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Early seedling vigour in sorghum and its relationship with resistance to shoot fly, *Atherigona soccata* Rondani

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ABSTRACT: Results of field experiments on the significance of early seedling vigour in sorghum for shoot fly (*Atherigona soccata* Rond.) resistance among different groups of parents having diverse breeding/selection history and their hybrids indicated that high early growth rate is associated with shoot fly resistance. Differences between seasons for expression of early seedling vigour was significant indicating strong seasonal effect on the genetic control of shoot fly resistance. The resistant parental groups and their hybrids showed significantly high seedling vigour compared to susceptible parental lines and their hybrid groups. Further, the low seedling vigour was dominant over high seedling vigour under low temperature conditions.

Sorghum shoot fly, *Atherigona soccata* Rondani is one of the major pests that destabilizes the performance of sorghum cultivars and ultimately reduce sorghum production in many parts of the world. Conventional methods for the control of shoot fly are not practical or cost effective to subsistence farmers. Under this circumstances, resistance cultivars are realistic alternative to chemical control. Silica deposition and abundance of sclerenchymatous cells in the leaf sheath (Ponnaiya, 1951), trichomes on the abaxial surface (Maiti and Bidinger, 1979), glossy leaves (Agarwal and House, 1982) and early seedling vigour (Jain and Bhatnagar, 1962; Blum, 1969) are reported to be the factors responsible for primary mechanism of shoot fly resistance. Additional information about seedling vigour and shoot fly resistance has been documented by Sharma *et al.* (1977), Sukhani and Jotwani (1979), Mate *et al.* (1979), Taneja and Leuschner (1985) and Vijayalakshmi (1993). Very little information is available on the genetic mechanism and nature of gene action of shoot fly resistance particularly on early seedling vigour, where separate sets of parents are used to develop hybrids. The present studies were carried out to find role of early seedling vigour in shoot fly resistance among different groups of parents having diverse breeding/selection history and their hybrids (Table 1), its interaction with seasons and nature of gene action involved.

MATERIALS AND METHODS

The studies were conducted at the International Crops Research Institute for

Table 1. Characteristic features of lines and testers

S. No.	Genotype	Pedigree	Days to 50% flowering	Height (mt)
I. Lines				
a) Rainy season-bred resistant cms lines (RBR cms)				
1.	SPSFR 94002A	(ICSB 51 x ICSV 705) PS 19349B)8-2-1-1-2	80	*1.30*
2.	SPSFR 94003A	(PS 21303 x SPV 386)-I-3-2-2-1	76	1.70
3.	SPSFR 94001A	(ICSB 37 x ICSV 705)13-5-2-1	74	1.00
4.	SPSFR 94031A	(ICSB 102 x PS 280603) 4-2-2-2-2	74	1.90
b) Posti-ainy season-bred resistant cms lines (PRBR cms)				
5.	SPSFPR 94001A	[ICSB II x (S 35 x Fara Fara)1-1-1-1-1	80	1.50
6.	SPSFPR 94002A	(ICSB 37 x ICSV 705)13-3-2-2	76	1.25
7.	SPSFPR 94005A	(ICSB 101 x ICSV 705) 7-2-3-1	78	1.75
8.	SPSFPR 94007A	(PS x 1349-2-2-1)	79	1.10
c) Susceptible cms llines (SB cms)				
9.	ICSA 20	[(BTU 623 x CSV 4)B-Bulk]-4-2-5	71 -K 73 -R	1.40 -K 1.30 -R
10.	ICSA 89001	(BTU 623 x CSV 4) x B-Bulk) x ICSR 23 x (BTU 623 x B-Bulk) x (296B x SPV 105) x (2077B x M 35-1)-1-3-2-2-2-1-4-4	70 -K 76 -R	1.50 -K 1.10 -R
11.	ICSA 89004	(ICSB 3 x ICSR 72) x ICSB 11)-9-4-2	70 -K 80 -R	1.40 -K 1.20 -R
12.	ICSA 90002	[ICSB x (BTU 678 x Uchv2) B Lines Bulk)-3-4 x ICSR 71	68 -K 68 -R	1.40 -K 1.20 -R
II. TESTERS				
a) Resistant bred restorer lines (RBR)				
1.	ICSV 712	(PS 21303 x ISPYT 2/E#20)-2-2-1-1-2	73	2.00
2.	ICSV 88088	(PS 14454 x SPV 351)-1-2-1-1	76	1.70
3.	ICSV 89015	(PS 19230 x SPV 351)-9-1-1-1	57	2.10
4.	ICSV 89030	(PS 28062 x R 11952)-12-2-2-3	69	2.10
b) Susceptible bred restorer lines (SBR)				
5.	ICSR 89076	[(ICSB 22 x ICSR 35) x (BT x 623) B Bulk]-3-1-6-1-4-2	71 -K 70 -R	1.60 -K 1.40 -R
6.	ICSR 90002	(C 85-2 x ICSV 1) x MR 929)-1-3	78 -K 71 -R	1.50 -K 1.60 -R
7.	ICSR 90005	(C 138 x ICSV 112) x SPL 711)-5-3-1	69 -K 69 -R	1.90 -K 1.40 -R
8.	ICSR 90014	(PM 14403 x MR 855)-5-3-1-1	65 -K 72 -R	1.70 -K 1.40 -R
c)	Postrainy season-adapted land races (PRLR)			
9.	ICSR 93031	M 35-1-36	65	2.80
10.	ICSR 93011	IS 18372	67	3.00
11.	ICSR 93009	IS 33843	70	3.00
12.	ICSR 93010	IS 33844	70	3.25

K = Kharif-, R = Rabi

the Semiarid Tropics, Patancheru, Andhra Pradesh, India in four sowings in two seasons during the rainy and postrainy seasons of 1995-96. Nine groups of hybrids (comprising 12 x 12 => 144 F_1S) obtained by crossing three groups of cytoplasmic male sterile (cms) lines [rainy season-bred resistant cms lines, SPSFR 94001A, SPSFR 94003A, SPSFR 94002A, and SPSFR 94031A (RBR cms), postrainy season-bred resistant cms lines, SPSFPR 94001A, SPSFPR 94002A, SPSFPR 94005A, and SPSFPR 94007A (PRBR cms), and rainy seasonbred susceptible cms lines, ICSA 20, ICSA 89001, ICSA 89004, and ICSA 90002 (SB cms)], and three groups of restorer lines [resistant bred restorers, ICSV 712, ICSV 88088, ICSV 89015, and ICSV 89030 (RBR), susceptible high yielding restorers, ICSR 89076, ICSR 90002, ICSR 90005, and ICSR 90014 (SBR), and postrainy season-adapted landraces, ICSR 93031, ICSR 93011, ICSR 93009, and ICSR 93010 (PRLR)] along with their parents and checks. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The plot size was 2 m x 0.75 m.

Different levels of infestation were created by adjusting the sowing dates and by enhancing shoot fly population through the use of infestor rows. Natural environment-I in the rainy season (EIK) and in the postrainy season (EIR) was created just by allowing the shoot fly population to develop naturally to represent farmers field conditions (Starks, 1970). Artificial environmental in the rainy season (EIIK) and in the postrainy season (EIIR) was created by enhancing shoot fly abundance by sowing CSH 1 (a susceptible hybrid) in four rows, 21 days prior to the planting of the test material. Moist fish meal packets of 500 g each were placed within the infestor rows to attract shoot flies (Starks, 1970). Sowings were taken four to six weeks later than the normal planting period to have sufficient shoot fly pressure.

Observations on early seedling vigour and dead heart percentage were recorded at 14 and 21 days after emergence, respectively. Early seedling vigour was scored on a 1-9 scale, where 1= highly vigorous (quick growing) and 9= least vigorous (slow growing and weak) seedlings observed at 14 DAE (Jayanthi, 1997). Dead heart counts were made and expressed in percentage by recording total number of plant per plot.

RESULTS AND DISCUSSION

Early seedling vigour was relatively high in EIIK, EIK and EIR with 3.52, 3.45 and 3.37, respectively (on 1-9 scale). However, it was low in the postrainy season compared to the rainy season, the least (5.30) being in the late planted postrainy season (EIIR) when there were low temperatures during the early crop growth. This tendency did not exist in all the parental lines and hybrid groups uniformly. Among the parental lines, the susceptible (SBR and SB cms) lines and their hybrids showed markedly poor vigour than any other groups of parental lines and hybrids in the late sown postrainy season (EIIR) (Table 2).

This signifies that the susceptible parental lines were also selected indirectly

Table 2. Group means of sorghum genotypes for early seedling vigour (SV) (1-9 scale)[1] and deadheart percentage (DH%) in rainy (EIK & EIIK)[2] and postrainy (EIR & EIIR)[2] seasons of 1995-96

Genotype groups	EIK		EIIK		EIR		EIIR		Mean	
	SV	DH%	SV	DH%	SV	DH%	SV	DH%	SV	DH%
Hybrids										
RBR cms x RBR	3.29	84.69	3.57	87.83	3.93	51.26	4.50	62.70	3.82	71.62
PRBR cms x RBR	3.39	86.45	3.77	87.93	3.78	43.45	4.61	63.21	3.89	70.26
SB cms x RBR	3.73	95.03	3.63	96.84	3.31	61.44	6.75	86.10	4.35	84.85
RBRcmsxSBR	3.78	92.31	4.09	96.56	4.10	59.91	6.81	78.31	4.70	81.77
PRBRcmsxSBR	4.02	93.61	4.02	96.24	3.75	52.93	6.13	69.41	4.48	78.05
SBcmsSBR	4.15	94.38	3.90	96.63	3.35	71.18	7.57	85.31	4.74	86.88
RBRcmsxPRLR	2.23	85.55	2.56	83.40	2.60	36.98	3.23	65.44	2.66	67.84
PRBRcmsxPRLR	2.77	88.02	2.60	85.03	2.89	37.88	3.19	67.25	2.86	69.55
SBcmsxPRLR	4.02	91.09	3.85	96.13	2.79	65.40	6.48	86.27	4.29	84.72
CD at 5%	0.43	3.02	0.37	3.22	0.58	7.15	0.69	7.86	0.39	3.51
Female Parents										
RBRcms	3.75	73.10	3.17	80.17	3.58	16.40	3.33	37.95	3.46	51.91
PRBRcms	3.25	82.08	4.50	82.81	4.08	38.09	4.50	50.26	4.08	63.31
SB cms	3.25	96.07	4.25	98.82	3.58	64.75	7.83	76.40	4.73	84.01
CD at 5%	0.85	6.03	0.74	6.44	1.15	14.30	1.38	15.73	0.40	7.03
Male Parents										
RBR	2.83	84.87	2.58	80.47	2.33	28.79	3.67	51.79	2.85	61.48
SBR	3.50	94.65	2.92	98.61	2.00	72.17	6.61	81.03	3.76	88.62
PRLR	2.08	86.59	1.42	81.99	1.67	27.81	1.50	52.89	1.67	62.32
CD at 5%	0.85	6.03	0.74	6.44	1.15	14.30	1.38	15.73	0.40	7.03
Checks										
Resistant	3.33	74.49	3.73	77.20	4.60	35.45	2.33	47.80	3.50	58.74
Susceptible	4.56	92.05	4.33	98.13	4.11	68.14	8.22	75.96	5.31	83.57
CD at 5%	0.60	4.27	0.52	4.55	0.81	10.11	0.97	11.12	0.28	4.97
Mean (Overall)	3.45	89.17	3.52	84.17	3.37	69.79	5.30	70.60		
CD at 5%	1.70	12.07	1.48	6.57	2.30	28.58	1.78	21.12		

[1] Scale, l=highly vigorous and quick growing seedlings; 9=least vigorous and slow growing seedlings
[2] EIK= Rainy season natural environment; EIIK= Rainy season artificial environment, EIR = Postrainy season natural environment; EIIR= Postrainy season artificial environment

for low seedling vigour under low temperatures, and that the resistant genotypes for high seedling vigour.

Mean performance of the nine distinct groups with regard to early seedling vigour revealed the superiority of PRLR group in both the seasons. In general, seedling vigour was low when susceptible parents were used as one of the parents in the hybrids. Unlike the susceptible parental line groups (SB cms and SBR), the resistant parental groups RBR cms and PRBR cms, bred for shoot fly resistance behaved uniformly in both the seasons. Among all lines, PRLR group, which were not bred specifically, but selected by farmers, showed the highest vigour. As a result, their hybrid groups (RBR cms x PRILR and PRBR cms x PRLR) showed greater vigour compared with the hybrid groups, RBR cms x RBR and PRBR cms x RBR which involved bred restorers (Table 2, Fig.1).

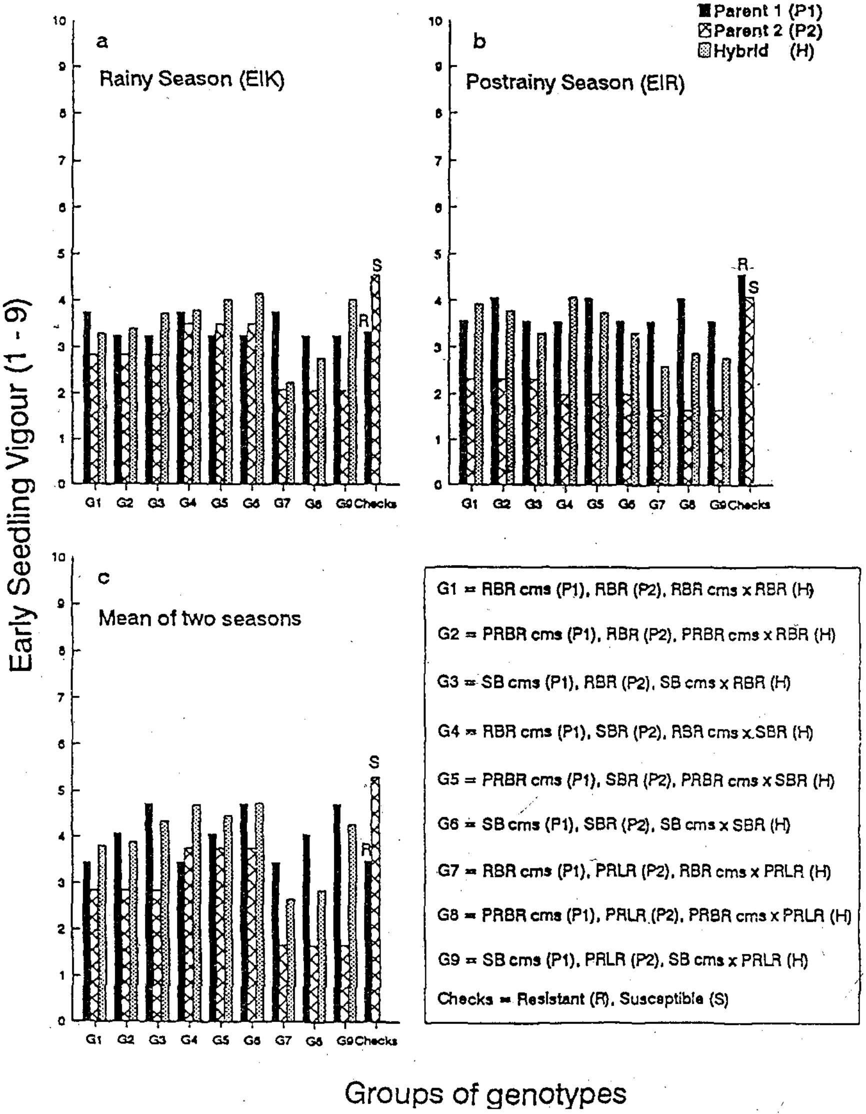

Fig. 1. Mean early seedling vigour of parents and their hybrid groups (a) Rainy season (EIK) (b) Postrainy (EIR) (c) Mean of two seasons

Further examination of susceptible x resistant and their reciprocal hybrid groups (SB cms x RBR, SB cms x PRLR, RBR cms x SBR, and PRBR cms x SBR) in relation to their parental groups for seedling vigour in the late planted experiment (EIIR) showed that low vigour was dominant over high seedling vigour (Table 3). This is particularly evident under low temperature conditions.

Table 3. Gene action for low seedling vigour in various hybrid groups

Hybrid Group	Season/ Environment	P_1	P_2	Mid Parental value	Hybrid	Gene action (Low vigour)*
RBR cms x RBR	EIK	3.75	2.83	3.29	3.29	
	EIIK	3.17	2.58	2.88	3.57	Over dominant
	EIR	3.58	2.33	2.96	3.93	Over dominant
	EIIR	3.33	3.67	3.50	4.50	Over dominant
PRBR cms x RBR	EIK	3.25	2.83	3.04	3.39	Over dominant
	EIIK	4.50	2.58	3.54	3.77	Dominant
	EIR	4.08	2.33	3.21	3.78	Dominant
	EIIR	4.50	3.67	4.09	4.61	Over dominant
SB cms x RBR	EIK	3.25	2.83	3.04	3.73	Over dominant
	EIIK	4.25	2.58	3.42	3.63	Dominant
	EIR	3.58	2.33	2.96	3.31	Dominant
	EIIR	7.83	3.67	5.75	6.75	Dominant
RBR cms x SBR	EIK	3.75	3.50	3.63	3.78	Dominant
	EIIK	3.17	2.92	3.05	4.09	Over dominant
	EIR	3.58	2.00	2.79	4.10	Over dominant
	EIIR	3.33	6.61	4.97	6.81	Over dominant
PRBR cms x SBR	EIK	3.25	3.50	3.38	4.02	Over dominant
	EIIK	4.50	2.92	3.71	4.02	Dominant
	EIR	4.08	2.00	3.04	3.75	Dominant
	EIIR	4.50	6.61	5.56	6.13	Dominant
SB cms x SBR	EIK	3.25	3.50	3.38	4.15	Over dominant
	EIIK	4.25	2.92	3.59	3.90	Dominant
	EIR	3.58	2.00	2.79	3.35	Dominant
	EIIR	7.83	6.61	7.22	7.57	Dominant
RBR cms x PRLR	EIK	3.75	2.08	2.92	2.23	Partially dominant
	EIIK	3.17	1.42	2.29	2.56	Dominant
	EIR	3.58	1.67	2.63	2.60	Dominant
	EIIR	3.33	1.50	2.42	3.23	Dominant
IIRBR cms x PRLR	EIK	3.25	2.08	2.67	2.77	Dominant
	EIIK	4.50	1.42	2.96	2.60	Partially dominant
	EIR	4.08	1.67	2.88	2.89	Partially dominant
	EIIR	4.50	1.50	3.00	3.19	Dominant
SB cms x PRLR	EIK	3.25	2.08	2.67	4.02	Over dominant
	EIIK	4.25	1.42	2.84	3.85	Dominant
	EIR	3.58	1.67	2.63	2.79	Dominant
	EIIR	7.83	1.50	4.67	6.48	Dominant

P_1= Parent 1; P_2= Parent 2; EIK= Natural Environment-I in Rainy season; EIR= Natural Environment-II in Postrainy season; EIIK=Artiricial Environment-I in Rainy season; EIIR=Artificial Environment-II in Postrainy season; * Vigour on 1-9 scale (I= highly vigorous (quick growing) and 9=least vigorous (slow growing).

Thus, seedling vigour gives an idea about the growth rate during early stages, critical period for shoot fly incidence. It is expected that resistant cultivars may have high seedling vigour which enables them to grow fast, and have a relatively shorter period of susceptible stage (seedling stage) than the slow growing susceptible cultivars. Similar results have also been reported by Taneja and Leuschner (1985); Mate *et al.* (1979), and Singh and Jotwani (1980).

A critical analysis of mean performance of hybrids and parental groups over two seasons in two different environments viz., rainy (EIK and EIIK) and postrainy (EIR and EIIR) seasons revealed that the shoot fly resistance (low deadheart %) was found to be influenced positively by early seedling vigour, which in turn related with primary resistance. Thus early seedling vigour, can be considered as one of the reliable measures of escape from shoot fly infestation. Considering the gene action it was clear that low seedling vigour dominates over high seedling vigour. Differences between seasons for expression of early seedling vigour was significant. This was probably due to environmental variation which in turn exhibits strong seasonal effect on the genetic control of shoot fly resistance. Further ~~the land-race germplasm lines~~ adapted to postrainy season which showed high seedling vigour could be used as restorers in crosses with the resistant females to produce resistant hybrids.

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