Expression of antixenosis and antibiosis components of resistance to spotted stem borer *Chilo partellus* in sorghum under greenhouse conditions

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Introduction

Sorghum (*Sorghum bicolor*) is one of the major cereal crops in the semi-arid tropics (SAT), but the grain yields on peasant farms are low (500–800 kg ha^{-1}). It is damaged by more than 150 insect species, of which spotted stem borer *Chilo partellus* is one of the most important pests worldwide (Sharma 1993). The stem borer larvae first feed on whorl leaves resulting in irregular-shaped holes on the leaves. The older larvae bore into the stem and destroy the growing point resulting in deadheart formation. The larvae continue to feed inside the stem causing extensive tunneling, and at times also damage the peduncle, resulting in production of chaffy panicles. Insecticide application for stem borer control is uneconomic under subsistence farming, and is largely beyond the means of resource-poor farmers in the SAT. Therefore, host plant resistance assumes a pivotal role for controlling stem borer damage either alone or in combination with other methods of control (Sharma 1993). Sources of resistance to spotted stem borer *C. partellus* have earlier been identified by several workers (Jotwani 1978, Singh and Rana 1984, 1989). Over 30,000 germplasm accessions have been screened for resistance to *C. partellus* at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and many sources of resistance have been identified (Taneja and Leuschner 1985, Sharma et al. 1992, 2003). The levels of resistance in the cultivated germplasm are low to moderate, and therefore, it is important to identify sorghum genotypes with different mechanisms of resistance to increase the levels and diversify the bases of resistance to this insect. We studied antixenosis and antibiosis mechanisms of resistance to *C. partellus* at the seedling stage in a diverse array of stem borer resistant genotypes, and landraces/improved varieties susceptible to stem borer under greenhouse conditions.

Materials and methods

Oviposition non-preference. Antixenosis for oviposition was studied under multi-choice conditions at ambient conditions (25 to 27°C, 65 to 90% RH, and 10 h photoperiod). The insects were obtained from the culture maintained in the laboratory on artificial diet (Sharma et al. 1992). The plants were grown in pots (30 cm diameter, and 45 cm deep) in the greenhouse. The potting mixture consisted of 2:1 ratio of red laterite soil and FYM (farmyard manure). Diammonium phosphate was applied before sowing at 50 g per pot. Five seeds were sown in each pot at 7 cm below the soil surface, and watered immediately. Three plants were retained in each pot at 10 days after seedling emergence. Twenty-day-old plants (the stage at which the stem borer females lay eggs on plants under natural conditions) were placed on a table in a randomized complete block design, and covered with a nylon net (2.0 m × 1.0 m × 0.6 m). There were four replications. Eighty pairs of newly emerged adults were released inside the nylon net. The moths were provided with water in a cotton swab, and allowed to oviposit on the test genotypes for three days. Observations were recorded on the number of egg-masses and number of eggs laid on each genotype. Relative oviposition preference (ROP) was computed in relation to the susceptible check CSH 1.

Survival and development. Survival and development of neonate larvae of *C. partellus* was studied on 20-day-old seedlings under greenhouse conditions. The plants were raised in pots as described above, and there were three plants in each pot. The plants were infested with 10 first-instar larvae per plant at 25 days after seedling emergence. The plants were covered with a paper bag (5 cm × 30 cm), which was attached to the base of the plant with a sticky tape to prevent the movement of larvae away from the plants, while the top end was kept open for aeration. The experiment was laid out in randomized complete block design, and there were five replications. One plant from each pot was sampled at 5 days after infestation to record larval establishment. At 25 days after infestation, the plants were dissected to remove the larvae, which were then placed in a plastic jar along with 10-cm pieces of sorghum stems of the same genotype. Data were recorded on pupal weights and post-embryonic development period. Pupal weights were recorded separately for the males and females one day after pupation.

Data on insect numbers were subjected to square root transformation, and those on percentages to angular transformation before analysis of variance. The significance of differences between the treatments was measured by *F*-test, while the treatment means were compared using the least significant difference (LSD) at $P = 0.05$.

Results and discussion

Oviposition non-preference. The genotypes IS 2123, IS 2205, IS 2309, IS 13100 and IS 18573 showed antixenosis for oviposition (≤5 egg-masses per 3 plants compared to 10.2 egg-masses on ICSV 112) (Table 1). These genotypes had 183 to 334 eggs per 3 plants compared to 797 eggs on ICSV 112. Based on relative oviposition preference, IS 1054, IS 2123, IS 2205, IS 2309, IS 12308, IS 13100, IS 18333, IS 18573 and ICSV 714 were less preferred for oviposition as compared to ICSV 112. The genotypes IS 2146, IS 5469, IS 5566 and IS 5604, identified earlier to be resistant to borer damage under field conditions (Sharma et al. 1992, 2003), did not show antixenosis for oviposition, indicating the involvement of other factors/mechanisms of resistance to *C. partellus* in these genotypes. Oviposition non-preference has earlier been identified to be one of the components of resistance to *C. partellus* in sorghum (Singh and Rana 1984, Alghali 1985, Saxena 1990, van den Berg and van der Westhuizen 1997). Most of these studies were aimed at identifying sorghum lines with resistance to stem borer under field or greenhouse conditions. In the present studies, significant differences in oviposition were observed among the sorghum genotypes identified earlier to be resistant to spotted stem borer under field conditions (Taneja and Leuschner

Table 1. Oviposition preference by the females of spotted stem borer *Chilo partellus* towards 25 sorghum genotypes under multi-choice cage conditions at ICRISAT, Patancheru, India.

Genotype	No. of egg masses per 3 plants	No. of eggs per 3 plants	ROP[1]	
			Egg masses (%)	Eggs (%)
IS 1044	7.6 (2.8)[2]	588 (24.23)	80.76	92.29
IS 1054	6.0 (2.5)	215 (14.4)	70.44	37.56
IS 2123	2.3 (1.7)	186 (13.5)	26.14	27.35
IS 2146	7.5 (2.8)	643 (25.3)	86.01	111.74
IS 2205	5.0 (2.3)	330 (17.3)	56.12	48.94
IS 2263	7.0 (2.8)	406 (20.1)	79.61	70.05
IS 2269	12.2 (3.4)	599 (23.5)	132.07	90.49
IS 2309	4.0 (2.1)	185 (13.2)	46.13	29.15
IS 5469	8.5 (2.9)	547 (22.8)	97.68	94.14
IS 5566	9.5 (3.2)	649 (25.5)	112.01	110.94
IS 5604	9.8 (3.1)	708 (24.4)	121.77	131.87
IS 12308	6.5 (2.5)	394 (17.3)	67.33	53.95
IS 13100	2.7 (1.7)	183 (11.3)	29.96	23.11
IS 18333	5.5 (2.4)	343 (18.4)	62.08	55.73
IS 18573	4.0 (2.1)	334 (18.1)	44.38	53.37
IS 21444	6.7 (2.6)	524 (22.1)	76.46	80.32
AF 28	7.0 (2.6)	698 (24.1)	74.06	95.06
Naga White	6.5 (2.6)	408 (20.2)	78.03	71.78
Seredo	5.7 (2.4)	532 (23.0)	63.90	89.70
ICSV 1	7.0 (2.7)	589 (23.3)	78.73	95.57
ICSV 112	10.2 (3.0)	797 (26.7)	105.98	114.62
ICSV 705	9.0 (3.1)	570 (23.5)	107.00	106.86
ICSV 714	6.0 (2.5)	284 (15.6)	67.03	39.58
ICSV 743	6.0 (2.5)	458 (20.1)	64.43	69.20
CSH 9	8.3 (3.0)	615 (24.5)	97.10	113.88
CSH 1	8.8 (3.0)	624 (24.7)	–	–
SE±	(0.26)	(2.86)	19.00	23.60
LSD ($P = 0.05$)	(0.72)	(7.90)	52.50	65.13

1. ROP = Relative oviposition preference in relation to CSH 1.
2. Figures in parentheses are square root transformed values.

1985, Sharma et al. 2003), suggesting that different mechanisms may be responsible for genotypic resistance to *C. partellus* in these genotypes.

Survival and development. There were significant differences in larval survival, pupal weights, and post-embryonic development periods of *C. partellus* on different sorghum genotypes. Larval survival at five days after infestation varied from 54 to 92% (Table 2). Larval survival was ≥90% on IS 2263, IS 2269, IS 5469 and IS 18333; 72 to 76% on IS 21444, Seredo, ICSV 1, ICSV 743, IS 13100 and IS 2205 as compared to 54% on IS 2146. The weights of both male and female pupae were lower in insects reared on IS 1054 and AF 28 as compared to those reared on IS 1044. Post-embryonic development period was >50 days for males, and >55 days for females when the larvae were reared on IS 2123, IS 18333, AF 28, ICSV 1, ICSV 112, ICSV 705, CSH 9 and IS 2205 compared to 43.1 days for the males on IS 2146, and 42.0 days for the females on ICSV 743. Antibiosis in terms of reduced larval survival and prolongation of post-embryonic development period has earlier been reported by Jotwani et al. (1978), Woodhead and Taneja (1987) and van den Berg and van der Westhuizen (1997).

The genotypes IS 2123, IS 13100, IS 2205, IS 1054, IS 18333, IS 18573, ICSV 714 and ICSV 705, which showed antixenosis and/or antibiosis towards the stem borer, can be used as parents in a resistance breeding program to increase the levels and diversify the bases of resistance to stem borer *C. partellus*.

Table 2. Survival and development of neonate larvae of spotted stem borer *Chilo partellus* on seedlings of 25 sorghum genotypes under greenhouse conditions at ICRISAT, Patancheru, India.

Genotype	Larval survival (%) at 5 DAI[1]	Pupal weight (mg)		Post-embryonic development period (days)	
		Males	Females	Males	Females
IS 1044	84 (69.5)[2]	47.1	94.3	44.9	53.5
IS 1054	78 (65.4)	30.8	66.5	55.0	52.3
IS 2123	82 (73.1)	45.8	78.4	51.5	56.7
IS 2146	54 (47.3)	43.2	75.3	43.1	55.8
IS 2263	90 (76.0)	40.7	83.5	47.4	54.5
IS 2269	90 (78.5)	43.6	71.2	49.0	50.5
IS 2309	70 (57.2)	42.0	85.2	47.7	51.3
IS 5469	92 (82.1)	44.7	99.6	50.1	50.3
IS 5566	78 (62.8)	47.8	72.8	52.3	53.5
IS 5604	88 (74.8)	40.5	84.4	49.3	58.8
IS 12308	82 (67.7)	40.7	57.0	48.8	49.7
IS 13100	72 (58.9)	50.9	78.0	46.5	48.5
IS 18333	92 (76.7)	40.4	86.3	50.6	56.2
IS 18573	88 (71.5)	41.9	80.6	49.4	48.4
IS 21444	76 (66.5)	39.7	71.4	51.8	51.7
AF 28	66 (58.2)	34.8	69.9	51.4	58.5
Naga white	88 (76.8)	36.6	87.4	44.3	57.7
Seredo	76 (64.1)	33.6	75.8	44.0	50.0
ICSV 1	73 (59.5)	45.4	79.3	52.8	61.7
ICSV 112	82 (70.2)	44.6	78.7	53.8	60.4
ICSV 705	82 (70.6)	40.6	70.4	53.0	54.8
ICSV 714	80 (69.0)	46.0	89.5	46.5	55.7
ICSV 743	76 (63.7)	41.1	67.1	50.1	42.0
CSH 9	84 (72.0)	38.7	90.4	53.8	59.9
IS 2205	72 (61.0)	38.2	71.6	51.6	58.6
SE±	(7.41)	0.92	1.95	0.70	0.90
LSD (P = 0.05)	(20.45)	2.54	5.38	1.93	2.48

1. DAI = Days after infestation.
2. Figures in parentheses are angular transformed values.

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