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Effect of Insecticide Application and Host Plant Resistance on Parasitization of Sorghum Midge, *Contarinia sorghicola* Coq.

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*Sorghum midge (*Contarinia sorghicola *Coq.) (Diptera: Cecidomyiidae) is one of the most important pests of grain sorghum. The effects of different insecticides applied at the complete-anthesis stage for insect control, and host plant resistance on the parasitization of sorghum midge, were studied.* Tetrastichus *spp. and* Eupelmus popa *are the major parasites of sorghum midge larvae. Of the several insecticides tested, monocrotophos reduced midge parasitization by half compared with the untreated control. Midge parasitization was lower on midge-resistant genotypes. Amongst the lines resistant to sorghum midge, the levels of parasitization were higher on the moderately resistant lines IS 10132 and PM 9760 compared to those on IS 3461, IS 7005, IS 9807, IS 19512 and AF 28, etc. Parasite activity closely followed the midge population density across sowing dates. The role of these factors on the effectiveness of midge parasites in integrated pest management are discussed.*

Keywords: *insecticides,* Contarinia sorghicola, *parasites, host plant resistance*

INTRODUCTION

The sorghum midge, *Contarinia sorghicola* Coq. (Diptera: Cecidomyiidae) is one of the most important pests of grain sorghum (Harris, 1976). Host plant resistance, timely planting and need-based application of insecticides are the principal components for control of this insect (Teetes, 1985; Sharma, 1993). Introduction of high-yielding compact-panicled hybrids has led to an increase in the severity of head bug (*Calocoris angustatus* Leth.) (Hemiptera: Miridae) and midge damage (Sharma & Leuschner, 1987). During periods of uneven rains and when cultivars with different maturities are planted in the same area, the population densities of these insects increase tremendously and may require insecticide application to minimize the losses in grain yield and quality. Considerable progress has been made in developing crop cultivars resistant to sorghum midge (Peterson *et al.*, 1985; Agrawal *et al.*, 1987; Sharma *et al.*, 1993). Introduction of midge-resistant cultivars and use of insecticides for the control of panicle-feeding insects may affect the activity and survival of natural enemies. *Aprostocetus diplosidis* Craw., *Tetrastichus coimbatorensis* Roh., *Eupelmus popa* Gir. (Eulophidae: Hymenoptera) and *Apanteles* sp. (Braconidae: Hymenoptera) are the major parasites recorded on sorghum midge (Chandurwar, 1977; Taley *et al.*, 1978; Wiseman *et al.*, 1978; Reddy & Davies, 1979; Thontadaraya *et al.* 1979, 1983; Baxendale *et al.*, 1983). The extent of parasitization can be very high (up to 80%), and natural enemies play a major role in reducing the carry-over and population build-up of sorghum midge *C. sorghicola*. There is no information available on either the effect of insecticide application or midge-resistant genotypes on the activity of natural enemies. In the present study, the effects of insecticide application and host plant resistance on the parasitization of midge larvae under field conditions were examined.

MATERIALS AND METHODS

Effect of Insecticide Application on Parasitization of Sorghum Midge Larvae

These experiments were conducted at the International Crops Research Institute for the Semi-Arid Tropics, Patancheru, A.P. India (18°N, 78°E). Commercial sorghum hybrid CSH 1 was raised on Vertisols during the 1982–84 rainy (July–October) and post-rainy (November–April) seasons. The crop was raised on ridges 75 cm apart. The seedlings were thinned to a spacing of 10 cm between the plants, 15 days after emergence. The experiments were conducted in a randomized block design with three replications. Each plot measured 12 m^2. The experiments were conducted primarily to develop a schedule for the chemical control of head bugs (Sharma & Leuschner, 1987). Observations were recorded on spikelets with midge larvae (%), chaffy spikelets due to midge damage (%) and chaffy spikelets with emergence holes of midge parasite(s)/100 spikelets. After completing development, the midge parasites make a small exit hole in the mid portion of the glume, and the number of such exit holes were counted in 100 chaffy spikelets drawn at random to record the activity of midge parasites. Data on midge larvae and chaffy spikelets were recorded in a sample of 500 spikelets drawn from five panicles at random as described by Sharma *et al.* (1988). The effects of different contact and systemic insecticides applied at the complete-anthesis stage, carbaryl (0.05, 0.1, 0.2 and 0.4% a.i.) applied at complete anthesis and carbaryl (0.1% a.i.) sprays applied at different stages of panicle development (i..e. half-anthesis, complete anthesis and milk stages), on midge parasitization were recorded.

Dynamics of Midge Incidence and Parasitization Across Sowing Dates

Fluctuations in midge damage and the extent of parasitization were studied on a midge-resistant cultivar (TAM 2566) and a midge-susceptible cultivar (CSH 1) planted at fortnightly intervals during 1980–81. There were three replications in a randomized complete block design (RBD) in each sowing. RBD was followed for each sowing to avoid problems in field operations, crop management and shading effect caused by different plant heights in crops planted at different intervals. The crop was raised on red Alfisols and was planted sequentially over 24 sowing dates. Other agronomic details were similar to those described earlier. Data were recorded on chaffy spikelets and percentage of chaffy spikelets with parasite exit holes as described earlier.

Effect of Midge-resistant Cultivars on Parasitization of Midge Larvae

Midge parasitization was studied on 25 sorghum genotypes consisting of 13 resistant, nine moderately resistant and three susceptible commercial cultivars. The entries were planted in two row plots, 4-m long on red Alfisols during the 1984–85 post-rainy season. The trial was planted in a RBD with three replications. Other agronomic details are similar to those described earlier. Data were recorded on percentage of chaffy spikelets in a sample of 500 spikelets drawn at random from five panicles in each replication (Sharma *et al.*, 1988). Midge parasitization (spikelets with parasite exit holes) was recorded in 100 chaffy spikelets drawn at random from five panicles in each replication.

TABLE 1. Effect of different insecticides applied at the complete-anthesis stage on the parasitization of sorghum midge, *C. sorghicola* (ICRISAT Center, 1982–83)

Insecticide	Conc. (% a.i)	Midge larvae (%) 1982–83 PR	1983 R	Chaffy spikelets (%) 1982–83 PR	1983 R	Parasite holes/ 100 spikelets 1982–83 PR	1983 R
Carbaryl	0.1	3.2	4.5	17.0	8.8	7.2	9.0
Malathion	0.05	5.4	6.5	12.6	9.5	8.2	8.3
Quinalphos	0.05	5.0	9.8	22.8	15.5	9.5	9.5
Fenvalerate	0.01	3.8	8.3	21.0	9.5	7.2	7.5
Chlorpyriphos	0.05	7.0	6.3	19.4	10.0	7.0	9.3
Untreated control		7.0	6.0	22.2	14.3	6.0	7.8
SE		± 0.97	± 2.65	± 2.98	± 2.97	± 0.88	± 1.57

R = rainy season; PR = post-rainy season.

Statistical Analysis

Data were subjected to analysis of variance to test the significance of differences between treatment means and to compute the standard error of mean.

RESULTS

Effect of Insecticide Application on Parasitization of Midge Larvae

Differences in spikelets with midge larvae (%) and chaffy spikelets (%) were not significant in different experiments. Malathion, carbaryl, quinalphos, fenvalerate and chlorpyriphos did not affect midge parasitization (7.0–9.5%) compared with the untreated control (6.8%) (Table 1). During the 1984 rainy season, plots sprayed with monocrotophos recorded only 6% parasitization of midge larvae compared with 12% in the untreated control plots (Figure 1); slight reduction in midge parasitism was also recorded in plots sprayed with carbaryl. Carbaryl sprayed at different concentrations at the complete-anthesis stage did not influence the extent of midge parasitization (Figure 2). Within seasons, there were no differences in midge parasitization levels in plots sprayed at different stages of panicle development with carbaryl (Table 2).

Dynamics of Midge Incidence and Parasitization of Midge Larvae Across Sowing Dates

Midge damage and larval parasitization were greater on CSH 1 than on TAM 2566 across sowing dates (Figure 3). Parasite activity was closely associated with the level of midge infestation on both the cultivars. Peaks in midge density were closely followed by an increase in the level of midge parasitization. Relatively greater parasite activity was recorded in crops planted during July. Maximum midge activity was recorded in crops planted during August. Peak parasite density was recorded nearly 1 month later than that of the sorghum midge. Both midge and parasite activity were low in crops planted during November–December and April–May.

Effect of Host Plant Resistance on Parasitization of *C. sorghicola* larvae

Parasitization of midge larvae was $<4\%$ on the midge-resistant genotypes compared with 8–16% parasitization on the susceptible commercial cultivars CSH 1, CSH 5 and Swarna (Table 3). Larval parasitization was $<1\%$ on the midge-resistant lines IS 3461, IS 7005, IS 8571, IS 9807, IS 19512, PM 9250, PM 10291, PM 10678, PM 10750, PM 11344 (ICSV 197), AF 28 and DJ 6514. On IS 10132 and PM 9760 (moderately resistant), midge parasitization was $>5\%$. Parasitization of midge larvae was positively correlated with the extent of midge damage ($r = 0.64$).

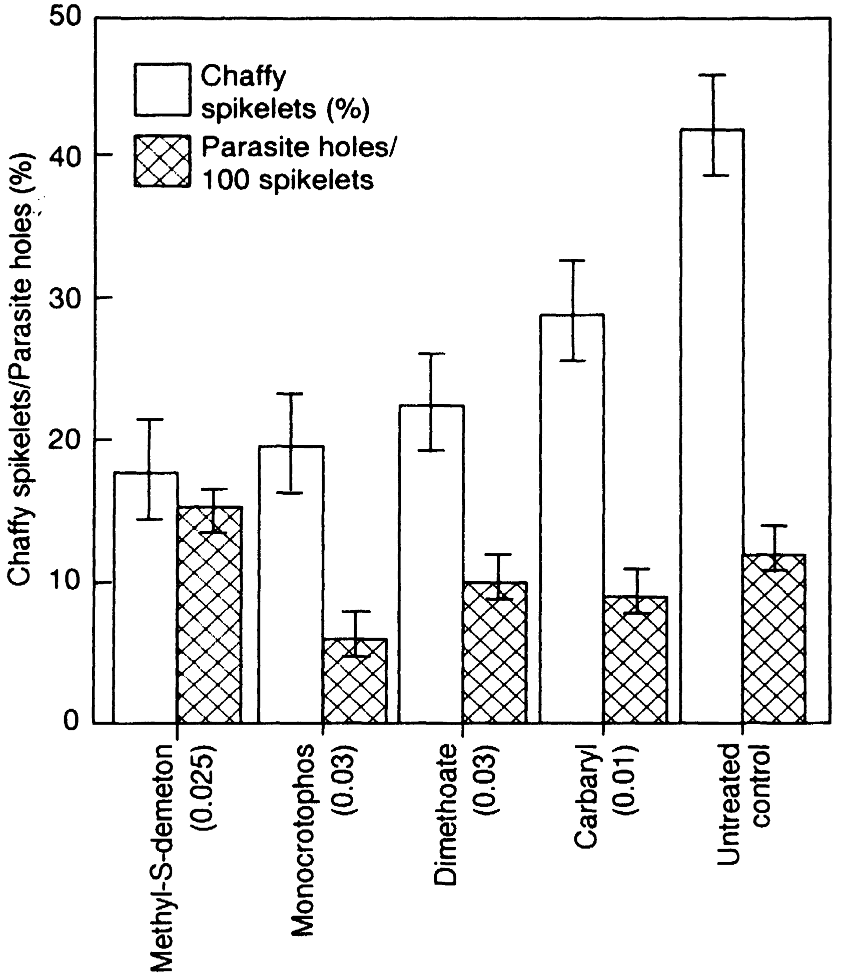

FIGURE 1. Effect of four insecticides applied at the complete-anthesis stage on parasitization of sorghum midge, *C. sorghicola* (ICRISAT Center, 1982, rainy season).

DISCUSSION

Insecticides in general are toxic to natural enemies; however, some insecticides are less toxic (Sharma & Adlakha, 1985). Elimination of natural enemies due to insecticide application leads to greater damage in sorghum by shoot fly, *Atherigona soccata* Rond. (Davies & Jowett, 1966) and by the bollworms (*Earias vittella* F. and *Pectinophora gossipiella* Saund.) in cotton (Sharma *et al.*, 1980). Of the various insecticides tested, only systemic insecticides (dimethoate, methyl-S-demeton and monocrotophos) resulted in lower levels of midge infestation. Carbaryl sprayed at different concentrations or at different stages of panicle development did not result in a significant reduction in midge incidence and parasite activity. Application of contact insecticides (Table 1) at the complete-anthesis stage did not affect midge infestation and the extent of parasitization because midge and parasite larvae are fully protected inside the glumes. By the time the parasite adults emerge from the spikelets, the residual toxicity of the insecticides had decreased substantially. However, systemic insecticides decreased midge damage, of which monocrotophos was toxic to the parasite. Phosphomidan has earlier been reported to be deleterious to midge parasites because of quick knock-down effect (Sharma *et al.*, 1988). More specific studies need to be conducted on the relative toxicity of insecticides recommended for the control of panicle feeding insects on the development and survival of midge parasites.

Parasitization of midge larvae is influenced by the genotypic resistance to sorghum midge. However, there is some variation in the levels of parasitism on different midge-resistant

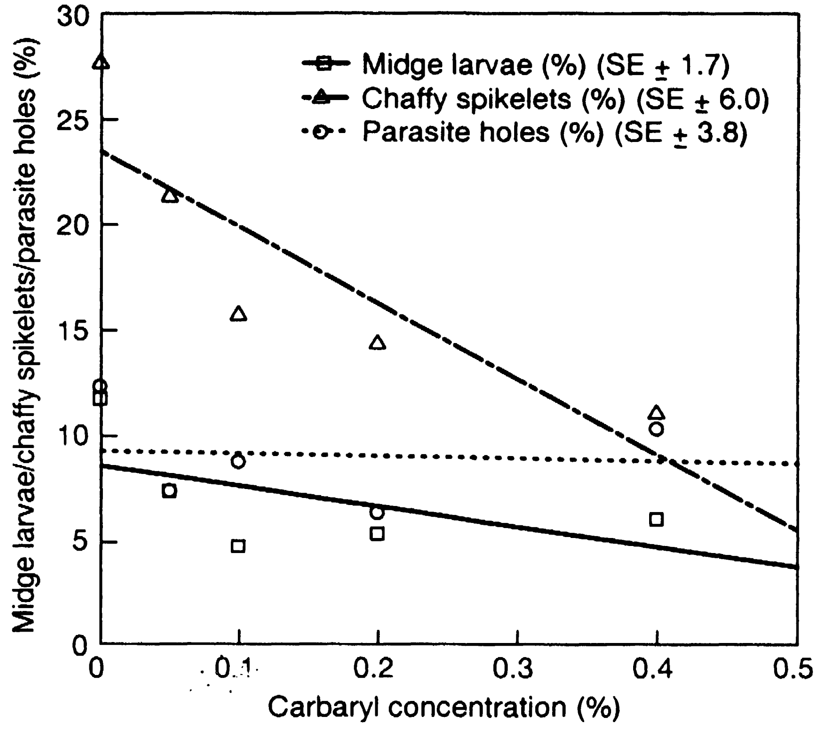

FIGURE 2. Effect of different concentrations of carbaryl at the complete-anthesis stage on parasitization of sorghum midge, *C. sorghicola* (ICRISAT Center, 1983, rainy season).

genotypes. Midge-resistant genotypes that allow greater activity of midge parasites can be utilized effectively in an integrated pest management system. However, genotypes with high levels of resistance to midge can be used to suppress midge populations without the involvement of natural enemies (Sharma, 1993). In such cases, the presence of factors that deter the midge parasites is of little consequence. However, genotypes with moderate levels of resistance need to be supplemented with natural enemies to keep the midge populations under economic threshold levels, and such genotypes should be hospitable to the natural enemies. The results of this study indicate that there is considerable variation in the relative preference of different genotypes by the midge parasites and so there is a considerable scope for integrating host plant resistance with natural enemies for integrated management of sorghum midge. The levels of parasitism were

TABLE 2. Effect of carbaryl sprays (0.1% a.i.) applied at different stages of panicle development on the parasitization of sorghum midge, *C. sorghicola* (1982–83)

Stage of panicle development	Midge larvae (%)		Chaffy spikelets (%)		Parasite holes/ 100 spikelets	
	1983 R	1982/83 PR	1983 R	1982/83 PR	1983 R	1982/83 PR
Half-anthesis	2.8	0.5	28.3	11.3	16.5	8.3
Complete anthesis	3.5	1.7	29.5	14.7	14.3	9.3
Milk	6.0	1.2	26.0	15.3	12.0	11.0
Untreated control	4.0	0.9	28.3	12.7	14.3	10.7
SE	± 0.97	± 0.3	± 2.88	± 4.1	± 2.78	± 2.2

R = rainy season; PR = post-rainy season.

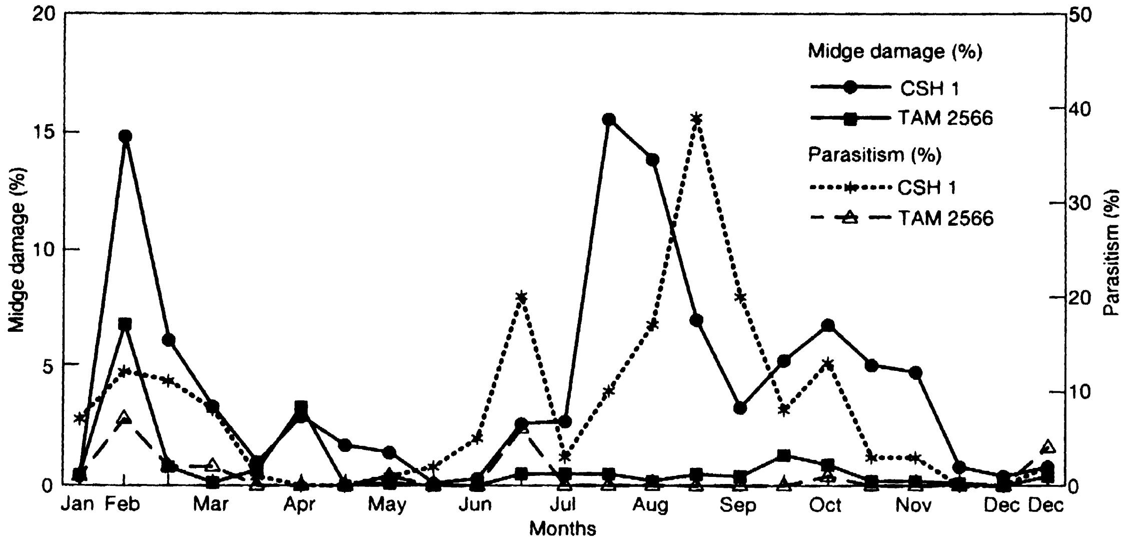

FIGURE 3. Damage and parasitization of sorghum midge on a resistant (TAM 2566) and a susceptible (CSH 1) cultivar across 24 sowing dates (ICRISAT Center, 1981).

related to the level of midge incidence. Thus, both host plant resistance and population density of midge may determine the effectiveness of midge parasites. In general, there is a beneficial potentiation between biological control and host plant resistance. On sorghum and barley, *Lysiphlebus tetraceips* (Cresson) is effective in controlling the greenbug, *Schizaphis graminum* Rond., on resistant genotypes (Starks *et al.*, 1972; Salto *et al.*, 1983). *Aphidius matricariae* Hal. is effective in controlling *Myzus persicae* Sulz. on aphid-resistant chrysanthemums (Wyatt, 1970). Such interactions between parasites, insect host and the plant are highly crop- and natural enemy specific.

Parasitoids orientate towards the odours of the host plant rather than to their insect hosts (Van Emden, 1991; Cheah & Coaker, 1992). Similar results have been obtained in behavioural studies with midge parasites (McMillian & Wiseman, 1979). Thus, differences in host odours from resistant and susceptible sorghum genotypes could be responsible for low levels of parasitization of *C. sorghicola* on midge-resistant genotypes. Secondary plant chemicals contributing to host plant resistance can be toxic to the parasitoids within the hosts (Campbell & Duffey, 1979; Herzog & Funderburk, 1985); they can prolong the post-embryonic development (Isenhour & Wiseman, 1989) or reduce the number of adult parasitoids arriving on the host (Van Emden, 1978).

In-depth studies are needed on the interactions between midge-resistant genotypes and the effectiveness of natural enemies. Midge-resistance genotypes that are compatible with natural enemies, and use of insecticides that are relatively safer to biocontrol agents, can form an important component for insect pest management on sorghum.

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TABLE 3. Parasitization of sorghum midge, *C. sorghicola*, on 25 sorghum genotypes (ICRISAT Center, 1984–85 post-rainy season)

Genotype	Resistance level	Chaffy spikelets (%)	Midge parasitization (%)
IS 3461	R	31.3	0.3
IS 7005	R	28.3	0.0
IS 8571	MR	20.0	0.0
IS 8721	MR	31.7	2.3
IS 9807	R	20.7	0.0
IS 10132	MR	34.7	8.3
IS 12666C	R	26.7	4.0
IS 18733	MR	35.3	4.0
IS 19474	R	23.0	1.3
IS 19512	R	31.0	0.0
IS 21873	MR	29.3	3.7
PM 9250	MR	24.7	1.0
PM 9760	MR	27.7	5.0
PM 10291	R	18.7	0.3
PM 10678	MR	34.0	1.0
IS 10712	R	15.7	1.7
PM 10750	R	24.7	0.0
PM 11344	R	22.0	0.3
AF 28	R	17.3	0.0
DJ 6514	R	18.7	0.0
TAM 2566	R	33.0	1.7
CSH 1	S	40.3	8.7
CSH 5	S	44.3	15.7
IS 61	S	45.3	3.7
SWARNA	S	58.3	13.3
SE		± 3.75	± 1.4
CV (%)		22.0	79.1

R = resistant; MR = moderately resistant; S = susceptible.

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