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Studies on Oviposition, Growth and Development of *Atherigona Soccata* (RONDANI) (Diptera: Muscidae) on different Sorghum Genotypes

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ABSTRACT

Studies on oviposition, growth and development of *Atherigona soccata* (Rondani) were carried out on two resistant, HC 171 and S 512 and two susceptible, HC 260 and ICSV1 sorghum genotypes at CCS Haryana Agricultural University, Hisar. Significant differences were observed between resistant and susceptible genotypes in regards to larval period, larval survival, larval weight, larval length, per cent pupation, pupal weight, fecundity per female and total life span of A. *soccata* Larval growth index, reproductive success and total growth index were also influenced by the resistant genotypes. It has been concluded that the resistant genotypes adversely affect the development and fecundity of the pest larvae as well as adults, thus suggesting that antixenosis and antibiosis as an important mechanism of resistance in these genotypes against *A. soccata*.

Key Words: *Atherigona soccata,* growth index, larval, pupal, resistant, sorghum, susceptible

INTRODUCTION

Sorghum, *Sorghum bicolor* (L.) Moench is one of the most important cereal crop widely grown for food, feed, fodder, forage and fuel in the semi-arid tropics of Asia, Africa, the Americas and Australia. In northern parts of India, sorghum is exclusively grown for fodder purpose because of its high yielding ability, palatability, high digestibility, fast growing habit, excellent hay making quality and above all for its resistance to drought. Among the factors responsible for low productivity of sorghum crop, insect-pests are the most important ones. The sorghum plant, right from sowing till harvest, is attacked by over 150 insect species (Verma and Singh, 2000). Among which sorghum shoot fly, *Atherigona soccata* (Rondani) (Diptera: Muscidae) being internal feeder, pose serious problems in achieving the target yield. The adult shoot fly lays white, elongated, cigar shaped eggs singly on the undersurface of the leaves, parallel to the midrib. After hatching, the larvae migrates to the upper side of the leaf, moves along the leaf whorl reaching the growing point through the leaf sheath. The larva cuts the growing point, resulting in wilting and drying of the central leaf, known as dead heart. The larva feeds on the decaying plant tissue. The dead heart can be pulled out easily, and it produces an offensive smell. Sorghum shoot fly causes an average loss of 50% in India (Jotwani, 1982), but the infestations at times may be over 90% (Rao & Gowda, 1967). The yield losses of about 45.0 and 80.0 per cent have been worked out due to shoot fly in forage and grain sorghum, respectively (Singh, 1997). Because of introduction of new improved varieties and hybrids, continuous cropping, ratooning and narrow genetic variability, the shoot fly has become principle pest of sorghum in India. Also its high fecundity and shorter generation period has resulted in rapid population built up. The studies on oviposition, growth and development of shoot fly on different forage sorghum genotypes would provide the clue to the antixenosis and antibiosis mechanisms of resistance in sorghum genotypes and their ultimate utilization in breeding resistant varieties. Scanty and scattered information on antibiosis mechanisms of resistance of shoot fly is available in India and aboard. Hence the present study was undertaken to meet the objective for exploring the required basic information.

MATERIALS AND METHODS

The present studies were carried out on two susceptible i.e., HC 260, ICSV 1 and two resistant HC 171, S 512 sorghum genotypes in the laboratory and green house of Department of Entomology as well as in the Research Area, Forage Section, Department of Plant Breeding, CCS HAU, Hisar during 2001-2002. The infested sorghum seedlings (dead hearts) containing shoot fly larvae were taken and placed in the jars containing 6-7 cm thick layer of moist sand, covered with filter paper for pupation of the larvae. The adults collected from such pupae as well as the adults caught in the fish meal traps as suggested by Singh and Verma (1988) were utilized for further study on oviposition, growth and development of shoot fly on different sorghum genotypes.

Two susceptible i.e., HC 260, ICSV 1 and two resistant HC 171, S 512 genotypes were grown in a randomized block design with three replications in a plot size of 3 x 3m (6 rows of 3 m length). Plant to plant distance of 10 cm was maintained. One day after germination, each plot was covered with nyon net to prevent natural infestation of shoot fly. Twenty gravid females of shoot fly were released for two days in each plot on five days old seedlings. The seedlings oviposited by the shoot fly were tagged with date of oviposition and total number of eggs laid. Observations were taken twice a day for recording incubation period and per cent hatchability from each genotype. On the following day of hatching, ten seedlings of each genotype were pulled out and dissected under a binocular to observe exuviae. Such observations were continued every day for recording the larval period. Finally, length and weight of fourth instar larvae were recorded within 24 hr of its moulting i.e., before pupation. For recording the pupal period, the newly formed pupae recovered from each genotype were transferred to the battery jars containing 6-7 cm thick moist sand layer covered with a filter paper to avoid direct contact of pupae with moist sand. Thirty pupae in each sorghum genotype were examined for recording the adult emergence as well as length and weight of pupae (within 24 hr of its formation). Information on successful pupation was also recorded. Males and females of newly emerged flies of *A. soccata* from each forage sorghum genotype were separated by observing four black spots on the last segment of the abdomen in case of males and six black spots in case of females and thus, sex ratio was worked out. For studying the pre-oviposition period, oviposition period and post-oviposition period a pair of fleshly emerged adult flies was released on the potted seedlings and enclosed in a glass chimney, covered with muslin cloth on the top and a cotton swab soaked in 10 per cent glucose solution was provided to serve as food for the shoot flies. Every day the seedlings were examined for egg laying till the death of the flies. Three sets of each genotype were maintained. Thus, pre-oviposition period, oviposition period, post-oviposition period, fecundity and longevity of the adults were recorded.

Larval growth index, reproductive success and total growth index were calculated by the formulae suggested by Singh and Verma (1988), Prabha and Sehgal (1990) and Sharma *et al.* (1992) respectively.

$$\frac{\text{Per cent pupation}}{\text{x 100}}$$

$$\text{Larval Growth Index} = \text{Average larval period (days)}$$

$$\text{Reproductive Success} = \frac{\text{Number of adults emerged}}{\text{Number of eggs laid}} \times 100$$

$$\text{Total Growth Index} = \frac{\text{Adult emergence (\%)}}{\text{Mean total developmental period (days)}}$$

(Larval + Pupal period)

The collected data on various parameters were subjected to analysis of variance. The significance of treatment effects were computed with the help of 'F' (variance ratio) test and to judge the significance of differences between means of two treatments, critical difference (CD) was worked out as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Data recorded on various development parameters of *Atherigona soccata* is presented in Table 1. The incubation period and hatchability of shoot fly eggs on different forage sorghum genotypes varied from 1.97 to 2.07 days and 81.00 to 84.67 per cent respectively with no significant difference. Dhawan (1992) also reported similar results. Larval period vary significantly on different sorghum genotypes. It was minimum (8.03 days) on susceptible variety, ICSV 1 and was maximum (10.40 days) on HC 171 followed by S 512 (9.97 days) and HC 260 (8.33 days). The present findings are in conformity with those of Singh and Verma (1990) and Dhawan (1992). The prolonged larval period on both resistant genotypes (HC 171 and S 512) indicates that resistant genotypes either contain some inhibiting compound(s) or is of poor nutritional quality. Singh and Jotwani (1980) have reported that the leaves of susceptible hybrid, CSH 1 were containing higher percentage of nitrogen, reducing sugars, total sugars, moisture, chlorophyll and lysine as compared with resistant genotypes viz., IS 1054, IS 5469 and IS 5490. These constituents might be playing an important role in governing the antibiosis mechanism to sorghum shoot fly. The per cent larval survival was also significantly lesser on resistant genotypes i.e. HC 171 and S 512 as compared to HC 260 and ICSV 1. The maximum larval survival (75.56%) was observed when the shoot fly was reared on ICSV 1. The minimum survival (40.00%) was recorded on HC 171 followed by S 512 (45.56%) and HC 260 (67.78%). The high mortality of larva indicates the presence of some antibiotic factor(s) in both resistant genotypes which may be due to presence of certain toxic compounds. But no specific compound has so far been determined which can be considered as mainly responsible for antibiotic effects. The present results also corroborate with those of Dhawan *et al.* (1993) who recorded significantly lower larval morality on ICSV 1 and JS 20 as compared to HC 171 and IS 18551. Differential larval survival of shoot fly on sorghum genotypes has also been recorded by Raina *et al.* (1981). The weight of fourth instar larva ranged from 3.46 to 5.32 mg on different forage sorghum genotypes. The larva reared on resistant genotypes, HC 171 and S 512 weighted significantly lower (3.46 and 4.12 mg, respectively) as compared to susceptible genotypes, HC 260 (4.81 mg) and ICSV 1 (5.32 mg). Similar trend were recorded in case of larval length which ranged from 4.88 to 7.36 mm when reared on different forage sorghum genotypes. The minimum larval length was recorded on HC 171 (4.88 mm) and maximum (7.36 mm) on ICSV 1 followed by HC 260 (6.97 mm) and S 512 (5.14 mm). Larval weight and larval length were adversely affected on resistant genotypes. Thus, the resistant genotypes seemed to have exerted greater antibiotic effect on the larval development in terms of weight loss and reduced length as against the least amount of antibiosis shown by the susceptible genotypes, ICSV 1 and HC 260. The present findings are in conformity to those of Singh and Narayana (1978), Singh and Jotwani (1980) and Raina (1981). Singh and Verma (1990) and Dhawan *et al.* (1993) also recorded significantly more larval weight and length of *A. soccata* on susceptible sorghum genotypes as compared to resistant genotypes.

The per cent pupation on resistant genotypes was significantly lower (43.33% & 47.78%) than that obtained on susceptible ones (68.89% & 65.56%). This further confirms that the food materials present for the larvae in the resistant genotypes either contain some inhibiting agent(s) or is deficient in some essential nutrients. The pupal period was significantly higher on resistant genotypes, HC 171 (9.73 days) and S 512 (8.96 days) compared to susceptible genotypes, ICSV 1 (7.07 days) and HC 260 (7.42 days). It might be due to preference for good quality food on susceptible genotypes. The present findings are in conformity with those of Singh and Verma (1990) and Dhawan (1992). The minimum pupal length (3.21 mm) was recorded on S 512 followed by HC 171 (3.24 mm). The maximum length (4.31mm) was recorded on ICSV 1 followed by HC 260 (4.01 mm). The pupal weight varied from 2.21 to 4.42 mg on different sorghum genotypes. The minimum pupal weight of 2.21 and 3.01 mg was recorded on sorghum genotypes, HC 171 and S 512, respectively. However, it was maximum (4.42 mg) on ICSV 1 followed by HC 260 (3.74 mg). The resistant genotypes resulted in poor growth of the pest, thus, reducing the weight and size of the pupa as compared with those reared on susceptible sorghum genotypes. The present findings are in conformity to those of Singh and Narayana (1978), Singh and Jotwani (1980), Singh and Verma (1990) and Dhawan *et al.* (1993).

The adult emergence on different genotypes varied from 49.00 to 81.67 per cent. Genotypes, HC 171 and S 512 showed the least emergence i.e., 49.00 and 53.33 per cent, respectively. The maximum adult emergence (81.67%) was observed on ICSV 1 followed by HC 260 (75.33%). The females always outnumbered the males when this pest was reared on any of the genotypes used. The sex-ratio (M:F) varied from 1: 1.39 to 1: 1.45 on different forage sorghum genotypes but the differences were non-significant among the resistant and susceptible genotypes. There were no significant differences in the duration of pre-oviposition period on difference sorghum The shoot fly reared on HC 171 and S 512 showed significantly lower ovipositional duration of 4.67 and 5.10 days, respectively compared to oviposition period on susceptible genotypes, ICSV 1 (7.07 days) and HC 260 (6.90 days). Post-oviposition period ranged from 1.77 to 2.20 days on different forage sorghum genotypes. Resistant genotypes, HC 171 and S 512 recorded significantly lower post-oviposition duration of 1.77 and 2.03 days, respectively. Shorter oviposition period on resistant genotypes may be due to the short duration survival of this pest on resistant genotypes. The longevity was significantly higher on susceptible genotypes, ICSV 1 (10.54 days) and HC 260 (10.10 days) compared to resistant genotypes, HC 171 (7.90 days) and S 512 (8.60 days). The moths reared on resistant sorghum genotypes, HC 171 and S 512 laid significantly lower number of eggs i.e., 18.33 and 21.80 eggs per female, respectively as compared to 28.93 and 30.37 eggs per female on susceptible sorghum genotypes, HC 260 and ICSV 1, respectively. The eggs per female per day ranged from 3.32 (HC 171) to 4.19 (ICSV 1). It is clearly evident from the data that reproduction was adversely affected by rearing *A. soccata* larvae on resistant sorghum genotypes *viz.*, HC 171 and S 512. The significantly higher fecundity per female on susceptible genotypes may be due to better availability of preferred food and good survival on these genotypes. Singh and Verma (1990) and Dhawan *et al.* (1993) also observed similar trend and recorded comparatively less number of eggs on resistant genotype. Thus, the present investigations also corroborate the findings of the aforesaid research workers.

Larval growth index of *A. soccata* was minimum (3.21) on resistant sorghum genotype, HC 171 followed by S 512 (3.79). The maximum growth index (6.99) was recorded on susceptible sorghum genotype, ICSV 1 followed by HC 260 (6.38). The total growth index of an insect on a particular host and its genotypes is an important biological parameter in designating the genotypes as resistant/susceptible. The minimum growth index (2.43) was recorded in HC 171 followed by S 512 (2.82). Thus the genotypes, HC 171 and S 512 manifesting low growth index values adversely affected the growth and development of *A. soccata* thereby indicating antibiosis, which further need to be confirmed by studying the biochemical constituents in resistant and susceptible genotypes. The development period got significantly prolonged when the larvae were reared on resistant genotypes, HC 171 (30.11 days) and S 512 (29.53 days) as compared to susceptible genotypes, ICSV 1 (26.63 days) and HC 260 (26.82 days). These results suggest that on susceptible genotypes the pest attained the rapid growth and development due to shorter larval and pupal period and thus completing the life span in a shorter duration than on resistant sorghum genotypes. The resistant genotypes adversely affected its growth and development due to high degree of antibiosis. Reproductive success of shoot fly minimum (16.67%) on HC 171 followed by S 512 (21.67%). Reproductive success of shoot fly was significantly higher on susceptible genotypes (40.00% & 33.33%) as compared to resistant genotypes (21.67% & 26.67%). Singh and Verma (1990) and Dhawan *et al.* (1993) also recorded significantly higher growth index and reproductive success of *A. soccata* on susceptible sorghum genotypes as compared to resistant genotypes. Overall response of the biological parameters showed that resistant genotypes, HC 171 and S 512 have higher degree of antibiotic factor(s) that ultimately influenced the biology of shoot fly at all stages as compared to susceptible genotypes, ICSV 1 and HC 260.

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Table 1. Mean* growth and development parameters of various stages of *A. soccata* on resistant and susceptible sorghum genotypes

Parameter	Genotype				Mean	'F' test	C.D. at 5%
	Resistant		Susceptible				
	HC 171	S 512	HC 260	ICSV 1			
Incubation period (days)	2.07	2	1.97	1.99	2.00	N.S.	-
Hatchability (%)	81 (64.17)	81.33 (64.40)	83.33(65.99)	84.67 (67.09)	82.58	N.S.	-
Larval period (days)	10.40	9.97	8.33	8.03	9.18	Sig.	0.53
Survival (%)	40.00 (39.21)	67.78 (42.41)	45.56 (55.46)	75.56 (60.50)	57.23	Sig.	(8.03)
Larval length (mm)	4.88	5.14	6.97	7.36	6.09	Sig.	0.38
Larval weight (mg)	3.46	4.12	4.81	5.32	4.43	Sig.	0.49
Pupation (%)	43.33 (41.15)	65.56 (43.71)	47.78 (54.07)	68.89 (56.20)	56.39	Sig.	(5.18)
Pupal period (days)	9.73	8.96	7.42	7.07	8.30	Sig.	0.65
Pupal length (mm)	3.24	3.21	4.01	4.31	3.35	Sig.	0.42
Pupal weight (mg)	2.21	3.01	3.74	4.42	3.69	Sig.	0.30
Adult emergence (%)	49.00(47.47)Y	53.33(50.62)	75.33(60.27)	81.67(62.75)	67.08	Sig.	(7.49)
Sex ratio (M:F)	1:1.43	1:1.39	1:1.45	1:1.41	-	N.S.	-
Pre oviposition Period (days)	1.47	1.37	1.17	1.27	1.32	N.S.	-
Oviposition Period (days)	4.67	5.10	6.90	7.07	5.94	Sig.	0.46
Post oviposition Period (days)	1.77	2.03	2.13	2.20	2.03	Sig.	0.16
Adult longevity (days)	7.90	8.60	10.10	10.54	9.29	Sig.	0.38
Eggs/female/day	3.32	3.54	4.18	4.19	3.81	Sig.	0.39
Eggs/female	18.33	21.80	28.93	30.37	24.86	Sig.	2.81
Total life span (days)	30.11	29.53	26.82	26.63	28.27	Sig.	1.18
Larval growth index	3.21	3.79	6.38	6.99	5.09	Sig.	1.18
Reproductive success	16.67(24.01)Y	21.67(27.68)	33.33(35.19)	40.00(39.19)	27.92	Sig	(4.89)
Total growth index	2.43	2.82	4.66	5.27	3.8	Sig.	0.49

* Based on two years data

** Figures in parenthesis represent angular transformed Values

N.S. = Not Significant