# Entomology

## Cytoplasmic Male-sterility Affects Expression of Resistance to Shoot Bug (*Peregrinus maidis*), Sugarcane Aphid (*Melanaphis sacchari*) and Spotted Stem Borer (*Chilo partellus*) in Sorghum

**MK Dhillon, HC Sharma***, **G Pampapathy** and **Belum VS Reddy**
[International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India]
*Corresponding author: h.sharma@cgiar.org

### Introduction

Discovery of cytoplasmic male-sterility (CMS) has led to large-scale exploitation of heterotic potential for increasing crop production (Kaul 1988). Most of the sorghum [*Sorghum bicolor* (L.) Moench] hybrids developed have been based on *milo* ($A_1$) cytoplasm with only a few hybrids based on $A_2$ cytoplasm in China (Shan et al. 2000). The $A_1$ cytoplasm-based hybrids have been reported to be highly susceptible to insect pests (Sharma 2001; Sharma et al. 2004; Dhillon et al. 2006). Therefore, it is important to diversify the CMS systems to safeguard against outbreaks of insect pests and diseases. In addition to diversifying CMS sources, it is also important to understand the interactions between the target insect pests and hybrid parents to develop appropriate strategies for development and deployment of insect-resistant hybrids. Therefore, we examined the influence of CMS on the expression of resistance to shoot bug [*Peregrinus maidis* (Ashmead)], sugarcane aphid [*Melanaphis sacchari* (Zehntner)] and spotted stem borer [*Chilo partellus* (Swinhoe)] for deploying insect-resistance genes through high-yielding hybrids of sorghum for integrated pest management.

### Materials and Methods

The present studies were undertaken on a diverse range of CMS (A), maintainer (B) and restorer (R) lines. Twelve A and B pairs (SPSFR 94011, SPSFR 94012, SPSFR 94010, SPSFR 94006, SPSFR 94007, SPSFR 94034, SP 55299, SP 55301, Tx 623, 296, CK 60 and ICSA 42), 12 R-lines (ICSV 705, ICSV 700, ICSV 708, PS 30710, SFCR 151, SFCR 125, ICSV 91011, CS 3541, MR 750, ICSV 745, Swarna and IS 18551), and their 144 $F_1$ hybrids were used to understand the influence of CMS on expression of resistance to sugarcane aphid, shoot bug and spotted stem borer. The CMS and restorer lines were mated in a line × tester mating design. The material was evaluated for resistance/susceptibility to shoot bug and sugarcane aphid under natural infestation in the field. For spotted stem borer, the test material was artificially infested with the laboratory-reared neonate *C. partellus* larvae using a bazooka applicator (Taneja and Leuschner 1985; Sharma et al. 1992). The material was sown in the field in 2 rows 2 m long and 75 cm apart. The seedlings were thinned to a spacing of 15 cm between plants at 10 days after seedling emergence (DAE). There were three replications in a randomized complete block design. Normal agronomic practices were followed for raising the crop, but there was no insecticide application in the experimental plots. The proportion of plants with stem borer deadhearts was recorded at 35 DAE (Sharma et al. 1992). Whorl damage by the shoot bug and extent of leaf damage by the sugarcane aphid were recorded visually on a 1–9 damage rating (DR) scale (1 = <10% leaf area damaged and 9 = >80% leaf area damaged) (Sharma et al. 1997). Data on insect damage and/or numbers were subjected to analysis of variance.

### Results and Discussion

Insect-resistant CMS lines (A-lines) were more susceptible than the respective maintainer lines (B-lines). Sugarcane aphid-resistant CMS lines suffered a damage rating of 3.2 compared to 2.0 for B-lines, while the CMS and maintainer lines of susceptible parents showed damage rating of 5.0 and 4.9, respectively (Fig. 1a). The A- and B-lines of shoot bug-resistant parents showed a damage rating of 6.7 and 5.4, respectively, while susceptible A- and B-lines showed a damage rating of 7.7 and 7.5, respectively (Fig. 1b). Deadheart formation due to stem borer damage in stem borer-resistant A- and B-lines (30%) was similar while susceptible B-lines showed more damage (54% deadhearts) than the A-lines (44.4% deadhearts) (Fig. 1c). In general, A-lines exhibited greater susceptibility than B-lines (except in the case of stem borer), suggesting that factors in the cytoplasm of the maintainer line influence the expression of resistance to insects. Similar findings have also been reported for midge [*Stenodiplosis sorghicola* (Coquillett)] (Sharma et al. 1994) and shoot

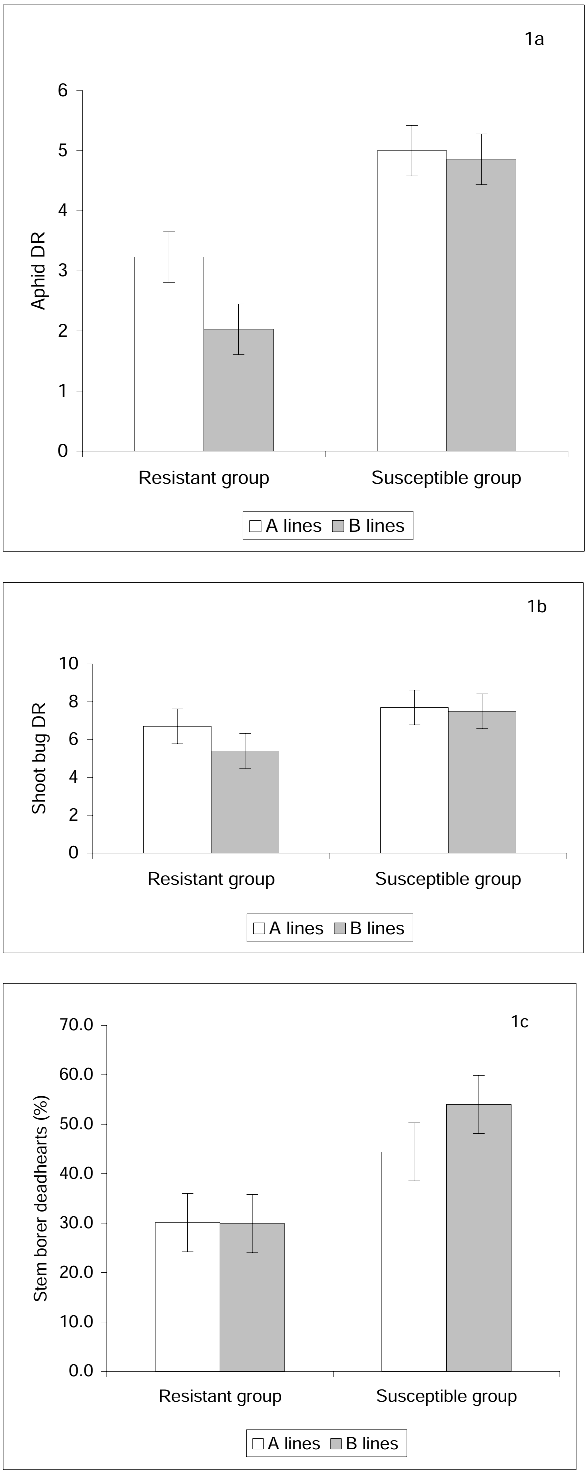


**Figure 1.** Effect of CMS on expression of resistance to insects: (a) sugarcane aphid, *Melanaphis sacchari*; (b) shoot bug, *Peregrinus maidis*; and (c) stem borer, *Chilo partellus*. Resistant group = Mean insect infestation in the insect-resistant A- and B-lines, and susceptible group = Mean insect infestation in insect-susceptible A- and B-lines. DR = Damage rating (1–9).

fly [*Atherigona soccata* (Rondani)] in sorghum (Dhillon et al. 2006). Expression of resistance may also be influenced by the interaction of factors in the cytoplasm of maintainer lines with nuclear genes.

Most of the sorghum hybrids grown in India are based on $A_1$ cytoplasm, and are susceptible to insect pests (Sharma et al. 2004). The aphid damage score in hybrids based on aphid-resistant parents was significantly lower (DR 3.3) than in hybrids based on other cross combinations (DR 4.1–5.2) (Fig. 2a). Hybrids based on aphid-resistant CMS × R-lines also had lower aphid damage rating (DR 4.1) than the hybrids based on susceptible CMS × resistant or susceptible R lines (DR 4.7 and 5.2). The shoot bug damage score in hybrids based on resistant × resistant parents was lower (DR 5.4) than in hybrids based on other cross combinations (DR 6.4–7.5) (Fig. 2b). The hybrids based on shoot bug-resistant CMS × susceptible R-lines had lower damage rating (DR 6.4) than hybrids based on susceptible CMS × resistant or susceptible R-lines (DR 7.2 and 7.5). Hybrids based on CMS lines resistant to sugarcane aphid or shoot bug and susceptible R-lines suffered less damage by these insects than the hybrids based on susceptible CMS × resistant or susceptible R-lines, suggesting that CMS lines influenced the expression of resistance to these insects. Similar results have also been reported in case of sorghum midge and shoot fly (Sharma et al. 1996; Sharma 2001; Dhillon et al. 2006).

Hybrids based on stem borer-resistant or susceptible A-lines and resistant R-lines showed significantly lower deadheart formation (18.6% and 20.2%, respectively) as compared to hybrids based on stem borer-resistant or susceptible CMS lines and susceptible R-lines (30.3% and 33.0%, respectively) (Fig. 2c), suggesting that restorer genes influenced the expression of resistance to stem borer in sorghum.

Resistance to insects is largely governed by additive gene action, and resistance is needed in both parents to produce insect-resistant hybrids (Sharma et al. 1996; Dhillon et al. 2006). The present studies indicated that resistance to sugarcane aphid and shoot bug is influenced by CMS lines, while resistance to spotted stem borer is influenced by R-lines. Hybrids based on resistant CMS and R-lines were more resistant than those based on other cross combinations, suggesting that there is a need to transfer insect resistance genes into A-, B-, and R-lines to develop hybrids with multiple resistance to insect pests for sustainable crop production.

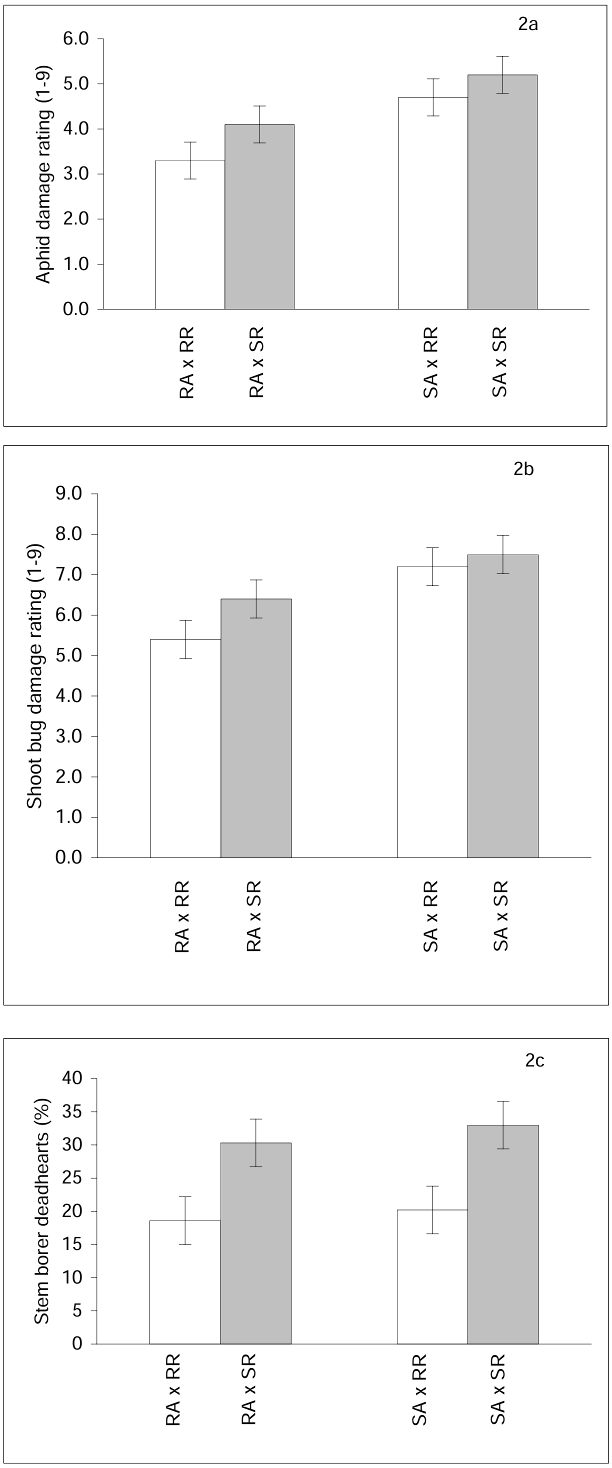


**Figure 2.** Insect damage/numbers in sorghum hybrids based on insect-resistant or -susceptible CMS and restorer lines: (a) sugarcane aphid, *Melanaphis sacchari*; (b) shoot bug, *Peregrinus maidis*; and (c) stem borer, *Chilo partellus*. RA = Resistant CMS (A) lines. SA = Susceptible CMS (A) lines. RR = Resistant restorer (R) lines. SR = Susceptible restorer (R) lines.

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