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STABILITY OF HOST PLANT RESISTANCE TO SORGHUM CHARCOAL ROT

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ABSTRACT : Twentynine entries including elite hybrids, varieties, parents and resistant stocks were evaluated for charcoal rot resistance over four environments covering *rabi* and *kharif* seasons. The artificial epiphytotic condition was created by tooth-pick method. There was no host immunity to disease. However, inspite of significant genotype × environment interactions, the varietal differences persisted. SPV-34, CSH 9 and 36B among the improved lines developed in AICSIP and 6 39, 8-55 and SC 120-14 among the basic stocks were highly resistant. CSH-9, 36B and 6-39 were average while 8-55 and SC 120-14 were above average in stability of disease resistance. The seasonal change in host plant resistance of some of the varieties appears due to their photoperiodic sensitivity.

Keywords : Stability of host resistance, Sorghum charcoal rot, Macrophomina phaseolina

The knowledge of genotype × environment interaction is of considerable importance for the polygenic characters of the host plant. Resistance to charcoal rot, *Macrophomina phaseolina* (Tassi.) Goid., is also a polygenic character with low heritability (Rana *et al.*, 1982). Yield stability is extensively studied in sorghum (Rao *et al.*, 1982 ; Barah *et al.*, 1981) and other crops but the concept of stability of resistance is of recent origin. Singh *et al.* (1978) established the group differences for stability of resistance to shoot fly in sorghum and such differences are expected for diseases also. The stability of host plant resistance to charcoal rot over different environment is thus examined in the present studies.

MATERIALS AND METHODS : A multilocation screening trial with 29 varieties/hybrids was planted during *kharif* and *rabi*, 1978 at IARI-Regional Station, Hyderabad and Sorghum Research Station, Parbhani and at UAS Regional Station, Dharwar during *kharif*, 1979. These trials were planted in a randomized block design with two replications. The entries included 5 popular hybrids (CSH-1, CSH-5, CSH-6, CSH-8R and CSH-9), 5 maintainers (36B, 296B, 2077B, 2219B and 2947B), 1 restorer parent (CSV-4), 2 improved *rabi* varieties (CSV-7R and CSV-8R), 7 promising experimental varieties (SPV Nos. 34, 35, 80, 81, 104, 126 and 232), 4 basic resistant stocks from Karper Nursery, USA (6-39, 8-55, 25-98 and SC 120-14), 3 resistant stocks for other diseases (QL 3, IS 3687 and IS 12573), 2 local checks (*Aispuri* and M 35-1). Each plot represented 3 meter long rows planted at 60 cm apart. A uniform fertilizer dose of 80 kg N + 40 kg P_2O_5 was given at all the locations.

The artificial inoculation method described for corn by Young (1943) was modified for the present studies. Sorghum stems affected with charcoal rot disease were collected from the fields and the culture was prepared by growing the fungus on

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potato-dextrose agar medium. Subsequently, the pathogen was cultured on tooth-picks in honey-peptone (honey 5 ml, peptone 1 g and distilled water 94 ml) for artificial inoculation of the plants.

The tooth-picks were arranged in screw-cap bottles keeping the pointed ends up and after washing in distilled water, the bottles with tooth-picks were sterilized for 20 minutes at 15 lb pressure. The bottles were removed and the previously mixed inoculum and honey-peptone medium was poured on to the tooth-picks in aseptic conditions and kept at 35°C for 7 days. The cultured tooth-picks were ready for field inoculations. Ten days after flowering, third basal node of twenty plants in each row was inoculated by tooth-picks. At maturity, data on disease resistance parameters such as number of internodes crossed by disease, per cent infection and susceptibility index were recorded. The per cent infection was determined as the percentage of the disease spread in the stem to the total height of the plant. The susceptibility index was calculated as square root of per cent infection × disease intensity. Disease intensity was scored at 0 (resistant) to 5 (susceptible) scale. Three plant characters e.g., plant height (cm), number of nodes and grain yield/plant (g) were also recorded.

The stability analysis was done following Eberhart and Russell (1966).

RESULTS : The ANOVA for stability is presented in Table 1. There were significant differences noted due to environments. The incidence was maximum at Dharwar and Parbhani during *kharif* season. The differences among varieties and variety × enviroment interactions were also significant for per cent infection, susceptibility index, grain yield, plant height and number of nodes. It revealed that varietal interaction with environments was different for the level of resistance as well as for yield components.

Environmental (linear) component was significant indicating the additivity of environmental effects which was represented by mean deviations of respective characters over locations. Linear component of variety × environment interaction was significant for all the characters except number of nodes crossed by disease when tested against the pooled deviations as well as against the pooled error. Hence, varietal response to environment can be predicted. The deviations from the predicted values were not significant for resistance parameters as well as for grain yield.

The stability parameters are presented in Table 2. SPV–34, SPV–232, M 35–1 and SC 120–14 were absolutely stable for number of nodes crossed by disease as indicated by low value of regression coefficients, significantly not different from zero. The per cent infection varied from 3.6 to 15.9 and none of the varieties were absolutely resistant at all the locations. The infected stem length was low (<.6 per cent) in SPV–34, 6–39, SC 120–14, CSH–9, 36B, 2219B, CSV–7R. Both the local varieties, *Aispuri* and M 35-1 possessed more than 11 per cent infection. The rate of change (b) in varietal reaction over locations was lowest in M 35–1 followed by SC 120–14, SPV–34, SPV–81, CSH–5, 8–55, and 25–98 for per cent infection. SPV–35, CSH–6, CSH-8R, CSV–4, 296B, 2947B, QL 3, IS 12573, *Aispuri* and CSV–7R were more sensitive (b>1.0) and tended to show high infection in endemic environments. These varieties showed below average stability. Deviations from linearity were significant only for 296B and *Aispuri*. Susceptibility index (SI) varied from 0.4 to 3.2. Low SI (< 1 per cent) was observed in SPV–34, SPV–81, CSH–9, 36B, 2219B, 2247B, 6–39 and SC 120–14. Relatively more stable varieties for this character were SPV–34, SPV–104, 25–98, SC 120–14 and M 35–1.

TABLE 1 : Analysis of variance for stability of charcoal rot resistance and yield attributes

Source	DF	No. of nodes crossed	Per cent infection	Suscepti-bility index	Grain yield per plant	Plant height	No. of nodes
Environment	3	3.34**	928.0**	26.7**	12088.5**	13416.4**	116.7**
Variety	28	0.15	40.9**	1.6**	566.2**	5409.3**	3.7**
Variety × Environment	84	0.12	30.7**	0.9**	371.4**	542.4**	0.9**
Environment (l)	1	10.02	2784.0**	80.1**	36265.5**	40249.2**	350.1**
Variety × Environment (l)	28	0.11	55.6**	1.6**	901.0**	889.1**	1.4**
Deviation	58	0.12	17.6	0.6	102.3	356.3**	0.7**
Pooled Error	112	0.10	18.8	0.4	101.3	76.8	0.3

**Significant at 1%.

TABLE 2 : Stability parameters for charcoal rot resistance and yield attributes

S. No.	Entries	(1) No. nodes crossed			(2) Percent infection			(3) Susceptibility index		
		Mean	b	δ^2	Mean	b	d^2	Mean	b	d^2
1.	CSV-4	0.6	1.15	0.04	9.5	1.27**	6.07	1.2	1.15	0.04
2.	CSV-7R	0.8	2.29**	0.28	13.4	2.79**	0.99	2.7	3.55**	3.83**
3.	CSV-8R	0.5	1.40**	0.04	6.3	0.86	7.15	1.0	0.91	0.43
4.	SPV-34	0.3	0.05**	0.16	3.6	—0.38**	49.45	0.4	—0.29**	0.56
5.	SPV-35	0.5	1.38**	0.02	8.4	1.34**	1.68	1.4	1.40**	0.002
6.	SPV-80	0.8	0.50**	0.14	9.1	0.63**	1.63	1.5	0.75**	0.23
7.	SPV-81	0.5	0.59**	0.09	6.3	0.44**	3.12	0.9	0.61**	0.21
8	SPV-104	0.7	0.79	0.21	9.2	0.57**	14.61	1.4	0.48*	0.65
9.	SPV-126	0.5	0.39**	0.10	7.4	0.63**	1.74	1.1	0.78*	0.37
10.	SPV-232	1.0	—0.13**	0.26	13.3	0.20**	4.47	2.5	0.61**	0.09
11.	CSH-1	0.7	0.97	0.02	7.0	0.99	5.54	1.2	0.99	0.17
12.	CSH-5	0.7	0.86	0.31	6.7	0.53**	16.78	1.1	0.58**	0.37
13.	CSH-6	0.5	0.85	0.14	7.0	1.20*	7.96	1.0	0.99	0.25
14.	CSH-8R	0.6	1.70**	0.06	8.3	1.32**	6.18	1.4	1.44**	0.18
15.	CSH-9	0.4	1.26*	0.05	5.4	1.04	5.82	0.8	0.93	0.20
16.	36B	0.5	1.46**	0.06	5.4	0.96	17.88	0.9	0.92	0.43
17.	296B	0.6	1.41**	0.11	6.1	0.13**	1.65	1.7	1.49**	0.71
18.	2077B	0.6	1.39**	0.04	6.6	0.85	3.02	1.0	0.94	0.06
19.	2219B	0.5	1.09	0.05	5.9	0.83	7.70	0.9	0.74**	0.38
20.	2947B	0.4	1.19	0.02	6.7	1.23**	1.55	0.9	1.02	0.04
21.	6-39	0.5	1.51**	0.07	5.0	0.93	7.20	0.8	0.93	0.17
22.	8-55	0.6	1.01	0.10	6.0	0.55**	20.04	1.0	0.62**	0.52
23.	25-98	0.8	0.57**	0.41*	9.1	0.35**	3.43	1.3	0.41**	0.17
24.	SC 120-14	0.6	0.21**	0.22	5.2	0.32**	5.96	0.8	0.32**	0.18
25.	QL 3	0.6	1.35**	0.05	8.6	1.23**	2.50	1.4	1.33**	0.05
26.	IS 3687	0.6	1.18	0.04	7.6	0.99	3.84	1.3	0.96	0.14
27.	IS 12573	0.6	1.69**	0.09	11.7	2.34**	17.13	2.0	2.40**	0.53
28.	Aispuri	1.2	1.26*	0.23	15.9	1.79**	64.64	3.2	2.36**	5.05
29.	M 35-1	0.9	—0.11**	0.11	11.6	0.05**	9.05	1.9	—0.23**	0.43
	Mean	0.62			8.34			1.32		
	S. E.	0.22	0.109		3.06	0.080		0.47	0.083	

*Significant at 5%. **Significant at 1%.

TABLE 2 : Stability parameters for charcoal rot resistance and yield attributes (Contd.)

S. No.	Entries	(4) Grain yield/plant			(5) Plant height (cm)			(6) No. of nodes		
		Mean	b	d²	Mean	b	d²	Mean	b	d²
1.	CSV-4	40.4	0.93	83.60	149.8	1.55**	694.4**	9.7	1.04	0.49
2.	CSV-7R	53.1	2.43**	121.51	168.9	2.23**	439.8**	10.6	1.15**	0.15
3.	CSV-8R	47.5	1.71**	206.37	194.4	2.20**	1247.2**	12.4	1.24**	0.52
4.	SPV-34	26.4	0.78**	31.00	146.7	1.75**	1382.2**	10.0	0.66**	0.52
5.	SPV-35	38.7	0.78**	0.22	124.5	0.52**	88.7	9.4	0.70**	0.01
6.	SPV-80	34.5	1.29**	13.55	177.0	2.19**	39.5	11.2	0.87**	0.37
7.	SPV-81	33.6	0.03**	31.71	117.6	0.14**	136.4	9.3	1.39**	0.25
8.	SPV-104	57.1	1.65**	51.04	169.8	1.21**	97.3	9.9	0.69**	0.22
9.	SPV-126	34.7	—0.26**	358.50	183.3	1.21**	1041.0**	9.1	—0.09**	1.05
10.	SPV-232	28.4	0.86*	1.32	133.3	1.76**	388.0**	9.7	0.72**	3.90**
11.	CSH-1	42.7	0.20**	21.07	126.6	0.17**	96.3	9.6	0.79**	0.20
12.	CSH-5	58.5	2.05**	44.54	152.2	0.06**	317.9*	11.3	0.73**	1.31*
13.	CSH-6	54.2	1.90**	42.83	145.5	0.04**	1219.7**	9.0	1.02	0.02
14.	CSH-8R	68.0	2.99**	125.37	150.6	1.21*	120.7	10.9	1.11**	0.25
15.	CSH-9	68.9	− 0.83**	163.70	152.1	1.35**	67.4	10.4	1.42**	0.22
16.	36B	27.0	0.45**	90.07	97.9	0.53**	22.8	9.9	1.03**	0.27
17.	296B	45.7	1.07	114.30	120.0	0.60**	156.3	10.3	1.21**	0.99
18.	2077B	44.1	—0.03**	381.17*	125.2	1.58**	244.5	10.7	0.95**	0.01
19.	2219B	27.7	0.72**	3.05	105.7	0.39**	68.3	8.8	1.09	1.03
20.	2947B	42.1	1.08	97.65	105.5	0.27**	7.7	10.8	1.41**	0.18
21.	6-39	54.7	1.45**	104.22	98.9	0.46**	24.2	10.5	0.95*	0.34
22.	8-55	39.0	—0.15**	31.84	114.3	0.45**	240.2	10.0	0.50**	2.85**
23.	25-98	36.1	1.18**	49.76	96.6	0.08**	55.6	9.1	1.12**	0.84
24.	SC 120-14	31.4	0.56**	57.41	113.5	1.32**	930.9**	10.8	1.38**	0.33
25.	QL 3	29.3	0.77**	77.81	111.5	0.26**	71.3	10.2	0.87**	0.24
26.	IS 3687	33.2	0.76**	7.33	106.4	0.26**	21.0	8.8	0.97	0.32
27.	IS 12573	46.3	1.87**	291.48	86.5	0.67**	16.4	8.9	1.31**	0.28
28.	Aispuri	50.4	1.72**	346.22*	236.9	2.90**	87.0	12.2	1.73**	1.72**
29.	M 35-1	34.5	1.02	26.43	207.7	1.74**	989.7**	11.2	1.13**	0.19
	Mean	42.3			138.6			10.2		
	S. E.	7.12	0.053		6.19	0.094		0.38	0.043	

*Significant at 5%. **Significant at 1%.

The grain yield under disease pressure varied from 26.4 to 68.9 g per plant. CSH-9 and CSH-8R were the highest yielding hybrids followed by SPV-104, CSH-5, CSH-6, 6-39, *Aispuri* and CSV-7R. All of them except CSH-9, showed below average stability. *Aispuri* was particularly unstable for grain yield. SPV-34, SPV-81, SPV-232, CSH-1, 36B, 2219B SC 120-14 and IS 3687 were relatively low yielding but above average (b<1.0) in stability. The plant height ranged from 87 to 237 cm. Twelve varieties viz., 36B, IS 12573, 6-39, 25-98, SPV-81, 296B, 2219B, 2947B, QL 3, 8-55, SC 120-14 and IS 3687 were dwarf (< 120 cm). Above average stability for plant height was observed for SPV-35, SPV-81, CSH-1, 36B, 296B, 2219B, 2247B, QL 3, IS 12573, 6-39, 8-55, 25-98 and IS 3687 as indicated by b≤1.0. However, SPV-34, CSV-8R, SPV-126, CSH-5, CSH-6, CSV-4, SC 120-14, M 35-1 and CSV-7R were highly unstable for plant height. Less than nine stem nodes were observed in SPV-35, SPV-81, SPV-126, CSH-1, CSH-6, CSH-4, 36B, 2219B, IS 12573, 25-98 and IS 3687 while more than 11 nodes were observed in *Aispuri* M 35-1, SPV-80, CSV-8R and CSH-5. The varieties having less number of nodes varied in the stability of performance. Among them SPV-35, SPV-104 and CSH-1 exhibited above average stability. CSH-5, 8-55 and *Aispuri* were highly unstable for this character.

DISCUSSION : Charcoal rot caused by *Macrophomina phaseolina* (Tassi.) Goid., is a fungus of common occurrence in the soil and invades more than 300 host plants in different parts of the world (Gaffar and Zentmyer, 1968). The host is predisposed due to moisture stress and higher temperature at the time of grain development (Hsi, 1967 ; Edmunds, 1962). Dodd (1977) explained the photosynthetic stress translocation balance concept of predisposition to stalk rot. It leads to the conclusion that disease is due to the interaction of environment-host-pathogen. The distintegration of pith of the lower internodes due to disease curtails the normal grain development and therefore the disease could influence the stability of yield. The study of host pathogen interactions over different locations revealed that there is no host plant immunity to charcoal rot. However, inspite of significant variety × environment interactions the vareital differences persist for stability of resistance as well as for yield and other plant characters. The changes in charcoal rot reaction can be predicted for per cent infection and susceptibility index over locations. Based on stability parameters, SPV-34, CSH-9, 36B, 6-39, 8-55 and SC 120-14 showed least disease susceptibility but differ in degree of interaction. SPV-34 shows better resistance in highly endemic locations during *kharif* season. CSH-9, 36B and 6-39 entries are average in stability while SC 120-14 and 8-55 entries possess above average stability for both the resistance parameters inspite of increase in disease incidence.

Voight and Edmunds (1970), Frederiksen and Rosenow (1971) also reported differences among sorghum resistance to charcoal rot but none of these lines possessed high level of resistance. However, Rao *et al.* (1978b) observed varietal differences and reported CSV-5, SPV-34, SPV-35, SPV-104 and SPV-126 moderately to highly resistant to charcoal rot. Among resistant entries, CSH-9 is the only high yielding hybrid with average stability under disease pressure and recently released for general cultivation in India. The below average stability of other hybrids (CSH-5, CSH-6 and CSH-8R) for grain yield can be attributed to their relatively high disease susceptibility. Other varieties including locals are low yielding.

Various stresses which stimulates the charcoal rot are known to influence the plant growth also. Incidence of charcoal rot and the plant characters may thus be related. The tall local varieties were more susceptible than the improved ones but it appears that these varieties are surviving in nature with the disease (Rao *et al.*, 1982). M 35-1 (Maldandi B) was clasified as susceptible on the basis of soft stalk and per cent disease spread. (Rao *et al*, 1978a). On the other hand the tall mutants, SPV-80 and SPV-126 show better resistance than the original dwarf source varieties. Esechie *et al*. (1977) observed that resistant lines were shorter in plant height, later maturing, higher in total carbohydrates and appeared to be more perennial in habit. Since the dwarf varieties also vary in disease reaction, no specific relation between plant stature and charcoal rot resistance could be established. The increase of susceptibility of *kharif* varieties such as SPV-34, SPV 35, SPV-80, SPV 81, SPV-104 and SPV-126 in *rabi* and higher degree of resistance of rabi varieties, CSV-7R and CSV-8R in *kharif* can be attributed to their photoperiodic sensitivity.

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REFERENCES

Barah, B. C., H. P. Binswanager, B. S. Rana and N. G. P. Rao (1981). The use of risk aversion in plant breeding : Concept and application. *Euphytica* **30** : 451-458.

Dodd, L. (1977). A photosynthetic stress-translocation balance concept of corn stalk rot. *Proc.* 32 *Ann. Corn & Sorghum Res. Conf.* **32** : 112-130.

Eberhart, S. A. and W. A. Russell (1966). Stability parameters for comparing varieties. *Crop. Sci.* **6** : 36-40.

Edmunds, L. K. (1962). The relationship of plant maturity, temperature, and soil moisture to charcoal rot development in grain sorghum *Phytopath.* **52** : 731.

Esechie, H. A., J. W. Maranville and W. M. Ross (1977). Relationship of stalk morphology and chemical composition to lodging resistance in sorghum. *Crop. Sci.* **17** : 609-612.

Frederiksen, R. A. and D. T. Rosenow (1971). Disease resistance in sorghum. *Proc.* 26 *Ann. Corn & Sorghum Res. Conf.* **26** : 71-82.

Ghaffar, A. and G. A. Zentmyer (1968). *Macrophomina phaseoli* on some new weed hosts in California. *Pl. Dis. Rep.* p. 223.

Hsi, D. C. H. (1967). Stalk rots. *Sorghum Newsletter* **10** : 90.

Rana, B. S., K. H. Anahosur, V. J. M. Rao, R. Parameswarappa and N. G. P. Rao (1982). Inheritance of field resistance to sorghum charcoal rot and selection for multiple disease resistance. *Indian J. Genet.* **42** : 302-310.

Rao, K. N., V. S. Reddy, R. J. Williams, and L. R. House (1978). The ICRISAT charcoal rot resistance programme. *Proc. International Workshop on Sorghum Diseases*, Hyderabad, India, p. 315-321.

Rao, N. G. P., B. S. Rana, V. J. M. Rao and B. B. Reddy (1982). Genetic analysis of some exotic × Indian crosses in sorghum XXV. New hybrids and varieties and their performance. *Indian J. Genet.* **42** : 213-219.

Rao, N. G. P., R. V. Vidyabhushanam, B. S. Rana, V. Jaya Mohan Rao and M. J. Vasudeva Rao (1978). Breeding sorghums for disease resistance in India. *Proc. International Workshop on Sorghum Diseases*, Hyderabad, India pp. 430-433.

Singh, S. P., M.G., Jotwani, B. S. Rana and N. G. P. Rao (1978). Stability of host plant resistance to sorghum shoot fly, *Atherigona soccata* (Rondani). *Indian J. Ent.* **40** : 376-383.

Voight, R. L. and L. K. Edmunds (1970). Tolerance to charcoal rot in hybrid grain sorghumr *Agronomy Abstracts* p. 22.

Young, H. C. Jr. (1943). The toothpick method of incoulating corn for ear and stalk rot. *Phytopath.* **33** : 16.