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SUSCEPTIBILITY OF SOME INDIAN SORGHUM VARIETIES TO ANGOUMOIS GRAIN MOTH, *SITOTROGA CEREALELLA* (OLIVIER) (LEPIDOPTERA: GELECHIIDAE)

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Abstract

The susceptibility of some Indian sorghum varieties to the Angoumois grain moth, *Sitotroga cerealella* (Olivier) was investigated in the laboratory at a temperature of 28.0±2.0°C and relative humidity of 65.0±1.5%. The sorghum varieties tested included CSV 15, AVHT 303, AVHT 310, AVHT 313, AVHT 328, AVHT 644, AVHT 646, IHT 405, IHT 419 and IHT 424. In the first experiment, 100 (0-24h old) eggs of *S. cerealella* were used to infest twenty grammes of each sorghum variety while in the second experiment 0-24h old adults were paired in glass vials. Results showed that IHT 405, an initial variety (experimental), with longest developmental time (29.7days) and least percent survival of egg to adult of 20.6% was the least susceptible variety to *S. cerealella* infestation while CSV 15, with shortest developmental time (26.7days) and highest percent survival of egg to adult of 47.4%, had highest susceptibility. The weight of newly emerged adults ranged from 1.55g (AVHT 313) to 2.09g (AVHT 310) in males and 2.79g (IHT 405, 419) to 3.93g (IHT 424) in females. Virgin females lived longer than their mated counterparts while females generally lived longer than males. Significant differences were found in the number of eggs laid. Fecundity was highest (130eggs/female) in AVHT 303 and lowest (96eggs/female) in IHT 405. Hatchability ranged from 88.0% in AVHT 644 and 97.2% in AVHT 646.

Key words: fecundity, hatchability, *Sitotroga cerealella*, sorghum, susceptibility

Introduction

Sorghum, *Sorghum bicolor* (L.) Moench, is the fifth cereal crop in the world in terms of grain production and its 47 million cultivated hectares, is only surpassed by barley (79 million ha), maize (131 million ha), rice (145 million ha) and wheat (229 million ha) (Doggett, 1988). Sorghum is grown mainly in the semi-arid areas of the tropics and subtropics. It is the chief staple diet and basic source of nourishment in most parts of Africa, parts of India, Pakistan and mainland China. Sorghum is also useful as a major source of biomass for livestock feeds, fuel for cooking, ingredient in brewing industries, starch and various low-cost industrial products and materials for construction around the world (Doggett, 1988).

In countries where agriculture is predominantly at the subsistence level, between 60 and 70% of the cereal grain produced is stored at the farm level using traditional storage methods. Wongo and Pederson (1990) reported that unthreshed sorghum was more suitable than threshed ones

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for the development of *Sitotroga cerealella* (Olivier) and concluded that sorghum could be liable to severe infestation by *S. cerealella* particularly in Africa, where it is traditionally stored unthreshed or in-head and where the climatic conditions favours the development.

Susceptibility is the underlying cause of a pest problem and the degree of it in a species forms the basis of developing useful and pest-resistance types (Ashamo *et al*., 2008). Adult emergence, developmental period and female fecundity are some of the parameters that can be used to determine the susceptibility of a variety to stored products pests. One of the possible and desirable approaches of reducing infestations by stored-product insects is the development of varieties that are resistant to attack (Cogburn *et al*., 1989). Therefore, growing crop varieties resistant to insect pests is one of the primary methods of avoiding or reducing losses.

The genetic manipulation of grains to improve quality can modify the grain physical structure, such as its texture, shape, size and hardness. These modifications could affect pest-host relationship and consequently pest's performance such as growth rate, adult weight, female fecundity and fertility and future progeny will be affected (Slansky and Scriber, 1985; Consoli and Amaral Filho, 1995). The present investigation studied the susceptibility of recently released high yielding and experimental Indian sorghum varieties to infestation by *S. cerealella*.

Materials and methods

Rearing of *Sitotroga cerealella* (Olivier)

Sitotroga cerealella moths obtained from a culture maintained on rice paddy at the Storage laboratory of the Division of Entomology, Indian Agricultural Research Institute (IARI), New Delhi, India were used to start a new stock culture. The moths were subsequently reared on disinfested local sorghum variety in two-litre glass jars for three more generations (about three months) before they were used for experiments. Conditioning on sorghum was deemed necessary to avoid any short-term changes in insect behaviour or biology associated with the change of host grain. The openings of the glass jars were covered with muslin cloth held in place with rubber bands. The rearing and the experiments were carried out at a temperature of 28 ± 2.0°C and relative humidity of 65±1.5 % in incubators at 12h light and 12h dark regimes.

Sorghum varieties

Ten sorghum varieties, CSV 15 (standard variety released); AVHT 303, AVHT 310, AVHT 313, AVHT 328, AVHT 644, AVHT 646 (advanced sorghum hybrids, these are varieties that have reached an advanced stage of research and about to be released to the farmers); IHT 405, IHT 419 and IHT 424 (initial sorghum varieties, these varieties are still at experimental stage) developed at IARI, New Delhi were used for the investigations. The seeds were cleaned of foreign materials before the start of the experiment by keeping them in an oven at 60°C for 5 hours and then equilibrated to moisture content of 12.5-13.0%.

Physical characteristics of sorghum varieties

Random of 10 and 100 seeds per variety were taken to determine mean length and weight respectively.

Experimental procedure I

Twenty grammes of each variety of sorghum was weighed in six replicates into 250ml glass jars and infested with 100 *S. cerealella* eggs (<24h old). The jars were covered with muslin cloth held in place with rubber bands and arranged in a completely randomized manner inside incubators. Observations were made until adult emergence was noticed after which daily emergence was recorded. Mean developmental time (days) and the percentage survival from egg to adults were recorded.

Experimental procedure II

The newly emerged virgin adults from the above experiment were transferred (1 male: 1 female) to glass vials (7.0 x 3.5cm) and replicated twenty times to evaluate female fecundity. The vials were covered with muslin cloth held in place with rubber bands. A slit was made in the middle of the muslin cloth to allow the insertion of the oviposition paper. A piece of black crepe paper, on which the milky-white eggs of the moth could be seen easily, was folded accordion-like (pleated) with 6 folds and placed in the vial according to the method of Peters (1971). Fresh paper (for oviposition) was used daily. The longevity of the copulating (mated) male and female was determined by counting from the day adults were paired to the day they died. The paper strip with the eggs was carefully unfolded and the eggs (usually deposited in rows and clusters) were counted under a binocular microscope (Olympus VM, objective of 10x). Three replicates of one hundred 0-24hr old eggs were taken to evaluate egg hatch. The number of eggs that hatched was determined by counting the empty egg shells when observed under the microscope. Newly emerged adult weights were taken within 24h of emergence (ten replicates). The longevity of unmated adults was determined by isolating newly emerged adults in glass vials (one newly emerged adult per vial) and the days counted until they died.

Results

Table 1 shows the physical characteristics of the sorghum varieties tested. AVHT 646 was longest (0.47cm) but not significantly longer that CSV 15, AVHT 303 and AVHT 313. The weight of 100-seeds (4.2g) was significantly higher ($p<0.05$) in AVHT 646 than the other varieties. Developmental time was longest (29.7days) and percent survival from egg to adult was lowest (20.6%) in IHT 405 variety. However, developmental time was shortest (26.7days) and percent survival from egg to adult was highest (47.4%) in CSV 15 (Table 2). Fig. 1 shows that female *S. cerealella* reared on IHT 424 had the highest weight (3.93g) while those reared on IHT 405 and IHT 419 had the lowest weights (2.79g). The heaviest males were from those reared on AVHT 310 (2.09g). Fig. 2 shows that unmated *S. cerealella* lived longer than their mated counterparts while females generally lived longer than males. Fecundity was highest (103.0 eggs/female) in AVHT 303 and lowest (96.0 eggs/female) in IHT 405. Hatchability was lowest (88.0%) in AVHT 644 and highest in AVHT 646 (97.2%) (Table 3). A 1:1 sex ratio was observed among moths reared on all the sorghum varieties.

Table 1. Physical characteristics of sorghum varieties

Sorghum variety	Sorghum length (cm)	Weight of 100 seeds (g) of sorghum
CSV 15	0.45±0.04^{ab}	3.5±0.01^{c}
AVHT 303	0.45±0.04^{ab}	3.9±0.00^{b}
AVHT 310	0.42±0.02^{bc}	3.4±0.01^{c}
AVHT 313	0.45±0.04^{ab}	3.8±0.01^{b}
AVHT 328	0.41±0.02^{c}	3.8±0.01^{b}
AVHT 644	0.43±0.04^{bc}	3.8±0.01^{b}
AVHT 646	0.47±0.04^{a}	4.2±0.01^{a}
IHT 405	0.40±0.00^{c}	3.4±0.00^{c}
IHT 419	0.42±0.04^{bc}	3.8±0.00^{b}
IHT 424	0.43±0.04^{bc}	3.7±0.00^{bc}

* Means followed by the same letter along the vertical column are not significantly different (p>0.05) from each other by New Duncan's Multiple Range Test.

Table 2. Mean developmental period (days) and survival (%) from egg to adult of *S. cerealella* reared on some sorghum varieties (Mean±SE)

Sorghum varieties	*S. cerealella*	
	Developmental period (Days)	Survival (%) Egg to adult
CSV 15	26.7±0.6a	47.4±2.7a
AVHT 303	29.3±0.6ab	35.4±1.2c
AVHT 310	27.0±0.3ab	37.4±0.8bc
AVHT 313	28.0±1.1ab	40.0±0.9b
AVHT 328	27.7±1.2ab	40.0±1.7b
AVHT 644	27.3±0.1ab	39.4±3.2b
AVHT 646	28.7±0.1ab	39.4±1.6b
IHT 405	29.7±0.6b	20.6±1.6e
IHT 419	29.0±0.6ab	32.0±2.3cd
IHT 424	28.0±0.6ab	28.6±2.1d
Mean	28.1±0.5	36.0±1.8

*Means followed by the same letter along the vertical column are not significantly different (p>0.05) from each other by Tukey's test.

Table 3. Female fecundity (egg/female) and egg hatch (%) of *S. cerealella* reared on some sorghum varieties (Mean±SE)

Sorghum varieties	*S. cerealella*	
	Fecundity (egg/female)	**Egg hatch (%)**
CSV 15	108.1±10.2b	91.2±0.5b
	(40-250)	(89-97)
AVHT 303	130.0±6.0a	89.2±2.0ab
	(60-260)	(65-98)
AVHT 310	110.2±6.0a	90.0±1.2b
	(50-220)	(80-100)
AVHT 313	120.0±4.9a	94.2±1.6c
	(80-300)	(88-100)
AVHT 328	116.2±8.5a	95.4±0.9c
	(80-135)	(90-100)
AVHT 644	98.6±8.1b	88.0±3.2a
	(40-210)	(66-95)
AVHT 646	100.0±6.2b	97.2±4.1c
	(65-250)	(95-100)
IHT 405	96.0±4.1b	90.0±0.9b
	(31-210)	(86-96)
IHT 419	109.2±4.2b	92.6±0.6b
	(70-240)	(88-100)
IHT 424	98.4±10.1b	91.2±0.5b
	(68-212)	(78-100)
Mean	108.7±6.8	91.9±1.6
	(31-300)	(65-100)

*Means followed by the same letter along the vertical column are not significantly different ($p>0.05$) from each other by Tukey's test.

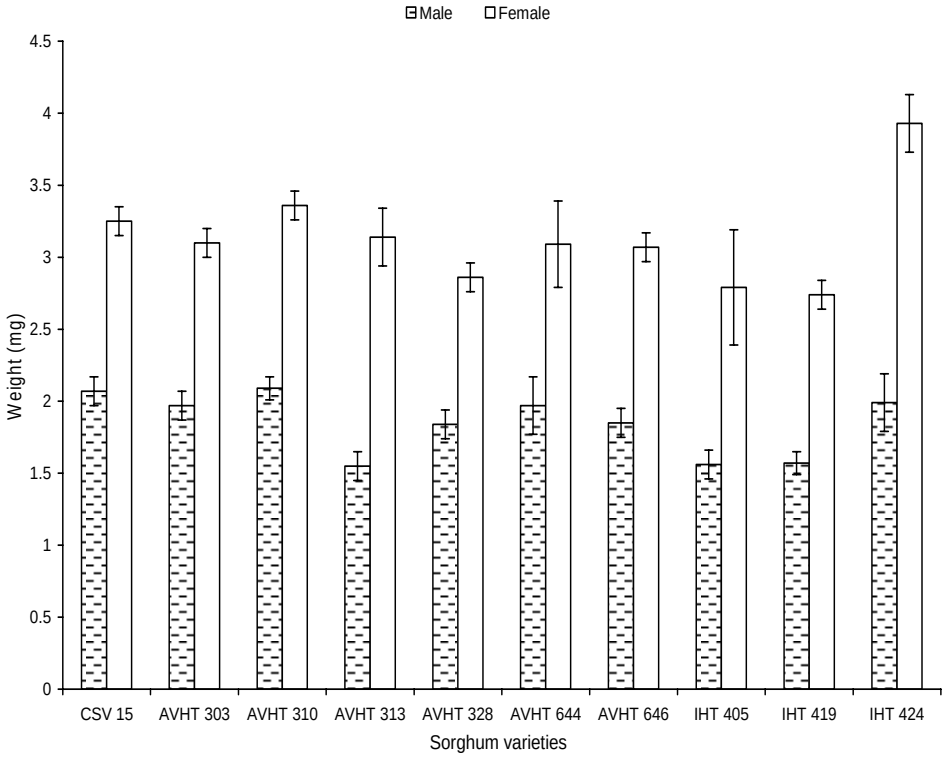

Fig. 1. Weight (mg) of newly emerged adult S. cerealella reared on some sorghum varieties

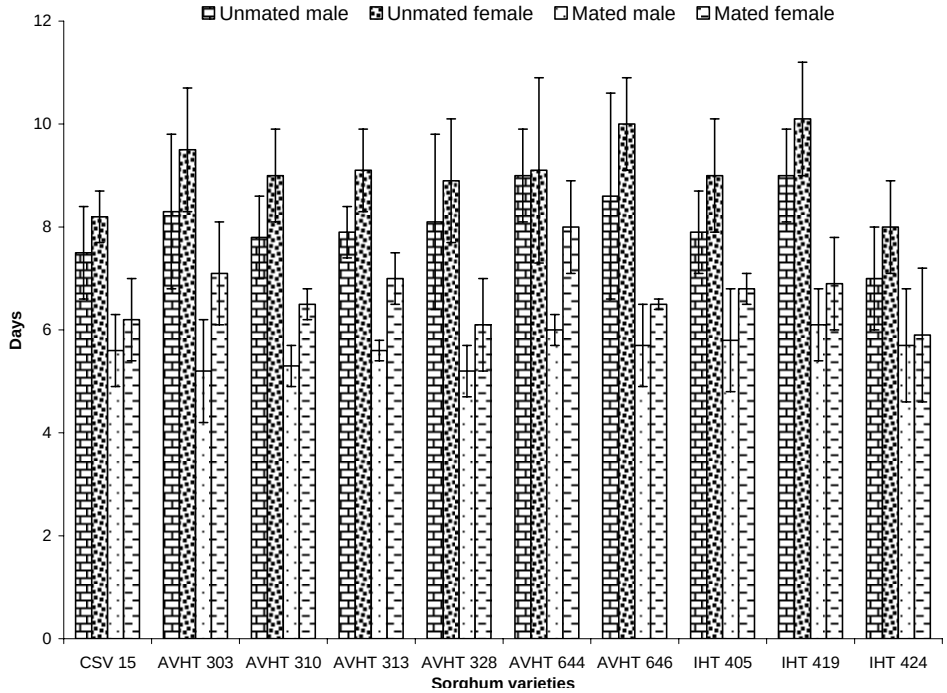

Fig. 2. Adult longevity of mated and unmated *S. cerealella* reared on some sorghum varieties

Discussion

The mean developmental time of *S. cerealella* observed in this study (28.1 days) was shorter than for similar works on sorghum (Wongo and Pedersen, 1990; Ashamo and Khanna, 2006a), paddy (Cogburn *et al*., 1989) and corn (Consoli and Amaral Filho, 1995; Ashamo and Khanna, 2006b). IHT405 variety which appeared to be the least preferred food had small sized seeds and this confirmed earlier works by Ashamo and Khanna (2006a). Larger seeds of *Oryza* spp. may enhance survival and thereby more susceptible to *S. cerealella* infestation (Cogburn *et al*., 1989). Bhatia (1976) also noted that small grains suffered less damage than larger ones due to weevil infestation. This may be due to insufficient endosperm for maximum development of the moths. Pedigo and Rice (2006) have described the mechanisms involved in the expression of resistance as antibiosis, non-preference and tolerance. The observed differences in development and performance of moths in this study may be due to differences in their biochemical characteristics. A 1:1 sex ratio was observed among moths from all sorghum varieties which corroborate earlier works by Hansen *et al.* (2004). The low weight in the moths reared on IHT 405 and IHT 419 might be due to low nutritional quality of the seed or endosperm. The heavier weights observed in the females might be due to deposition of fat layers and eggs in their ovaries. Unmated females lived longer than their mated counterparts probably because of depletion of fat and proteins in their bodies as egg development proceeded. This extended life increases the chances of unmated females meeting a male (Shazali and Smith, 1986; Ashamo, 2006). Female fecundity of *S. cerealella* in this present study (108.7eggs/female) was close to the results obtained by Shazali and Smith (1985), but percentage hatchability of 91.9% was higher. Hansen *et al.* (2004) observed a fecundity of 124 eggs per female in his study.

It can therefore be deduced from the results of this study that sorghum is liable to severe infestation by *S. cerealella* and variety IHT 405, an experimental variety that has not yet been released showed the least preference. Breeding for resistance to storage pests should form an integral part of the cereal improvement programme.

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