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REACTION OF DIFFERENT SORGHUM GENOTYPES TO INFESTATION BY THE SUGARCANE APHID, *MELANAPHIS SACCHARI* ZEHNTNER

H.C. SHARMA* AND M.K. DHILLON

International Crops research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru-502324

ABSTRACT

Sugarcane aphid, *Melanaphis sacchari* is emerging as a serious pest of sorghum during periods of prolonged drought or low humidity. Host plant resistance can be deployed to minimize the losses due to this pest. Evaluation of a diverse array of sorghum genotypes for resistance to this pest indicated that CSH 9, DJ 6514, ICSV 197, ICSV 745, IS 14334, IS 10712, and TAM 2566 suffered lower aphid damage and had low density of alates. Aphid infestation was lower on 1st and IInd leaves as compared to that on the Vth and VIth leaves. Aphid infestation resulted in an 18.5 to 55.8% decrease in total phenol content over the healthy leaves. The differences in tannin content of immature and mature seeds of the test genotypes were non-significant. The tannin content of grains showed a positive correlation with phenol content of healthy (r = 0.42) and aphid infested leaves (r = 0.29). Coccinellid density was significantly associated with aphid damage score (r = 70*). The results suggested that ICSV 745, ICSV 197, and ICSV 112 had moderate to high levels of resistance to sugarcane aphid, these genotypes can be deployed in areas prone to aphid outbreaks.

Key words: Sugarcane aphid, ***Melanaphis sacchari,*** tannins, phenols, plant resistance

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important cereal crops in the semi-arid tropics (SAT). In India sorghum is grown over 10.4 million ha, with annual production of 8 million tons (FAO, 2002). The productivity levels of sorghum under subsistence farming are quite low (500 to 800 kg ha^{-1}), mainly because of biotic and abiotic constraints. Amongst the biotic constraints, insect pests are predominant, and cause annual loss of over $1 billion in the SAT (ICRISAT, 1992). Nearly 150 species of insects damage the sorghum crop (Jotwani *et al.*, 1980), of which sugarcane aphid, *Melanaphis sacchari* Zehntner (Aphididae: Hemiptera) is an important pest in Asia, Africa, Australia, and the USA (Sharma and Nwanze, 1997). It is one of the vectors of sugarcane yellow leaf virus, one of the important viruses of sugarcane that occur in most of the sugarcane growing countries (Smith *et al.*, 2000). The nymphs and adults suck the sap from the under surface of the leaves. The infested leaves dry and turn yellow or brown. Under heavy infestation, the plants severely stunted. The aphids secrete the honeydew, which falls on the leaves and on the ground, on which sooty moulds grow. The insect multiplies by parthenogenesis i.e., give birth to apterous nymphs, which moults four times before becoming adults. Under crowded conditions or when host plants are stressed, they produce winged forms (alates), which moult five times before becoming adults (Meksongsee and Chawanapong, 1985). Each female gives birth to 60 to 100 nymphs in 13 to 20 days. The adults live for about 10 to 16 days. Its abundance is high during periods of prolonged drought during the rainy season, and is a regular pest during the postrainy season. The sugarcane aphid, *M. sacchari* infestation in the sorghum has been observed to be quite high during the flowering and grain filling stages in Taiwan (Fang, 1990). Long dry spells of drought and suitable environmental conditions result in heavy infestation by the sugarcane aphid (Raetano and Nakano, 1994). In addition to leaf feeding, *M. sacchari* also affects grain quality of the sorghum in terms of diastatic power, malt loss, and abrasive hardness index. This results in poor quality of sorghum beer, and milling. Reduced grain hardness resulting from aphid feeding may also result in increased flour losses during the milling process (Van den Berg *et al.*, 2003).

Agronomic practices, natural enemies, host plant resistance, and synthetic insecticides have been employed for minimizing the extent of losses due to insect pests. Insecticides are costly, and at times beyond the reach of resource poor farmers in the semi-arid tropics (Sharma, 1985). The natural enemies: *Coccinella septumpunctata* (Fab.), *Chilomenes sexmaculata* (Fab.), and *Micraspis discolor* (Fab.) are the most common predators of aphids. *Syrphus* *balteatus* (Degeer) and *Chrysopa basalts* Walker also feed on the aphids, but the ladybird beetles are the most important. The populations of natural enemies generally build up late in the seasons when the crop is already severely damaged. Application of chemical insecticides may not be economic, and therefore, it may be useful to identify sorghum cultivars that are resistant or less susceptible to this pest. Therefore, we evaluated a diverse array of sorghum genotypes to identify cultivars with resistance to this pest.

MATERIALS AND METHODS

Plant Material

The experiments were conducted at the International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India. Seventeen diverse sorghum genotypes were sown in three sowings at an interval of 15 days, and another set of nine genotypes was timely sown during the postrainy seasons. The experimental plots were given a basal dose of ammonium phosphate @ 150 kg ha^{-1}. Each entry was sown in 4 row plots, 4 m long, and the rows were 75 cm apart. There were two replications in a randomized complete block design (RCBD). The seeds were sown with a 4-cone planter at a depth of 5 cm below the soil surface. The field was irrigated immediately after sowing. One week after seedling emergence, thinning was carried out to maintain a spacing of 10 cm between the plants. No insecticide was applied in the experimental plots. Interculture and earthing up operations were carried out at 15 and 30 days after seedling emergence (DAE). Top dressing was done with urea @ 100 kg ha^{-1} before earthing up at 30 DAE. Hand weeding was carried out as and when required. The crop was irrigated at intervals of 20 days.

Observations

Data on aphid damage were recorded in the central two rows in each plot. The aphid density and damage were evaluated on a scale of 1 to 9 (1 = <10% leaf area infested and damaged by aphids, 2 = 11-20%, 3 = 21-30%, 4 - 31-40%, 5 = 41-50%, 6 = 51-60%, 7 - 61-70%, 8 = 71-80%, and 9 = >80% leaf area damaged infested and damaged by aphids). The first 6-leaves from the bottom were also scored individually for aphid damage, and the number of alates (winged aphids) and coccinellids (per five plants in a plot) present on these leaves were also recorded.

Total phenol content in aphid infested and uninfested leaves, and tannins in mature and immature grains were also estimated. The infested and healthy leaves of sorghum genotypes were collected in the icebox, and dried in shade, and total phenol were estimated using the standard protocol (AOAC, 1984). Tannin content was estimated from the 10 day-old (immature) and mature grains by the method of Price *et al.* (1978).

Data Analysis

Data were subjected to analysis of variance. Significance of differences between the genotypes was tested by F-test, while the treatment means were compared by least significant differences (LSD) at P = 0.05.

RESULTS AND DISCUSSION

The differences in aphid damage among the 17 genotypes tested in three sowing dates during the postrainy season were significant. The aphid damage was higher in the first planting as compared to other plantings. The genotypes CSH 9, DJ 6514, ICSV 197, and ICSV 745 suffered lower aphid damage across the three plantings as compared to CSH 1 (Table 1).

Aphid damage rating of nine sorghum genotypes evaluated during postrainy season varied from 3.0 to 8.5 (Table 2). Genotypes ICSV 197 and ICSV 745 suffered significantly lower leaf damage over seasons (DR 3.0 to 5.4) as compared to CSH 1, CSH 11, and DJ 6514 (DR 6.2 to 8.5). There were significant differences in aphid damage and number of alates (pterous aphids) on different genotypes tested during postrainy season. The Ist and IInd leaves had significantly lower number of alates and had lower aphid damage than the Vth and VIth leaves (Table 2). Genotypes ICSV 197 and ICSV 745 had low to moderate levels of aphid damage on most leaves. AF 28 had significantly lower numbers of alates across leaf positions. CSH 1 and CSH 11 had high numbers of alates and aphid damage across leaf positions. There was progressive increase in aphid damage and number of alates from leaf I to VI. There was no relationship between number of alates on different leaves and aphid damage. Number of alates showed a negative correlation with total number of aphids (r = -0.32).

Aphid infestation resulted in a decrease in phenol content in the infested leaves over the healthy leaves. Both healthy and infested leaves of CSH 1 had

Table 1: Reaction of 17 sorghum genotypes to sugarcane aphid, *Melanaphis sacchari* across three sowings at 15 days interval during postrainy season (ICRISAT, Patancheru, India)

Genotypes	Aphid damage rating*			
	I**	II	III	Mean
AF28	9.0f	4.0ab	4.5abcd	5.8abc
CSH1	7.8def	5.3ab	4.8abcd	6.0bc
CSH11	7.5de	5.0ab	7.0de	6.5cd
CSH9	4.0a	4.0ab	4.5abcd	4.2ab
DJ6514	5.0ab	4.0ab	3.0ab	4.0a
ICSV112	6.5cd	4.5ab	7.0de	6.0bc
ICSV 197	6.0bc	3.5a	3. Sab	4.3ab
ICSV 745	5.5bc	4.0ab	4.0abc	4.5ab
IS 10712	8.0e	4.5ab	5.5bcd	6.0bc
IS 14334	9.0f	4.0ab	2.5a	5.2abc
IS 16357	8.5e	5.0ab	4.0abc	5.8abc
IS 17610	9.0f	6.0ab	S.Oabcd	6.7cd
IS 19955	8.5e	4.5ab	6.5cde	6.5cd
IS 20740	9.0f	6.0ab	S.Oabcd	6.7cd
IS 21444	9.0f	6.0ab	4.5abc	6.5cd
IS 23748	8.0e	5.5ab	4.0ab	5.8abc
TAM 2566	9.0f	6.5b	8.5e	8.0d
SE±	0.46	0.83	0.97	0.64
LSD (P=0.05)	1.36	2.50	2.90	1.85

*1 = <10% leaf area damaged, and 9 = >80% of leaf area damaged.

Values followed by the same letters are not statistically different at P = 0.05.

significantly lower phenol content as compared to other genotypes tested. Reduction in phenol content in the infested leaves over the healthy leaves was very high in case of ICSV 197 (55.8%) and CSH 1 (44.0%) (Table 3). The genotypes AF 28, DJ 6514 and ICSV 745 had a lower reduction in phenol content than the other genotypes tested. There were no significant differences in the tannin content of immature and mature seeds of the genotypes tested, except in case of IS 10712, AF 28, and TAM 2566 (Table 3). The immature grains of TAM 2566, and mature and immature grains of AF 28 had high tannin content. The tannin content of both immature and mature grains had a positive correlation with total phenol content of healthy (r = 0.42) and aphid infested leaves (r = 0.29).

Low numbers of apterous aphids and coccinellids were observed on ICSV 745, but had more number of pterous (alates) forms (Fig. 1). ICSV 197 was comparable with ICSV 745 in aphid damage and number of coccinellids, but the former had low numbers of apterous aphids. Number of alates was negatively correlated with phenol content of healthy (r = -0.61) leaves, and tannin content of immature and mature grains (r = -0.46). The coccinellid numbers were significantly and positively associated with aphid damage (r = 70*), but not with numbers of apterous (r = 0.13) and pterous (0.15) aphids. Aphid score was negatively associated with healthy (r = 0.40), but positively correlated with tannin content of the immature and mature (r = 0.25) grains. The increase/

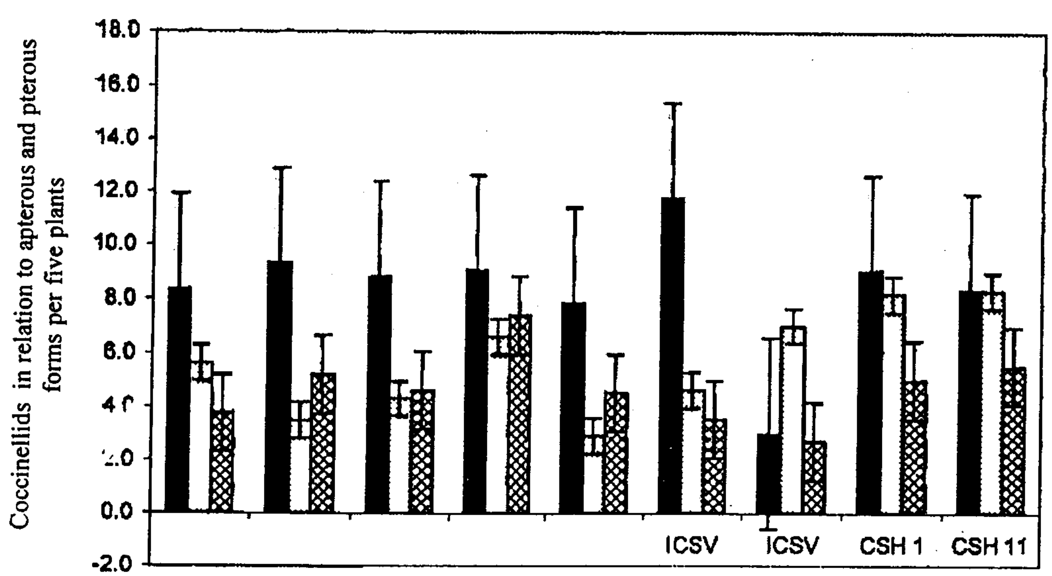

Fig. 1. Coccinellids activity in relation to apterous and pterous aphid forms

Table 2. Reaction of different positioned leaves of nine sorghum genotypes for resistance to sugarcane aphid, *Melanaphis sacchari* during postrainy seasons (ICRISAT, Patancheru, India)

Genotypes	Aphid damage rating**							
	Leaf positions (1st season)							IInd season
	I	II	III	IV	V	VI	Mean	
IS 10712	3.2(1.0)*	3.4(6.0)	5.5(6.0)	6.2(9.0)	7.2(6.0)	8.2(6.0)	5.6(5.7)	7.0bc
AF28	1.3(0.0)	4.0(2.0)	6.0(5.0)	7.8(5.0)	8.5(5.0)	9.0(3.0)	6.1(3.3)	7.5bc
TAM 2566	2.7(1.0)	4.5(3.0)	5.2(4.0)	6.7(5.0)	7.6(6.0)	6.8(8.0)	5.6(4.5)	6.5b
DJ6514	2.1(0.0)	4.2(1.0)	5.8(6.0)	7.3(9.0)	8.7(12.0)	9.0(12.0)	6.2(6.7)	8.5c
ICSV112	2.9(1.0)	4.6(3.0)	6.5(4.0)	7.6(3.0)	8.2(3.0)	8.7(4.0)	6.4(3.0)	6.0b
ICSV 197	1.1(1.0)	1.7(3.0)	3.7(6.0)	5.6(6.0)	7.2(7.0)	7.8(6.0)	4.5(4.8)	4.0a
ICSV 745	2.5(3.0)	3.2(7.0)	4.4(7.0)	6.1(8.0)	7.3(10.0)	8.8(8.0)	5.4(7.2)	3.0a
CSH1	4.0(3.0)	5.6(9.0)	6.6(10.0)	6.8(10.0)	7.6(9.0)	7.9(7.0)	6.4(8.0)	8.5c
CSH11	5.0(2.0)	6.7(7.0)	7.3(9.0)	7.5(8.0)	8.0(11.0)	8.6(12.0)	7.2(8.2)	7.5bc
Mean	2.8(1.3)	4.2(4.6)	5.7(6.3)	6.8(7.0)	7.8(7.7)	8.4(7.3)	-	
SE±	0.41(0.37)	0.48(0.91)	0.37(0.69)	0.25(0.78)	0.19(1.00)	0.28(0.66)		0.64
LSD (P=0.05)	1.22 (1.10)	1.42 (2.70)	1.10 (2.04)	0.75 (2.32)	0.56 (2.97)	0.83 (1.96)	1.89	

*Figures in the parenthesis are number of alates.

**1 = <10% leaf area damaged, and 9 = >80% of leaf area damaged.

Values followed by the same letters are not statistically different at P = 0.05.

Table 3. Total phenol content in sugarcane aphid infested and uninfested leaves and tannin content in immature and mature grains of sorghum (ICRISAT, Patancheru, India)

Genotypes	Total phenol content (%)Tannin (%)				
			% Decrease		
	Healthy leaves	Infested leaves	over healthy leaves	Immature grains	Mature grains
IS 10712*	X	X	X	4.40a	3.00a
AF28	11.5b	7.7bc	33.0	7.60ab	9.1 Ob
TAM 2566*	X	X	X	10.34b	0.92a
DJ6514	10.9b	8.4c	23.0	-	-
ICSV112	10.0b	6.0ab	40.0	-	-
ICSV 197	11.3b	5.0a	55.8	-	-
ICSV 745	10.3b	8.4c	18.5	-	-
CSH1	7.5a	4.2a	44.0	-	-
CSH11*	X	X	X	-	-
SE±	0.61	0.74		1.3[illegible]	1.01
LSD (P=0.05)	1.80	2.19		3.95	3.00

x = Data not recorded - = Undetectable.

* = No healthy leaves were present in these genotypes.

Values followed by the same letters are not statistically different at P = 0.05.

decrease in aphid damage was associated with a corresponding increase or decrease in numbers of apterous forms. The results suggested that ICSV 745 and ICSV 197 had a good level of resistance to aphids, while ICSV 112 a widely adapted high yielding sorghum genotype showed moderate level of resistance/ susceptibility sugarcane aphid.

Aphid density and damage to the plants are highly correlated (Hagio, 1992). Both pterous and apterous forms exhibit a strong preference for susceptible sorghums (Kawada, 1995). *Melanaphis sacchari* reared on resistant sorghums results in an increase in nymphal period and their mortality, and reduction in longevity and fecundity (Liu *et al*, 1990; Kawada, 1995). Hybrids CSH 16 and 9728 have been reported to be resistant to sugarcane aphid compared to SPH 388, CSH 9 and CSH 14 (Ghuguskar *et al*, 1999). In South Africa, sorghum hybrids PAN 8446, SNK 3939 and NS 5511 have been reported to have tolerance to aphid damage (Van den Berg, 2002).

Genotypes with greater height, longer distance between 2 leaves, smaller leaf angle, and the presence of waxy lamina are less susceptible to the aphid damage. Development of aphids was faster on varieties with higher nitrogen, sugar, and total chlorophyll (Mote and Shahane, 1994). Varieties with high phosphorus, potassium and polyphenol content were less preferred by aphids (Mote and Shahane, 1994). Total sugar and the free amino acids were more in the resistant varieties than in the susceptible ones, while there were no differences in the resistant and susceptible genotypes in leaf surface wax (Tsumuki *et al.,* 1995). Aconitic acid (200 ug/g wet weight of leaves) shows anti-feedant effects on aphids (Rustamani *et al.,* 1992).

In the present studies, the genotypes ICSV 197, ICSV 112 and ICSV 745 suffered lower aphid damage, and had lower numbers of alates. There was considerable decrease in total phenol content in the infested leaves over the healthy leaves. The tannin content of immature and mature grains showed positive correlation with total phenol content of healthy ($r = 0.42$) leaves. Numbers of alates was negatively correlated with phenol content of healthy leaves ($r = -0.61$), and therefore phenol content can be used as a marker trait to select for aphid resistance in sorghum. Genotypes such as ICSV 745 and ICSV 112, showing less susceptibility to aphids, can be deployed in areas prone to aphid outbreaks.

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