'	7 (15)	24	11 (20)	11	12 (20)	12	12	11	0 (0)	10 (18)	8	14
'DRSB 9'	44 (42)	17	6 (14)	8	16 (23)	12	24	44	19 (26)	22 (26)	21	21
'DRSB 10'	12 (20)	12	4 (11)	7	24 (29)	6	13	12	16 (22)	13 (20)	14	10
'DRSB 11'	25 (30)	21	6 (14)	6	17 (25)	9	24	9	18 (24)	16 (23)	17	14
'IP 9294'	6 (14)	7	8 (16)	4	12 (20)	8	23	9	11 (19)	9 (17)	9	10
'IP 5549'	22 (28)	8	7 (15)	6	21 (27)	13	17	21	9 (17)	16 (23)	15	13
'IP 14188'	17 (25)	6	6 (14)	0	24 (29)	8	9	9	16 (23)	16 (23)	16	6
'IP 14305'	8 (16)	9	0 (0)	8	8 (16)	11	8	9	1 (6)	5 (11)	4	9
'IP 17395'	7 (16)	9	9 (17)	9	10 (19)	13	12	10	5 (12)	9 (17)	8	11
'Giant Bajra'	21 (27)	12	11 (20)	6	9 (18)	8	7	8	5 (12)	14 (22)	12	8
Controls												96
'IP 18292'	0 (0)		0 (0)		57(49)				0 (0)	19 (16)	14	
'834 B'	10 (18)		84 (67)		11 (19)				6 (14)	35 (35)	28	
'7042 S'	97 (83)	92	92 (74)		100 (90)		97		96 (75)	96 (82)	96	
'MBH 110'				94								
'NHB 3'						95						
'852 B'								100				
Mean	18 (23)		13 (17)		21 (26)				14 (19)	18 (23)		
LSD ($P < 0.05$)									11.7 (10)			

ICRISAT, [a]Mean of 2 replications, 2 pots/replication, 30–40 seedlings/pot. LSD (< 0.05) for pathotype × host genotype means = 5.5(5.3) ;CV (%) =15.7 for greenhouse experiment, [b]data from soft-dough stage from downy mildew nursery; [c]arc-sin values.Field: ICRISAT Patancheru field population of the pathogen (sick plot)

IGFRI, LSD ($P < 0.05$) for pathotype × host genotype means : 3.17 (CV (%) = 13.3

Jodhpur pathotype (Sg139) and 0 to 11% for Jalna pathotype (Sg 150). Four genotypes, 'DRSB 3', 'DRSB 6', 'DRSB 7' and 'IP 14305', were downy mildew free from Jalna pathotype. No genotype was found downy mildew-free to Patancheru and Jodhpur pathotypes. Three genotypes 'DRSB 7', 'IP 14305' and 'IP 17395' were found resistant to all 3 pathotypes with ≤10% incidence (Table 1).

Field evaluation

In field evaluation only 'DRSB 8' was downy mildew free, whereas this genotype had 10% mean downy mildew incidence across the 3 pathotypes under greenhouse conditions. Three genotypes ('DRSB 7', 'IP 14305' and 'IP 17395') showed < 10% incidence, which confirmed the greenhouse results. Mean downy mildew incidence across the greenhouse and field evaluations indicated that 3 genotypes, 'DRSB 3', 'DRSB 7' and 'IP 14305' showed < 5% incidence compared to 96% incidence on a susceptible control, '7042 S' (Table 1).

At RRS, IGFRI, Dharwad, no genotype was found free from downy mildew across the 5 pathotypes. Seven genotypes, 'DRSB 6', 'DRSB 7', 'DRSB 10', 'Giant Bajra', 'IP 9294', 'IP 14188' and 'IP 14305' had 6 to 10% incidence compared to 96% on the control across pathotypes (Table 1). Three genotypes, 'DRSB 6', 'DRSB 7' and 'IP 14188', were downy mildew free to Jalna pathotype. One genotype, 'IP 14188' had <10% incidence across the pathotypes.

Hierarchical cluster analysis classified the 17 genotypes into 3 groups — resistant (R) group included 'DRSB 7', 'DRSB 8', 'IP 9294', 'IP 14305', 'IP 17395' and 'Giant Bajra'; moderately resistant group consisted of 'DRSB 1', 'DRSB 2', 'DRSB 3', 'DRSB 5', 'DRSB 6', 'DRSB 10', 'DRSB 11', 'IP 5549' and 'IP 14188'; and susceptible group included 'DRSB 4' and 'DRSB 9' along with a susceptible control (Fig 1).

The study identified the parental lines 'IP 14305' as resistant with 7% mean incidence across all 5 pathotypes, followed by 'IP 17395', 'IP 9294' with <10% mean incidence indicating that these would be more stable sources of resistance for fodder pearl millet in India. Among the fodder composites, all were resistant to Jalna pathotype. However, the differential response of the genotypes across different pathotypes revealed that these composites based on their resistance for single, or multiple pathotypes can be identified for cultivation in different parts of the country where these pathotypes pose problems as it is difficult to develop composites with resistance across all pathotypes. Based on these criteria composites 'DRSB 6' resistant to Patancheru (Sg 013) and Jalna (Sg 150) pathotypes, 'DRSB 7' and 'DRSB 10' resistant to Patancheru (Sg 008) and Jalna (Sg 150) pathotypes at Dharwad; 'DRSB 3' and 'DRSB 7' resistant to Jodhpur (Sg 139) and Jalna (Sg 150) pathotypes at ICRISAT, Patancheru, can be recommended to farmers who require dual-purpose pearl millet, especially in Rajasthan, Karnataka, Andhra Pradesh and Maharashtra.

Since these fodder composites are early with high yield, quality and resistance to downy mildew, growing of such fodder types resistant to particular isolate of a location would not pose any problem in either spread or enhancing population levels of the isolate designated for that region. Also results form a good basis for future research in developing good fodder pearl millet genotypes with different resistance genes and their strategic utilization in breeding programmes. Besides, the present study also has addressed the issue of fodder pearl millet grown should not become threat for pearl millet crop for grain.

REFERENCES

Andrews D J, King S B, Witcombe J R, Singh S D, Rai K N, Thakur R P, Tadulkar B S, Chavan S B, and Singh P. 1985. Breeding for disease resistance and yield in pearl millet. *Field Crops Research* **11** : 241–58.

Gupta V P and Minocha J L. 1980. Genetics of quality improvement. (*in*) *Proceedings on Trends in Genetical Research on Pennisetums*, Indian Council of Agricultural Research, New Delhi , pp 91–7.

Hazra C R and Shukla G P. 1998. Recent research advancement in forage pearl millet improvement program. *Forage Research* **24** (3) : 147–51.

Sastry J G, Ramakrishna W, Sivaramakrishnan S, Thakur R P, Gupta V S and Ranjekar P K . 1995. DNA fingerprinting detects genetic variability in the pearl millet downy mildew pathogen (*Sclerospora graminicola*). *Theoretical and Applied Genetics* **91** : 856–61.

Singh S D, King S B and Werder J. 1993. Downy mildew disease of pearl millet. *Information Bulletin 37, International Crops Research Institute for the Semi Arid Tropics, Patancheru*, pp 36.

Sukanya D H, Ramesh C R and Hosmani S V. 2003. Development of populations with improved fodder potential in pearl millet. *International Sorghum and Millets Newsletter* (in press).

Thakur R P, Rao V P, Sastry J G, Sivaramakrishnan S, Amruthesh K N and Barbind L D. 1999. Evidence for a New Virulent Pathotype of *Sclerospora graminicola* on pearl Millet. *Journal of Mycology and Plant Pathology* **29**(1) : 61–9.

Thakur R P, Rai K N, Rao V P and Rao A S. 2001. Genetic resistance of pearl millet male-sterile lines to diverse Indian pathotypes of *Sclerospora graminicola*. *Plant Disease* **85** : 621–6.