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Influence of panicle compactness and host plant resistance in sequential plantings on population increase of panicle-feeding insects in *Sorghum bicolor* (L.) Moench

(*Keywords:* sorghum, midge, head bugs, head caterpillar, sowings, resistance, India)

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Abstract. The effects of panicle compactness and host plant resistance on the rate of population increase of sorghum midge (*Contarinia sorghicola* Coq.), head bugs (*Calocoris angustatus* Leth.) and head caterpillar (*Helicoverpa armigera* Hb.) in large concentric plots over three sequential sowings during the 1985–86 rainy seasons were studied. Early-planted crops suffered less damage than the late-planted crops. *H. armigera* damage was negligible in genotypes with loose panicles. *Calocoris angustatus* population increase was lower in genotypes with loose panicles. Panicle compactness did not affect the damage caused by *C. sorghicola* and *Campylomma* spp. Host plant resistance had a marked effect on the rate of population increase across sowing dates in the case of sorghum midge and head bugs. Thus, cultivars with resistance to insects and/or with loose panicles can help to reduce the losses caused by panicle-feeding insects in sorghum.

1. Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is an important cereal crop in the semi-arid tropics. Grain yields in farmers' fields are generally low (0·6–0·8 tonnes/ha), although yield levels of up to 7·2 tonnes/ha have been obtained in experimental plots on research farms. One of the major causes of low yield is the damage caused by insect pests. Over 150 species of insects damage the sorghum crop (Reddy and Davies, 1979; Jotwani *et al.*, 1980); of these, the major pests are: sorghum shoot-fly [*Atherigona soccata* Rond. (Diptera: Muscidae)], stem-borers [*Chilo, Eldana*, and *Diatraea* (Lepidoptera: Pyralidae), *Busseola* and *Sesamia* (Lepidoptera: Noctuidae)], aphids [*Schizaphis graminum* Rond., *Melanaphis sacchari* Zehnt., and *Rhopalosiphum maidis* Fitch. (Hemiptera: Aphididae)], armyworms [*Mythimna separata* Wlk., *Spodoptera exempta* Wlk. and *S. frugiperda* J. E. Smith (Lepidoptera: Noctuidae)], midge [*Contarinia sorghicola* Coq. (Diptera: Cecidomyiidae)], head bugs [*Calocoris angustatus* Leth., *Campylomma* spp., *Creontiades pallidus* Ramb., and *Eurystylus bellevoyei* Odh. (Hemiptera: Miridae)], and head caterpillars [*Helicoverpa armigera* Hb., *Eublemma* spp., and *Celama* (Lepidoptera: Noctuidae), and *Cryptoblabes* spp. (Lepidoptera: Pyralidae)] (Sharma, 1993).

The introduction of high-yielding varieties and hybrids, particularly compact-panicled types, has changed the relative composition and importance of insects feeding on the sorghum panicle (Sharma, 1985). Compact-panicled genotypes have been reported to be susceptible to head bugs and head caterpillars (Balasubramanian *et al.*, 1979). Severe damage by head bugs and head caterpillars during the rainy season predisposes the developing grain to grain mould infection (Sharma *et al.*, 1992a). Head-bug-damaged grain is of poor nutritional quality, may become unfit for human consumption (Sharma and Lopez, 1989; Sharma *et al.*, 1993 a, b), and fetches half the price of grain produced during the post-rainy season.

Damage by head bugs (*C. angustatus* and *E. immaculatus*) and the head caterpillar (*H. armigera*) has been reported to be greater in compact-panicled sorghum genotypes (Balasubramanian *et al.*, 1979; Sharma, 1985; Sharma *et al.*, 1993a). However, loose-panicled genotypes are also badly damaged when head bug infestation is high (Sharma, 1985; Sharma *et al.*, 1993a). On the other hand, midge damage has been reported to be low in compact-panicled genotypes (Murty and Subramaniam, 1978). In general, genotypes with open panicles suffer less damage from head caterpillars (Wilson, 1976; Patel *et al.*, 1986). Most of these observations are based on the results of small-plot experiments where the inter-plot movement of insects can overcome the effects of panicle compactness on survival and population increase of these insects. In the present study, we examined the effects of panicle compactness on the incidence and damage of sorghum midge, head bugs, and head caterpillars in concentric sequential sowings in large plots.

2. Materials and Methods

These experiments were conducted during the 1985–86 rainy seasons (July–Oct.) at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Andhra Pradesh, India. Six cultivars (CSH 5, IS 9692, ICSV 197, IS 2761, IS 17610 and IS 17618) were tested during the 1985 rainy season. Because of late flowering of IS 17610, IS 17618 and IS 2761, a different set of four cultivars (CSH 5, ICSV 189, IS 9692 and CSH 11) was used for the 1986 rainy season experiments. These cultivars were similar in height (200–225 cm) and days to 50% flowering (65–70 days after seedling emergence) but differed in panicle compactness. Morphological and agronomic traits of these cultivars are given in Table 1.

Table 1. Agronomic characteristics of eight sorghum cultivars used to study the effect of panicle compactness on population increase and damage by panicle-feeding insects

Cultivar	Plant height (cm)	Days to 50% flowering	Panicle compactness[a]	Grain colour[b]	Glume length[c]	Insect resistance[d] Midge	Head bug
CSH 11	200	65	L	W	SH	S	S
CSH 5	200	67	C	W	SH	S	S
ICSV 189	220	65	L	W	M	S	S
ICSV 197	300	67	SC	W	SH	R	S
IS 2761	300	75	SC	R	SH	MR	MR
IS 9692	200	63	C	R	M	S	MR
IS 17610	300	110	L	W	L	S	R
IS 17618	300	90	L	W	L	S	R

[a] C = Compact, SC = semi-compact, L = loose.
[b] Grain colour: W = white, R = red.
[c] Glume length: SH = short, M = medium, L = long.
[d] Insect resistance: S = susceptible, MR = moderately resistant, R = resistant.

Table 2. Effect of cultivars and panicle compactness in sequential plantings on sorghum midge, C. sorghicola *(ICRISAT Centre, 1985 rainy season)*

Cultivar	Panicle compactness[a]	No. of midge flies/ 20 panicles I	II	III	Midge damage (%) I	II	III
CSH 5	C	0	126	10	6	62	77
		(0·3)[b]	(11·2)	(3·0)	(2·4)	(7·8)	(8·7)
IS 9692	C	8	7	44	16	60	66
		(2·6)	(2·6)	(6·7)	(4·0)	(7·8)	(8·1)
ICSV 197	SC	13	121	19	8	14	19
		(4·3)	(10·8)	(14·4)	(2·7)	(3·6)	(4·3)
IS 2761	SC	13	6	3	30	14	9
		(3·7)	(2·4)	(1·8)	(15·5)	(3·7)	(3·0)
IS 17610	L	9	4	5	32	—	—
		(3·1)	(0·9)	(2·3)	(5·6)		
IS 17618	L	5	4	2	24	20	25
		(2·2)	(1·9)	(1·5)	(4·9)	(4·5)	(5·0)
Mean		8	45	14	19	34	39
SE		± (0·4)**	± (0·5)**	± (0·3)**	± (0·4)**	± (0·4)**	± (0·2)**

[a] C = Compact, SC = semi-compact, L = loose.
[b] Figures in parentheses are $\sqrt{N + 0{\cdot}5}$ transformed values.
** Significant at $P < 0{\cdot}01$.
—, Not recorded.
I, II, and III = Sowings on 20 June, and 10 and 30 July, respectively.

The cultivars were planted in large concentric blocks in three sowings at intervals of 20 days (time sufficient for midge and head bugs to complete one generation and move from one planting to another). Plot size was 0·16 ha during the 1985 rainy season, and 0·25 ha during the 1986 rainy season. Different genotypes were separated by an alley of 2 m. The cultivars were planted in a randomized block design. This method of planting was adopted to avoid inter-plot effects, and to evaluate the effects of panicle compactness and host plant resistance on population build-up and grain damage by the panicle-feeding insects.

The seeds were sown on ridges 75 cm apart with a four-cone planter. Carbofuran 3G (1·2 kg a.i./ha) was applied at the time of sowing to protect the crop from sorghum shoot-fly, *Atherigona soccata*. In the second and third sowings, the crop was also sprayed twice with fenvalerate against shoot-fly at the seedling stage. No insecticide was applied during the reproductive phase of the crop. The seedlings were thinned to a distance of 10 cm between plants 15 days after emergence.

Observations were recorded in 3 m × 4 m marked plots in all four directions in each plot. Data were recorded on midge flies/20 panicles, midge damage (% chaffy spikelets in a sample of 500 spikelets drawn at random from five panicles at maturity) (Sharma *et al.*, 1988), and visual damage rating on a scale of 1 to 5 (1 = < 10% midge damage, and 5 = > 60% midge damage). *C. angustatus* density was recorded in five randomly marked panicles in each plot at the milk stage. Head caterpillar (*H. armigera*) density was recorded during the 1985 season at the hard-dough stage.

Grain yield, 1000-grain mass, and grain damage were recorded at maturity. Grain yield was recorded in an area of 4 m × 3 m on each of the four directions of the plot at maturity. Grain mass per 1000 grains was recorded from a sample

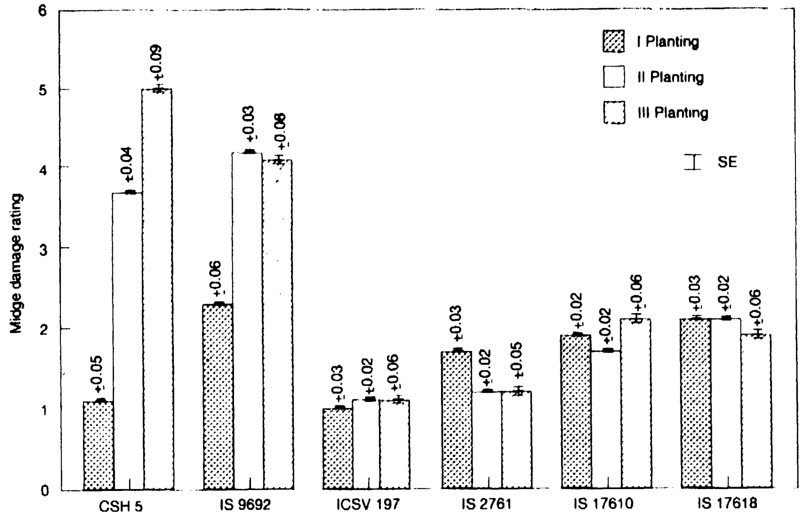

Figure 1. Midge damage in six sorghum cultivars across three planting dates (ICRISAT Centre, 1985 rainy season). Midge damage rating (1 – < 10% spikelets with midge damage, 5 – > 60% spikelets with midge damage).

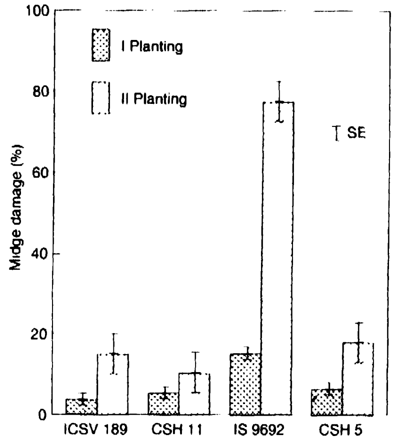

Figure 2. Midge damage in four sorghum cultivars across two planting dates (ICRISAT Centre, 1986 rainy season).

Table 3. Effect of cultivars and panicle compactness in sequential plantings on C. angustatus *(number of bugs/5 panicles) in six sorghum cultivars (ICRISAT Centre, 1985 rainy season)*

Cultivar	Panicle compactness[a]	Planting I	Planting II	Planting III
CSH 5	C	0·3	20·1	52·6
		(0·6)[b]	(17·9)	(7·0)
IS 9692	C	150·3	195·2	30·3
		(11·8)	(13·9)	(5·4)
ICSV 197	SC	302·6	299·2	4·4
		(17·0)	(17·3)	(2·0)
IS 2761	SC	21·8	13·3	4·6
		(4·6)	(3·7)	(2·1)
IS 17610	L	2·3	3·5	3·0
		(1·5)	(1·8)	(1·7)
IS 17618	L	12·1	20·1	13·1
		(3·2)	(4·3)	(3·4)
Mean		81·6	142·0	18·0
SE		± (1·0)**	± (0·6)**	± (0·5)**

[a] C = Compact, SC = semi-compact, L = loose.
[b] Figures in parentheses are $\sqrt{N + 0.5}$ transformed values.
** Significant at $P < 0.01$.
I, II, and III = Sowings on 20 June, and 10 and 30 July, respectively.

Table 4. Effect of cultivars and panicle compactness in sequential plantings on C. angustatus *(number of bugs/5 panicles) in four sorghum cultivars (ICRISAT Centre, 1986 rainy season)*

Cultivar	Panicle compactness[a]	Planting I	Planting II	Planting III
ICSV 189	L	0·4	92·3	4·4
		(0·6)[b]	(19·6)	—
CSH 11	L	4·1	98·8	5·0
		(2·0)	(9·9)	—
IS 9692	C	43·9	—	18·4
		(6·7)	—	—
CSH 5	C	1·2	119·9	18·2
		(1·1)	(10·9)	—
Mean		12·4	103·7	11·5
SE		± (0·2)**	± (0·3)**	—

[a] C = Compact, SC = semi-compact, L = loose.
[b] Figures in parentheses are $\sqrt{N+0{\cdot}5}$ transformed values.
*,** Significant at $P<0{\cdot}05$ and $<0{\cdot}01$, respectively.
I, II, and III = Sowings on 20 June, and 10 and 30 July, respectively.

Table 5. Effect of cultivars and panicle compactness in sequential plantings on H. armigera *incidence (number of larvae/panicle) in six sorghum cultivars (ICRISAT Centre, 1985 rainy season)*

Cultivar	Panicle compactness[a]	Hard dough stage I	Hard dough stage II	Hard dough stage III
CSH 5	C	1	3·75	6·25
		(1·0)[b]	(1·9)	(2·4)
IS 9692	C	20·5	1·5	1·75
		(0·6)	(1·0)	(1·2)
ICSV 197	SC	0·0	3·25	0·0
		(0·3)	(1·5)	(0·3)
IS 2761	SC	0·0	0·0	0·0
		(0·3)	(0·3)	(0·3)
IS 17610	L	0·0	0·0	0·0
		(0·3)	(0·3)	(0·3)
IS 17618	L	0·0	0·0	0·0
		(0·3)	(0·3)	(0·3)
Mean		0·25	1·42	1·33
SE		± (0·15)*	± (0·3)**	± (0·23)**

[a] C = Compact, SC = semi-compact, L = loose.
[b] Figures in parentheses are $\sqrt{N+0{\cdot}05}$ transformed values.
*, ** Significant at P 0·05 and 0·01, respectively.
I, II, and III = Sowings on 20 June, and 10 and 30 July, respectively.

drawn at random from the threshed grain of each plot. At maturity, the panicles were rated for head bug damage on a scale of 1 to 5 (1 = grain with a few feeding punctures, and 5 = grain showing >60% shrivelling, and highly tanned) (Sharma *et al.*, 1992b).

Data were converted to $\sqrt{N+0{\cdot}5}$ square root values and subjected to analysis of variance to test the significance of the effect of different cultivars on incidence and damage by different insects.

3. Results

3.1. *Sorghum midge* (Contarinia sorghicola)

Midge numbers and damage increased in the midge-susceptible cultivars CSH 5 and IS 9692 across sowing dates (Table 2, Figure 1). Such an increase in midge damage was not recorded in the highly- (ICSV 197) and moderately resistant (IS 2761) cultivars. Midge density and damage were also low in IS 17610 because of late flowering. Panicle compactness did not influence the midge populations across sowing dates, but plant resistance had a marked effect on midge numbers and there was no increase in midge damage in plots of ICSV 197 and IS 2761. However, midge numbers were considerably higher in plots of ICSV 197 in the second planting, possibly because of immigration of midges from the neighbouring plots. In general, midge numbers were lower in the third planting than in the second planting. During the 1986 rainy season, midge damage increased across sowing dates (Figure 2). Panicle compactness did not influence midge damage.

3.2. *Head Bug* (Calocoris angustatus)

C. angustatus density was higher on CSH 5, IS 9692 and ICSV 197 than on IS 2761, IS 17610 and IS 17618 (Table 3). The relative increase in bug numbers was lower in IS 9692 compared with CSH 5 and ICSV 197. The increase in bug numbers was greater on ICSV 197 than on IS 2761, although both have semi-compact panicles. The latter is moderately resistant to head bugs. There was no increase in bug density across sowing dates in plots of IS 2761, IS 17610 and IS 17618. These cultivars have loose panicles and are resistant to head bugs. Head bug density decreased in the third sowing. This may be because of low temperatures and low relative humidity. Head bug-resistant cultivars showed a marked effect on the rate of increase of *C. angustatus* populations across sowing dates. Head bug density decreased across sowing dates in plots of IS 2761 and IS 17610.

During the 1986 rainy season, the differences in bug numbers were significant between cultivars (Table 4). Bug numbers tended to be higher on the compact-panicled cultivar CSH 5 (120 bugs/5 panicles) compared with the loose-panicled cultivars ICSV 189 and CSH 11 (92–99 bugs/5 panicles) in the second planting, where maximum head bug infestations were recorded. In the third planting, there were 18 bugs/5 panicles in IS 9692 and CSH 5 (compact-panicled), compared with 4–5 bugs/5 panicles on the loose-panicled cultivars ICSV 189 and CSH 11.

3.3. *Head Caterpillar* (Helicoverpa armigera)

The density of *H. armigera* larvae was greater in the compact-panicled genotypes CSH 5 and IS 9692 than in loose-panicled ones (IS 2761, IS 17610 and IS 17618) (Table 5). No larvae were recorded in the loose-panicled genotypes because of easy access to the parasites and predators, and mortality caused by abiotic factors. There was an increase in larval density across sowing dates in the compact-panicled genotypes CSH 5 and IS 9692.

3.4. *Grain damage*

Grain damage by head bugs increased in CSH 5, IS 9692 and ICSV 197 but remained low across sowing dates in IS 2761, IS 17610 and IS 17618 (Figure 3). There was a progressive decrease in grain damage in plots of the head bug-resistant cultivars IS 2761, IS 17610 and IS 17618.

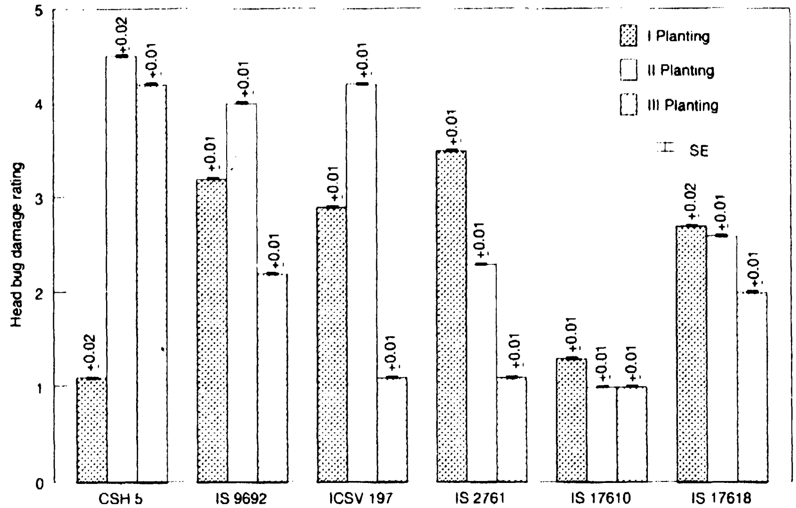

Figure 3. Head bug damage in six sorghum cultivars across three planting dates (ICRISAT Centre, 1985 rainy season). Head bug damage rating (1 = a few grains showing feeding punctures, 5 = grains showing > 60% shrivelling and highly tanned appearance)

Table 6. Grain yield and 1000-grain mass, in six sorghum cultivars across three planting dates (ICRISAT Centre, 1985 rainy season)

Cultivar	Panicle compactness[a]	Grain yield (kg/ha)			1000-grain mass (g)		
		I	II	III	I	II	III
CSH 5	C	3708	275	42	17·66	7·81	8·70
IS 9692	C	483	192	133	10·66	10·73	17·37
ICSV 197	SC	1750	442	242	11·60	7·02	18·17
IS 2761	SC	633	941	1092	11·21	11·49	11·42
IS 17610	L	608	692	525	21·52	24·26	23·12
IS 17618	L	817	583	250	23·06	22·61	23·12
Mean		1333	521	381	15·95	13·99	15·08
SE		± 203**	± 138**	± 75**	± 1·10**	± 1·60**	± 0·80**

[a] C = Compact, SC = semi-compact, L = loose.
** Significant at P 0·01.
I, II, and III = Sowings on 20 June, and 10 and 30 July, respectively.

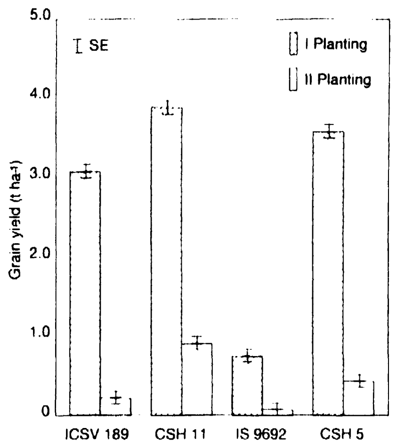

Figure 4. Grain yield (kg ha^{-1}) of four sorghum cultivars across two planting dates (ICRISAT Centre, 1986 rainy season).

3.5. Grain Yield

Grain yield decreased substantially across sowing dates in CSH 5, ICSV 197 and IS 9692 (Table 6). During 1985, some decrease in grain yield was recorded in IS 17618, while yields were moderately stable across sowing dates in IS 2761 and IS 17610. During the 1986 rainy season, grain yield declined substantially across sowing dates in ICSV 189, CSH 11 and CSH 5, while yields were consistently low across sowing dates for IS 9692 (Figure 4).

4. Discussion

Panicle compactness did not influence midge incidence, although Murty and Subramaniam (1978) reported that genotypes with compact panicles are less damaged by *C. sorghicola*. Host plant resistance, as expected, had a marked effect on midge infestation across sowing dates in different cultivars (Sharma, 1993).

Genotypes with loose panicles harbour low bug numbers (Balasubramanian *et al.*, 1979). However, loose-panicled cultivars are also highly damaged under situations of heavy infestation of *C. angustatus* (Sharma, 1985) and *E. immaculatus* (Sharma *et al.*, 1993a). The present studies indicated that grain damage was quite high in the head bug-susceptible loose-panicled cultivars (ICSV 189, CSH 11 and ICSV 197) in the second planting. However, *C. angustatus* numbers were comparatively low in plots of loose-panicled cultivars in the second and third sowings during the 1985 and 1986 rainy seasons. This may be because of greater mortality of immature stages as a result of biotic and abiotic factors. Loose-panicled head bug-resistant genotypes (IS 2761, IS 17610 and IS 17618) had a marked effect on the rate of increase of bug populations. In large-plot experiments with these genotypes, bug populations decreased across sowing dates. These cultivars also suffered low grain damage, and there was no significant decrease in grain yield. IS 9692, to which bugs show non-preference (Sharma and Lopez, 1990), showed moderate levels of increase in bug numbers across sowing dates. Similar results have earlier been obtained with this genotype under different levels of insecticide protection (Sharma and Lopez, 1993).

Panicle compactness had a marked effect on *H. armigera*. Cultivars with loose panicles were free of *H. armigera* larvae. Similar observations have been made earlier by Wilson (1976), Balasubramanian *et al.* (1979) and Patel *et al.* (1986).

5. Conclusions

Host plant resistance had a marked influence on the rate of increase of midge and head bug populations across sowing dates. Head bug populations were consistently lower on loose-panicled genotypes. Loose-panicled genotypes were free from damage by head caterpillars. Thus, the use of genotypes with resistance to insects and/or with loose panicles can help to minimize the losses caused by panicle-feeding insects in sorghum.

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References

BALASUBRAMANIAN, G., SHIVAPRAKASAM, K., KULANDAIVELU, R. and ROBINSON, J. G., 1979. Impact of sorghum earheads on the incidence of earhead bug, caterpillar, webber and mould. *Indian Journal of Agricultural Research*, **13**, 106–108.

JOTWANI, M. G., TEETES, G. L. and YOUNG, W. R., 1980. Elements of integrated control of sorghum pests. *FAO Plant Production and Protection Paper* (Rome, Italy: FAO), 159 pp.

MURTY, A. D. and SUBRAMANIAM, T. R., 1978. Screening of local kharif varieties of sorghum to the sorghum midge (*Contarinia sorghicola* Coq.). *Madras Agricultural Journal*, **65**, 180–182.

PATEL, R. H., DESAI, K. B., DESAI, M. S. and KUKADIA, M. U., 1986. Combining ability for resistance to earhead worms in sorghum. *Gujarat Agriculture University Research Journal*, **11**, 79–81.

REDDY, K. V. S. and DAVIES, J. C., 1979. Pests of sorghum and pearl millet and their parasites and predators recorded at ICRISAT Centre, India up to August 1979. *Cereals Entomology Progress Report 2* (Patancheru, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics).

SHARMA, H. C., 1985. Screening for host plant resistance to mirid bugs in sorghum. In *Proceedings, International Sorghum Entomology Workshop*, 15–21 July 1984, College Station, Texas, USA (Patancheru, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics). pp. 317–335.

SHARMA, H. C., 1993. Host plant resistance to insects in sorghum and its role in integrated pest management. *Crop Protection*, **12**, 13–34.

SHARMA, H. C. and LOPEZ, V. F., 1989. Assessment of avoidable losses and economic injury levels for sorghum head bug, *Calocoris angustatus* Leth. (Hemiptera: Miridae). *Crop Protection*, **8**, 334–340.

SHARMA, H. C. and LOPEZ, V. F., 1990. Mechanisms of resistance in sorghum to head bug, *Calocoris angustatus*. *Entomologia Experimentalis et Applicata*, **57**, 285–294.

SHARMA, H. C. and LOPEZ, V. F., 1993. A comparison of economic injury levels for sorghum head bug, *Calocoris angustatus* on resistant and susceptible genotypes at different stages of panicle development. *Crop Protection*, **12**, 259–266.

SHARMA, H. C., VIDYASAGAR, P. and LEUSCHNER, K., 1988. No-choice cage technique to screen for resistance to sorghum midge (Cecidomyiidae: Diptera). *Journal of Economic Entomology*, **81**, 415–422.

SHARMA, H. C., DOUMBIA, Y. O. and DIORISO, N. Y., 1992a. A technique to screen sorghums for resistance to head bug, *Eurystylus immaculatus* Odh. in West Africa. *Insect Science and its Application*, **13**, 417–427.

SHARMA, H. C., TANEJA, S. L., LEUSCHNER, K. and NWANZE, K. F., 1992b. Techniques to screen sorghums for resistance to insects. *Information Bulletin No 32* (Patancheru, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics). 48 pp.

SHARMA, H. C., DOUMBIA, Y. O., HAIDRA, M., SCHEURING, J. F., RAMAIAH AH, K. V. and BENINATI, N. F., 1993a. Sources and mechanisms of resistance to sorghum head bug, *Eurystylus immaculatus* Odh. in West Africa. *Insect Science and its Application* (in press).

SHARMA, H. C., SOMAN, P. and SUBRAMANIAN, V., 1993b. Effect of host plant resistance and chemical control of head bugs, *Calocoris angustatus* Leth. on grain quality and seedling establishment in Sorghum. *Annals of Applied Biology* (in press).

WILSON, A. G. L., 1976. Varietal responses of grain sorghum to infestation by *Heliothis armigera*. *Experimental Agriculture*, **12**, 257–265.