Euphytica 65: 167–175, 1993.

Genotypic effects of sorghum accessions on fecundity of sorghum head bug, *Calocoris angustatus* Lethiery

H.C. Sharma, V.F. Lopez & K.F. Nwanze
Cereals Program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh 502 324, India

Received 3 September 1992; accepted 1 December 1992

Key words: Calocoris angustatus, host-plant, resistance, fecundity, grain damage, sorghum, sorghum head bug, *Sorghum bicolor*

Summary

Sorghum head bug (*Calocoris angustatus* Leth.) (Hemiptera: Miridae) is an important pest of grain sorghum in India. We studied the fecundity of head bug females reared for one to three generations on head bug-resistant and head bug-susceptible genotypes during the 1988 and 1989 rainy and 1988-89 post-rainy seasons. Head bug population increase was lower for the first, second and/or third generation when the bugs were reared on IS 2761, IS 19955, IS 14334, IS 23748, IS 16357, IS 17610, and IS 21444 compared with the susceptible controls CSH 1, CSH 5, and CSH 9. These genotypes also suffered a low grain damage (damage rating (DR) ≤5) (except IS 2761) compared with the susceptible controls (DR >6). A marginal decrease in fecundity was observed when the bugs were reared on IS 2761, IS 14334, IS 16357, IS 20740 and IS 17610 and then transferred to the susceptible control, CSH 1. Sorghum genotypes having lower increase in bug population across generations, suffering low grain damage, and showing adverse effects on fecundity can be used in breeding for resistance to head bugs.

Introduction

Sorghum head bug, *Calocoris angustatus* Lethiery (Hemiptera: Miridae) is one of the most important pests of grain sorghum in India (Cherian et al., 1941; Sharma, 1985a, 1985b; Natarajan & Sundara Babu, 1987; Hiremath & Thontadaraya, 1984; Sharma & Lopez, 1990a). Adults and nymphs of *C. angustatus* suck the sap from the developing grain, which remain unfilled, shrivel, and under severe infestation, become completely chaffy. In different parts of India, avoidable losses of 7–84% due to head bugs have been estimated (Leuschner & Sharma, 1983). Under experimental conditions, 55–84% losses have been recorded in the commercial cultivars CSH 5, ICSV 1, and CSH 1 (Sharma & Lopez, 1989).

Host-plant resistance is one of the most important components for the management of sorghum head bug (Sharma, 1985b; Sharma & Lopez, 1991a, 1991b). At the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India, major emphasis has been placed on identifying sources of resistance, understanding the mechanisms of resistance, and transferring head bug resistance into high yielding agronomically acceptable cultivars.

Cultivar nonpreference by the adults, lower oviposition, and antibiosis are the major components of resistance in sorghum to *C. angustatus* (Sharma

& Lopez, 1990b; Padma Kumari, 1991). Antibiosis to head bugs is expressed in terms of a slight delay in the postembryonic developmental period, nymphal mortality, and reduced efficiency of consumption and utilization of food. Some of these effects on insect development may influence the fecundity of head bug females. Therefore, it is important to determine the reproductive potential of *C. angustatus* exposed to sorghum genotypes over successive generations. This paper reports the results of studies on head bug population increase on resistant and susceptible genotypes under no-choice conditions in headcages over two to three successive generations, and the effect of head bug resistant genotypes on the fecundity of *C. angustatus* females.

Materials and methods

The experiments were conducted out at the ICRISAT Center, Patancheru, India during the 1988 and 1989 rainy (July-October) and 1988/89 (November-April) post-rainy seasons.

Crop

Sorghum was raised under rainfed conditions during the rainy season, and under irrigated conditions during the post-rainy season. Test cultivars were planted in a randomized block design. There were two replications. Each plot was $24 m^2$, and had 8 ridges, 4 m long, and 75 cm apart. The plants were thinned to a spacing of 10 cm 15 days after seedling emergence. Three plantings were taken up in each season at an interval of 15 to 20 days to study the population buildup and grain damage from successive generations on the same genotype and on CSH 1, the susceptible control. Carbofuran 3 'G' was applied at the rate of 1.2 Kg a.i. ha^{-1} at sowing to control sorghum shoot fly (*Atherigona soccata* Rond.) and the spotted stem borer (*Chilo partellus* Swin.) during the seedling stage. No insecticide was applied during the reproductive phase of the crop.

Two less susceptible (IS 2761 and IS 9692) (Sharma & Lopez, 1991b), and three commercial cultivars (Swarna, CSH 5 and CSH 1) were tested during the 1988 rainy season. During the 1989 rainy season, six resistant cultivars (IS 17610, IS 20740, IS 16357, IS 14334, IS 21444, and IS 19955) (Sharma & Lopez, 1992b) were compared with three susceptible controls (ICSV 112, CSH 5 and CSH 9) for bug population increase and grain damage. During the 1988/89 post-rainy season, head bug fecundity on five bug-resistant genotypes (IS 14334, IS 21444, IS 19955, IS 23748 and IS 16357) was compared with that on two commercial cultivars (CSH 5 and ICSV 112). Head bug-susceptible hybrid, CSH 1 was used as a standard check to compare progeny production by the females reared on bug-resistant and -susceptible genotypes for one and/or two successive generations.

Insects

Head bugs collected from the field were reared on CSH 1 panicles (5 pairs/panicle) at the half-anthesis stage under the headcage to raise the insect culture for these studies (Sharma et al., 1988; Sharma & Lopez, 1992a). Twenty days after infestation, bugs were collected into 200 ml plastic bottles (5 pairs in each bottle) with an aspirator from the CSH 1 panicles, and were used for infesting different genotypes. Ten panicles were tagged at random in each plot at half-anthesis. Each panicle was infested with 5 pairs of bugs/panicle using the headcage technique (Sharma et al., 1988). The number of bugs produced from 5 pairs of bugs on each panicle were counted 20 days after infestation. Bugs from each genotype were collected in a muslin cloth bag, and the adults were collected in pairs of five with aspirators in 200 ml plastic bottles. Bugs reared on a genotype were used to infest the same genotype and CSH 1 in the second and third generations. Ten panicles were infested in each plot. Bug population increase in the infested panicles was taken as a measure of insect fecundity on the resistant and susceptible genotypes. Head bug numbers in the infested panicles were recorded 20 days after infestation.

Damage evaluation

Grain damage in the infested panicles was evaluated on a 1 to 9 scale at maturity (1 = a few grains with feeding punctures, and 9 = most grains with extensive feeding, tanning and showing more than 80% shriveling) (Sharma & Lopez, 1992a; Sharma et al., 1992a).

Statistical analysis

Data were subjected to analysis of variance to compute the standard error of mean for each genotype so as to compare genotypic effects on population increase and grain damage in different sorghum genotypes.

Results

Head bug numbers per panicle varied from 228 on IS 2761 to 452 on CSH 5 in the first generation during the 1988 rainy season (Fig. 1). In the second generation when the bugs were reared on the same genotype, there were 138 bugs/panicle on IS 2761 compared to 218 bugs per panicle on CSH 5. There were 260 bugs/panicle in the second generation on CSH 1 from bugs reared on IS 2761 in the previous generation compared with 351 bugs/panicle from those reared on CSH 1. Thus, there was a slight reduction in progeny production in the bugs reared on IS 2761 for one generation. Grain damage was considerably high on all the genotypes (damage rating 7.3 to 9.0) in the first generation. In the second generation, IS 2761 suffered moderate levels of grain damage (DR 5) compared to Swarna (DR 9).

During the 1988/89 post-rainy season, bug population increase was low on all genotypes (42 to 103 bugs/panicle) in the first generation, possibly because of low temperatures during January (15–25°C) (Fig. 2). Head bug population increase was lower on IS 17610, IS 20740, IS 16357, IS 14334 and IS 21444 compared to CSH 9. In the second generation, bug population increase was low (35 to 87 bugs/panicle) on IS 14334, IS 16357, IS 19955, IS 20740, IS 21444, ICSV 112 and IS 17610 compared to 198 and 232 bugs per panicle in CSH 9 and CSH 1, respectively. Progeny production on CSH 1 from bugs reared on different genotypes during the previous generation was low and at par with the same genotype in case of IS 19955 and IS 20740 (48–55 bugs/panicle). Moderate levels of population increase were recorded on CSH 1 from bugs reared on IS 14334, IS 16357, ICSV 112 and IS 17610 (111 to 118 bugs/panicle) for one generation compared with 166 and 157 bugs/panicle on CSH 9 and CSH 1, respectively. In the third generation, lower population increase was recorded on IS 14334, IS 16357 and IS 21444 (40–96 bugs/panicle) compared with 104 to 166 bugs/panicle on CSH 5, ICSV 112 and CSH 1. Progeny production on CSH 1 was marginally lower from bugs reared for two generations on IS 14334 and IS 16357. Low population increase observed in bugs reared on IS 19955 in the second generation was not confirmed in the third generation. Grain damage was lower (DR <5) in IS 17610, IS 14334, IS 19955, IS 20740, and IS 21444 over three generations compared with CSH 9, ICSV 112, and CSH 1 (DR 5.6 to 9.0).

Bug population increase was lower on IS 14334, IS 21444, IS 19955, and IS 23748 in the first generation, and these genotypes suffered moderate levels of grain damage (DR 4.5 to 6.0) during the 1989 rainy season (Fig. 3). In the second generation, lower increase in bug numbers was recorded on IS 14334, IS 21444 and IS 19955 compared with CSH 9 and ICSV 112. Differences in progeny production on CSH 1 from bugs reared on different genotypes were not substantial. Least increase in bug population was recorded in bugs reared on IS 21444 (207 bugs/panicle) compared with 293 bugs/panicle from those reared on CSH 9.

Discussion

Cultivar nonpreferences and antibiosis are the major components of resistance to *C. angustatus* (Sharma & Lopez, 1990b), and the antibiosis effects may influence the reproductive potential of the head bug females. There was a considerable variation in head bug population increase on different genotypes across successive generations, and/or across

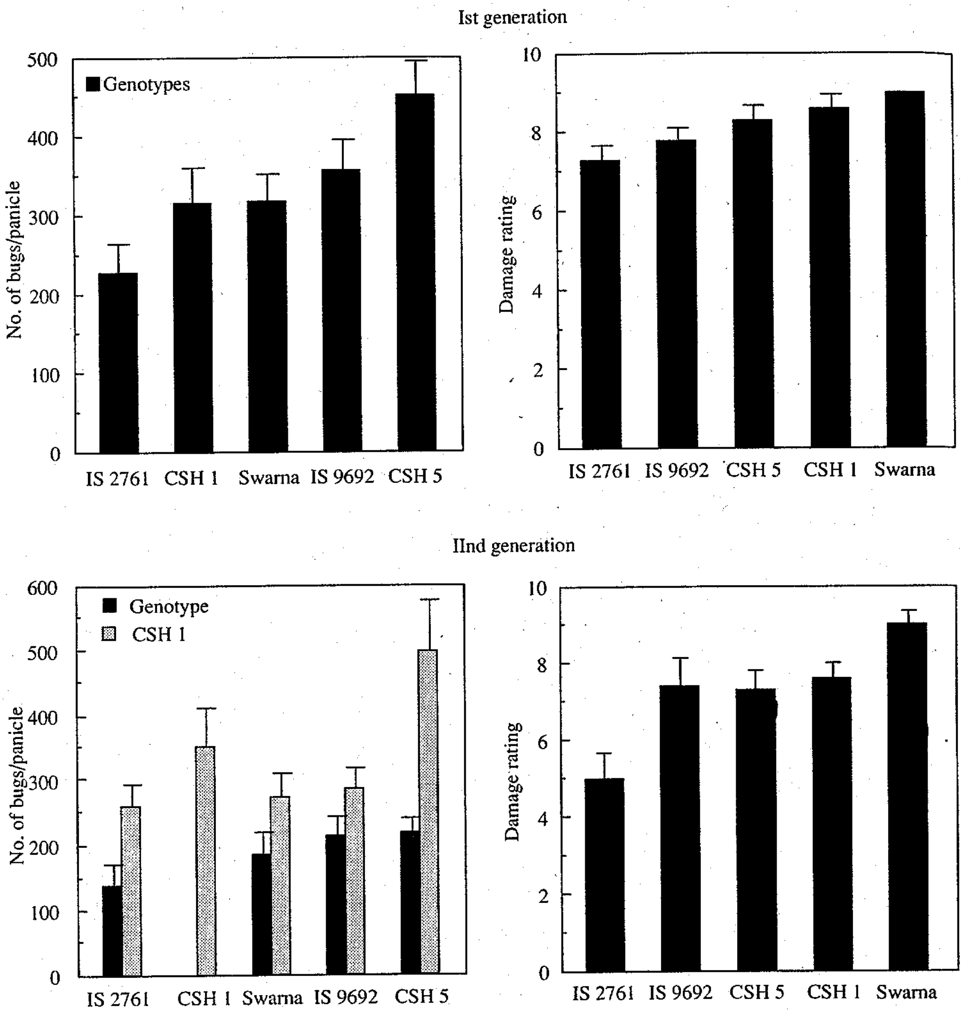

Fig. 1. Head bug population increase and grain damage (from 5 pairs of bugs/panicle) under headcage in five sorghum genotypes over two generations. In the second generation, bug population increase (fecundity) was recorded on CSH 1 and the respective genotypes on which the bugs were reared in the first generation. (ICRISAT Center, 1988 *rainy season.*) (Mean ±SEM.)

seasons. Progeny production on IS 16357, IS 19955 and ICSV 112; and of the bugs reared on these genotypes and then transferred on to CSH 1 for oviposition differed substantially across seasons. Environmental changes within and across seasons influence genotypic resistance to insects (Sharma et al., 1988; 1992b; Sharma & Lopez, 1991). Environmental conditions not only affect the survival and development of head bugs (Sharma & Lopez, 1990a), but also affect the physico-chemical characteristics of the host plants (Sharma et al., 1992b) which in turn may affect the genotypic resistance to and population increase of *C. angustatus*. Head bug population increase under no-choice conditions in the head-

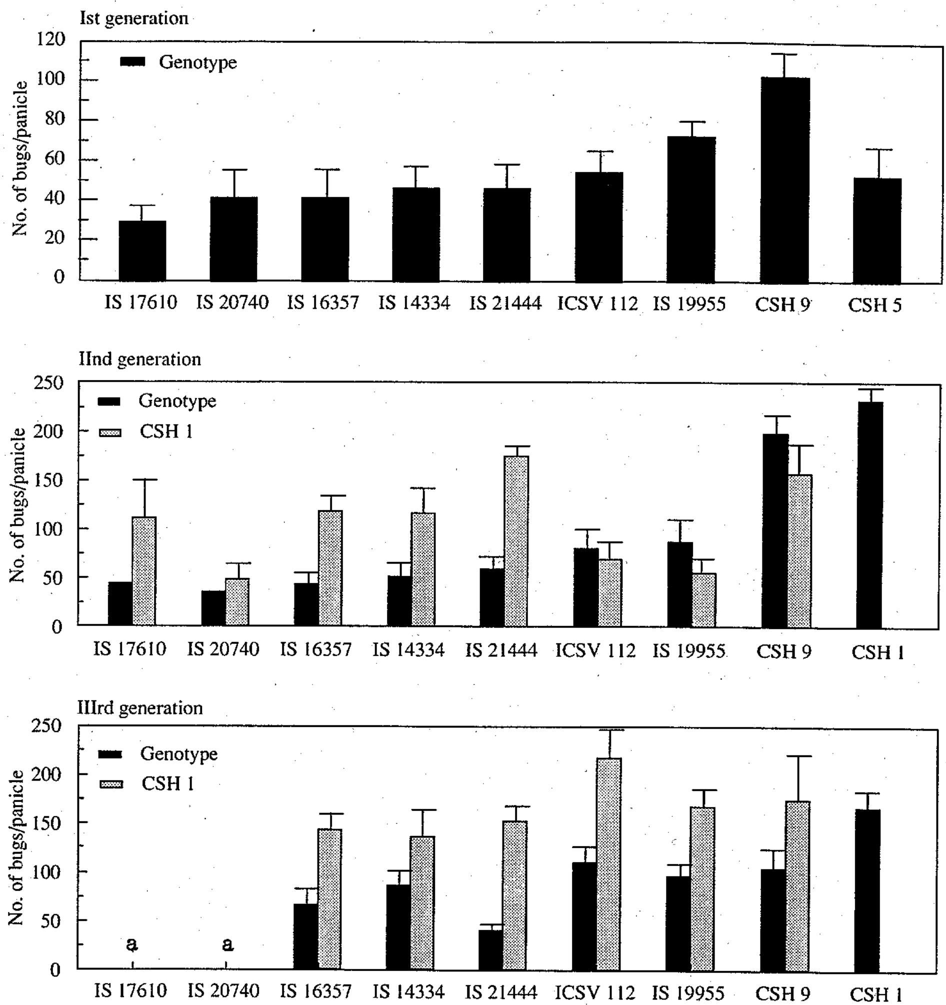

Fig. 2. Head bug population increase (from 5 pairs of bugs/panicle) in nine sorghum genotypes over three generations. In the second and third generations, the fecundity was recorded on CSH 1 and the respective genotypes on which the bugs were reared in the previous generation. (ICRISAT Center, 1988/89 *post-rainy season.*) a = Not studied. (Mean ±SEM.)

cage was lower on IS 2761, IS 14334, IS 16357, IS 19955, IS 20740, IS 21444, and IS 17610 compared to the susceptible controls. Lower population increase on these genotypes may be largely because of lower oviposition, and/or nymphal mortality (Sharma & Lopez, 1990b). These genotypes also suffered low grain damage (DR<5) (except IS 1761 and IS 16357) across seasons and/or successive generations.

Genotypic effects on insects fecundity have earlier been reported for sorghum shoot fly (*Atherigona*

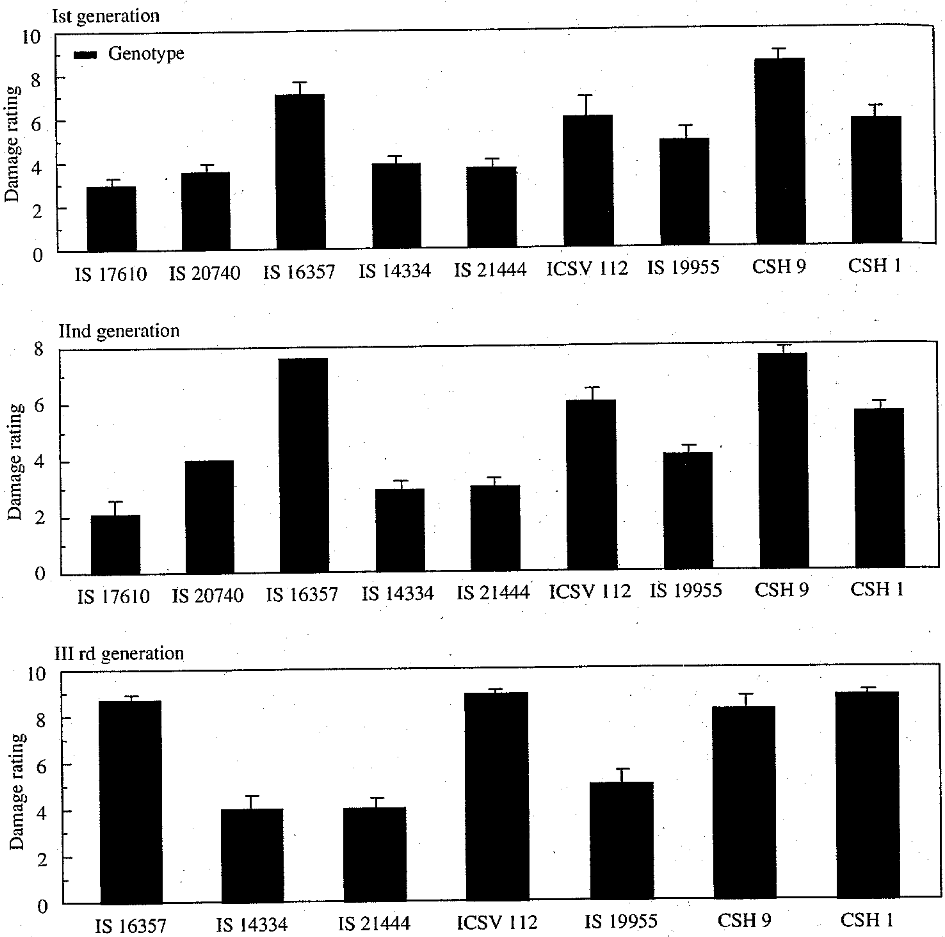

Fig. 3. Grain damage rating in nine sorghum genotypes infested with 5 pairs of bugs over three generations. Bugs reared n a genotype were used to infest the same genotype in the second and third generations. (ICRISAT Center 1988/89 *post-rainy season.*) (Mean ±SEM.)

soccata Rond.) (Singh & Narayana, 1978) and sorghum midge (*Contarinia sorghicola* Coq.) (Sharma et al., 1992b). Differences in progeny production on CSH 1 in the second and/or third generation from bugs reared on different genotypes were not substantial. Marginal reductions in progeny production were recorded in bugs reared on IS 2761, IS 14334, IS 20740, IS 21444 and IS 16357. Head bug fedundity in general was lower on the respective genotypes in the second generation (on which the bugs were reared during first generation) than on CSH 1 in the second generation. Bug population increase on different genotypes and on CSH 1 from bugs reared on bug-resistant genotypes varied substantially. This indicates that other components of resistance such as oviposition nonpreference and nymph survival varied between different genotypes. Differences in the fecundity of bugs on CSH 1

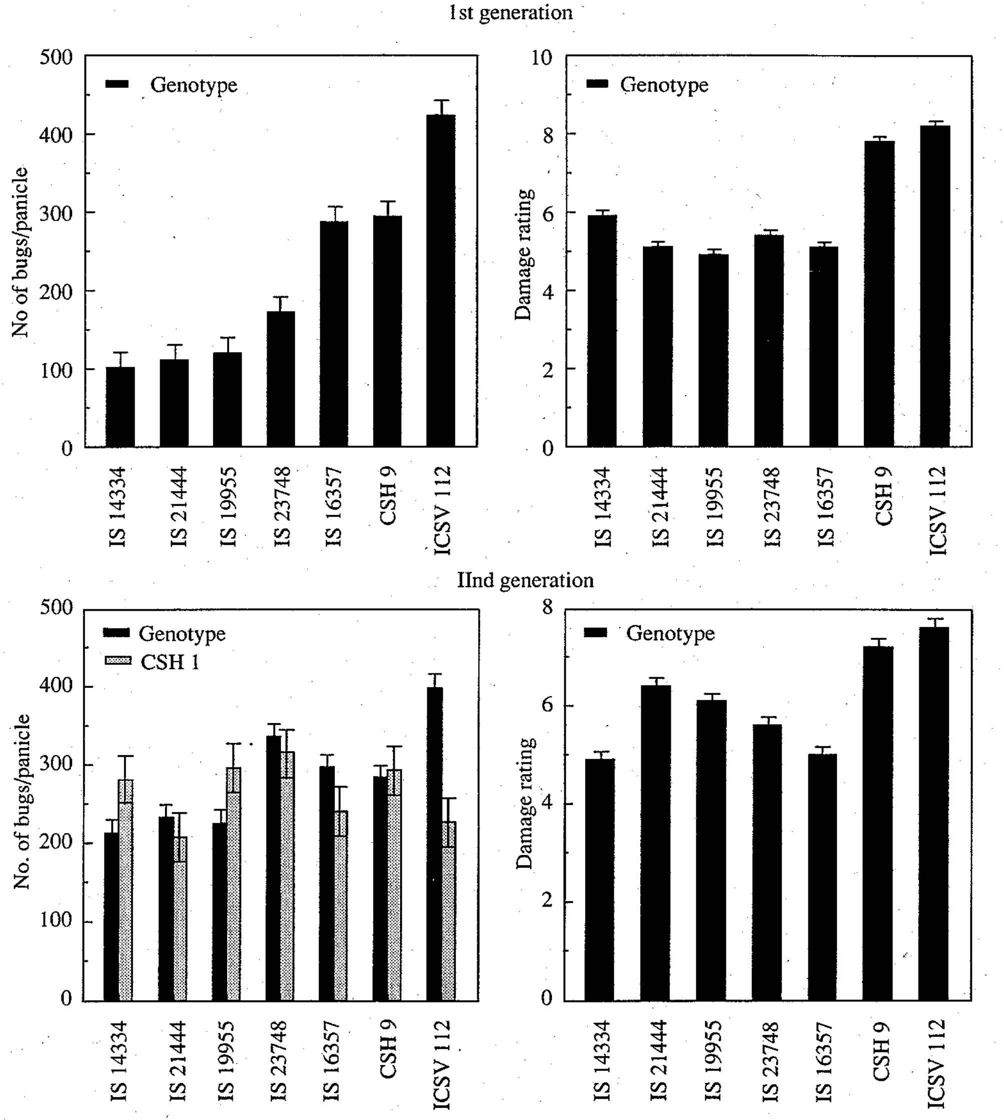

Fig. 4. Head bug population increase and grain damage (from 5 pairs of bugs/panicle) in seven sorghum genotypes over two generations. Head bug fecundity in the second generation was recorded on CSH 1 and the respective genotypes on which they were reared during first generation (ICRISAT Center, 1989 *rainy season.*) (Mean ±SEM.)

from bugs reared on different genotypes indicated that antibiosis effects of resistant genotypes are also expressed in terms of reproductive potential of head bugs although such differences were not large enough. Fecundity of bugs reared on different genotypes was lower on CSH 1 than the bugs reared on CSH 1 (except on CSH 5 during the 1988 rainy season and ICSV 112 during the 1988/89 post-rainy season). Rearing the bugs for one or two generations on a resistant genotype with antibiosis may not have resulted in substantial effects on fecundity. Head bug females continue to lay eggs for a period of 10 to 15 days (Sharma & Lopez, 1990a), and this gives them enough time to offset the adverse effects of resistant genotypes when confined with the susceptible cultivar (CSH 1) to determine their reproductive potential. Further studies are required to elucidate the adverse effects of resistant genotypes on bug fecundity, and this may require rearing the bugs for several generations on resistant genotypes, and restricting the egg laying period on the susceptible cultivar to 3–5 days so that bugs do not get enough time to feed on the susceptible cultivar to compensate for the adverse effects of resistant genotypes.

Several head bug resistant lines show lower increase in bug population under no-choice conditions in the headcage across successive bug generations, and suffer low grain damage. Some of these lines also seem to affect head bug fecundity, which can be used in combination with other mechanisms of resistance such as cultivar nonpreference to breed sorghum cultivars resistant to *Calocoris angustatus*.

Acknowledgements

We thank Mr. V.V. Rao and Mr. S. Raja Rao for their assistance in these studies, Mr. P. Vidyasagar for his help in statistical analysis, Dr. J.M.J. de Wet for his comments, and Mr. I. Krishna Murthy for typing the manuscript.

Approved as Journal Article No. 1319 by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, 502 324, India.

References

Cherian, M.C., M.S. Kylasam & P.S. Krishnamurthy, 1941. Further studies on *Calocoris angustatus* Leth. Madras Agric. J. 29: 66–69.

Hiremath, I.G. & T.S. Thontadaraya, 1984. Seasonal incidence of the sorghum earhead bug, *Calocoris angustatus* Lethiery. (Hemiptera: Miridae). Insect Sci. Applic. 5: 467–474.

Leuschner, K. & H.C. Sharma, 1983. Estimation of crop losses due to sorghum panicle pests. In: B.H. Krishnamurthy Rao & K.S.R.K. Murty (Eds.) Proceedings of the National Seminar on Crop Losses due to Insect Pests. Rajendranagar, Hyderabad, India: Entomological Society of India.

Natarajan, N. & P.C. Sundara Babu, 1987. Bionomics of sorghum head bug, *Calocoris angustatus* Lethiery. Madras Agric. J. 74: 186–192.

Padma Kumari, A.P., 1991. Mechanisms of resistance in sorghum to earhead bug, *Calocoris angustatus* Lethiery (Hemiptera: Miridae). M.Sc. Thesis. Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad, India.

Sharma, H.C., 1985a. Future strategies for pest control in sorghum in India. Trop. Pest Manag. 31: 167–185.

Sharma, H.C., 1985b. Screening for host-plant resistance to mirid head bugs in sorghum. In: Proceedings, International Sorghum Entomology Workshop, 15–21 July 1984, Texas A&M University, College Station, Texas, USA, pp. 317–336. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh. 502 324, India.

Sharma, H.C. & V.F. Lopez, 1989. Assessment of avoidable losses and economic injury levels for sorghum head bug, *Calocoris angustatus* Leth. (Hemiptera: Miridae). Crop Prot. 8: 429–435.

Sharma, H.C. & V.F. Lopez, 1990a. Biology and population dynamics of sorghum head bugs (Hemiptera: Miridae). Crop Prot. 9: 164–173.

Sharma, H.C. & V.F. Lopez, 1990b. Mechanisms of resistance to sorghum head bug, *Calocoris angustatus*. Entomol. Exp. Applic. 57: 285–294.

Sharma, H.C. & V.F. Lopez, 1991a. Stability of resistance in sorghum to *Calocoris angustatus* (Hemiptera: Miridae). J. Econ. Entomol. 91: 1088–1094.

Sharma, H.C. & V.F. Lopez, 1992a. Screening for plant resistance to sorghum head bug, *Calocoris angustatus* Leth. Insect Sci. Applic. 13: 315–325.

Sharma, H.C. & V.F. Lopez, 1992b. Genotypic resistance in sorghum to head bug, *Calocoris angustatus*. Euphytica 58: 193–200.

Sharma, H.C., P. Vidyasagar & K. Leuschner, 1988. No-choice cage technique to screen for resistance to sorghum midge (Diptera: Cecidomyiidae). J. Econ. Entomol. 81: 415–422.

Sharma, H.C., S.L. Taneja, K. Leuschner & K.F. Nwanze, 1992a. Techniques to screen sorghums for resistance to insect pests. Information Bulletin No. 32. Patancheru, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). 48 pp.

Sharma, H.C., P. Vidyasagar & V. Subramanya, 1992b. Anti-

biosis mechanism of resistance to sorghum midge, *Contarinia sorghicola*. Ann. Appl. Biol. (submitted).
Singh, R. & K.L. Narayana, 1978. Influence of different varieties of sorghum on the biology of sorghum shoot fly. Indian J. Agric. Sci. 48: 8–12.