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# Evidence of shoot fly *Atherigona soccata* Rondani (Dipt., Muscidae) oviposition response to sorghum seedling volatiles

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**Abstract:** The effects of shoot fly resistant (IS 18551) and susceptible (CSH 5) sorghum seedling volatiles on oviposition of shoot fly were investigated by exposing mated females to various treatments under greenhouse conditions. It is hypothesized that shoot fly susceptible genotype and younger [5–10 days after emergence, (DAE)] seedlings emit different quantities and/or blends of volatiles than resistant or older (14–21 DAE) ones. Shoot fly response was greater to host plant odour alone than to host plant plus fishmeal. Transparent trap with 10 day-old susceptible seedlings was found to be more effective and efficient for adult attraction than the other two types of traps [live fly trap and black trap]. The present study indicated that shoot fly females are attracted both to the volatiles emitted by the susceptible seedlings, and that phototactic (optical) stimuli that may facilitate orientation to its host for oviposition, but volatile blends associated with adult attraction will be reported in due course to confirm these results.

## 1 Introduction

Sorghum, *Sorghum bicolour* (L.) Moench is an important cereal grain, forage and fodder crop in Africa and Asia. About 45 million ha is grown to sorghum throughout the world (ICRISAT/FAO, 1996). Of this area, 22 million ha is grown in Africa and 13 million in India (ICRISAT/FAO, 1996). Grain yields on farmers' fields are generally low (500–800 kg/ha), insect pests being one of the major factors limiting sorghum production. Nearly 150 insect species have been reported as pests of sorghum (Seshu Reddy and Davies, 1979; Jotwani et al., 1980), the major being the sorghum shoot fly, *Atherigona soccata* Rondani, which attacks 7–28-day-old sorghum seedlings (Nwanze et al., 1990).

The adult fly lays white, elongated, cigar-shaped eggs singly on the undersurface of the leaves, parallel to the midrib. The eggs hatch in 1–2 days, and the larvae crawl along the leaf lamina to reach the plant whorl and then move downward through the central shoot till they reach the growing point. They cut the growing point and feed on the decaying leaf tissues, resulting in deadheart formation. The female has a life span of 30 days. During this period it has to locate sorghum genotypes for oviposition. The role of plant odours in host selection can be traced in the orientation of phytophagous insects toward particularly plants and in ultimate recognition of the host plants for feeding and oviposition (Visser, 1986). Olfactory receptor systems have evolved in phytophagous insects enabling them to perceive some of these plant volatiles, which then compile an odour that acts as a chemical message. Plant stimuli involved include in varying proportions visual, mechanical, gustatory and olfactory characteristics (Staedler, 1976). The colour of the leaves has been reported as important factor for the shoot fly in the selection of its oviposition substrate (Raina, 1982). It is generally assumed that sorghum seedlings emit volatiles that are specific to both adult fly oviposition attraction and larval orientation/migration (ICRISAT, 1996). However, there is no biological evidence to support the presence of volatiles and their role in ovipositional behaviour, and whether there are differences between sorghum genotypes and seedling age groups. A series of greenhouse experiments were initiated in order to provide such evidence.

## 2 Materials and methods

### 2.1 Effect of sorghum genotypes on shoot fly attraction and oviposition

Shoot fly resistant (IS 18551) and susceptible (CSH 5) sorghum genotypes, and three types of traps (a) live fly trap (LT, pale green plastic bin), (b) black trap (BT, painted black), and (c) transparent trap (TT) were used in this study. Each trap (BT and TT) consists of a cylindrical hollowed white plastic jar (5.5 cm diameter, 13.5 cm long), having six rows of 3 mm diameter holes with three holes per row, fitted with a plastic funnel (5 cm diameter, 10 cm long), for the passage of the flies to the collection container (2 cm diameter, 8 cm long) at its top. In the case of LT, the potted plants were placed inside a pale green plastic bin (11.5 cm diameter, 25 cm long) having entry holes together with a funnel (10 cm diameter, 20 cm long) fixed over the lid of the bin with entry holes (2 cm diameter) and a collection container (5.5 cm diameter, 13.5 cm long) at its top. Five plants were grown in a round plastic pot (6 cm diameter, 12 cm long) containing black soil (Vertisols); two pots were used for each genotype (20 plants). A few granules of ammonium phosphate were applied at sowing. Thinning was carried out 5 days after crop emergence. The shoot fly adults were obtained from field-infested sorghums at ICRISAT Asia Centre.

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When the seedlings were 10 days old, two traps of the same type were placed over two pots of each genotype, with a pot to pot distance of 30 cm. Fishmeal was spread over the soil surface in one pot of each genotype before placing the trap in order to distinguish the source of adult attraction. This procedure was repeated for all the test traps and replicated three times. The set-up containing LT was then placed in a wooden screen rectangular cage (100 cm × 60 cm × 45 cm) while those with BT and TT were in a square cage (75 cm × 75 cm × 50 cm) kept under greenhouse conditions at 26–30 ± 3°C, 60–75 ± 5% RH, and a photoperiod of 12 h : 12 h (light : darkness). Twenty gravid shoot fly females were released into each cage for 12 h. For control, another set of four pots (two pots of each genotype) were placed in a square cage and directly exposed (i.e. without traps) to shoot fly adult females.

The following observations were recorded in each replication: total number of females entering into each treatment (potted plants + fishmeal + traps; potted plants + traps; potted plants only); number of females trapped; and number of eggs laid every other day.

### 2.2 Shoot fly oviposition response in relation to age of sorghum seedlings

Using the same trap set-up as in experiment 2.1, the response of shoot fly to seedling volatiles from seedlings of four age groups [5, 10, 14 and 21 days after emergence, (DAE)] of susceptible CSH 5 were studied. Five plants were grown in a round plastic pot, one pot for each seedling age (20 plants). Sowings were done in such a way that the four required seedling ages fell on the same day to facilitate exposure. Each of the three types of trap (LT, BT, TT) was placed over different seedling ages. Twenty field-collected gravid shoot fly females were released into the cage, fed on diet (brewer's yeast powder + glucose in 1 : 1 ratio and cotton soaked in 10% sucrose solution), and were allowed to remain there for 12 h to facilitate attraction and oviposition. Treatments were replicated three times. Dead flies were replaced with fresh ones and the diet in the cages were changed daily.

Observations were recorded on the number of adults migrating into each trap, and the number of eggs laid.

### 2.3 Influence of attraction of sorghum seedlings to shoot fly

This experiment was conducted with a susceptible sorghum genotype (CSH 5) under greenhouse conditions. Five plants were grown in a round plastic pot and another pot with soil alone. When the seedlings were 10 days old, a TT was placed over the potted seedlings, and the pot with soil alone served as control. Traps with and without seedlings were placed in a wooden screened square cage. Ten gravid shoot fly females were introduced into each cage for 12 h. Treatments were repeated three times. Observations were recorded on the number of adult female flies trapped. Data were statistically analysed using a least significant difference (LSD) test at a 5% probability level.

## 3 Results

### 3.1 Effect of sorghum genotypes on shoot fly attraction and oviposition

Shoot fly females entered into the transparent traps (mean of one female/trap) without fishmeal (T6) through the entry holes and laid eggs (mean of 3.3 eggs/seedling) on susceptible genotype – CSH 5 (table 1). There were consistently more eggs on the susceptible (a total of 178 eggs) rather than on the resistant (a total of 66 eggs) genotypes when directly exposed without traps to the shoot fly in a cage. The other treatments did not show any impact on adult attraction and oviposition.

***Table 1.*** *Effect of sorghum genotypes on shoot fly female attraction and oviposition*

| Genotype | Treatment | No. of females trapped | No. of eggs laid |
|---|---|---|---|
| IS 18551 | T1 | 0.0 b | 0.0 c |
| | T2 | 0.0 b | 0.0 c |
| | T3 | 0.0 b | 0.0 c |
| | T4 | 0.3 b | 0.0 c |
| | T5 | 0.0 b | 0.0 c |
| | T6 | 0.0 b | 0.0 c |
| | Control | – | 22.0 b |
| CSH 5 | T1 | 0.0 b | 0.0 c |
| | T2 | 0.0 b | 0.0 c |
| | T3 | 0.0 b | 0.0 c |
| | T4 | 0.0 b | 0.0 c |
| | T5 | 0.0 b | 0.0 c |
| | T6 | 1.0 a | 3.3 bc |
| | Control | – | 59.3 a |

T1, potted plants + fishmeal + live fly trap.
T2, potted plants + fishmeal + black fly trap.
T3, potted plants + fishmeal + transparent trap.
T4, potted plants + without fishmeal + live fly trap.
T5, potted plants + without fishmeal + black trap.
T6, potted plants + without fishmeal + transparent trap.
Control, potted plants only.
Means within a column followed by the same letter are not significantly different at $P \geqslant 0.05$ using a Least Significant Difference (LSD) test.

### 3.2 Shoot fly oviposition response in relation to age of sorghum seedlings

More shoot fly females (numbers in parentheses indicate number of females) migrated into the transparent traps with 5-day-old (seven) and 10-day-old (eight) seedlings compared to 14-day-old (one) and 21-day-old (one) seedlings and laid a total of 102, 73, 14 and 47 eggs, respectively (table 2). Although, the 10-day-old seedlings attracted more females than the 5-day-old seedlings, the number of eggs laid on the latter was slightly higher than on the former which might be due to partially spent females released over the 10-day-old seedlings. This study indicates that TT are more efficient for adult attraction than the other two types of traps (LT and BT).

### 3.3 Influence of attraction of sorghum seedlings to shoot fly

A total of two shoot fly females (mean of 0.7 females/trap) migrated into the transparent traps placed on 10-day-old seedlings and laid 17 eggs (mean of 5.7 eggs/trap) on susceptible seedlings. In contrast, no flies were recovered from the treatment without seedlings. But the differences were not significant.

*Table 2. Effect of seedling age on shoot fly female attraction and oviposition*

| Seedling age (DAE) | Treatment | No. of females trapped | No. of eggs laid |
|---|---|---|---|
| 5 | T1 | 0.0 b | 0.0 b |
| 10 | | 0.3 b | 0.7 b |
| 14 | | 0.3 b | 3.3 b |
| 21 | | 1.3 ab | 14.3 ab |
| 5 | T2 | 0.0 b | 0.0 b |
| 10 | | 0.0 b | 0.0 b |
| 14 | | 0.0 b | 0.0 b |
| 21 | | 0.3 b | 1.0 b |
| 5 | T3 | 2.3 a | 34.0 a |
| 10 | | 2.7 a | 24.3 ab |
| 14 | | 0.3 b | 4.7 b |
| 21 | | 0.3 b | 15.7 ab |

T1, potted 5, 10, 14, 21 DAE CSH 5 plants + live fly trap.
T2, potted 5, 10, 14, 21 DAE CSH 5 plants + black trap.
T3, potted 5, 10, 14, 21 DAE CSH 5 plants + transparent trap.
Means within a column followed by the same letter are not significantly different at $P \geqslant 0.05$ using a Least Significant Difference (LSD) test.

## 4 Discussion

These observations indicate that sorghum genotypes emit volatile substances that guide the shoot fly females to their hosts for oviposition, and that volatile production follows the same pattern as sorghum susceptibility to this pest. Cabbage root fly (*Delia radicum* L.) is believed to locate its cruciferous host by responding to the volatile chemicals released from the plant (ELLIS et al., 1982). It is hypothesized that shoot fly susceptible genotype and younger (5–10 DAE) seedlings emit different quantities and/or blends of volatiles than the resistant or older (14–21 DAE) ones. The TT with 10 day-old susceptible seedlings was found to be more effective and efficient for adult attraction than the other two types of traps (LT and BT), because dipterans are characterized by their positive phototactic behaviour. SOTO (1974) reported that leaves of some of the sorghum varieties resistant to shoot fly were pale green compared to the dark green colour of the susceptible cultivars. This indicates that shoot fly females are attracted both to the volatiles emitted by the susceptible seedlings, and phototactic (optical) stimuli that may facilitate orientation to its host for oviposition. Therefore, phototactic and odour cues from host seedlings have a greater effect on flight orientation and oviposition responses than to host plus fishmeal. HARRIS et al. (1993) reported that phototactic and odour stimuli together elicit greater response from Hessian fly, *Mayetiola destructor* Say than phototactic stimuli alone. Fishmeal has been used to attract shoot flies into sorghum plots to increase the efficiency of selection of sorghum resistance to this pest (STARKS, 1970). SESHU REDDY et al. (1981) reported that catches were heaviest in fishmeal traps on the fourth day of exposure, indicating that biological degradation was a probable factor in the attraction. However, in the present study, none of the treatments with fishmeal cues attracted females due to the absence of moisture in the fishmeal and a shorter exposure period. Moisturized fishmeal or fishmeal soaked in plastic bags has been shown to have a high level of attraction for shoot fly (SESHU REDDY et al., 1981). These studies illustrate the importance of testing cues alone and in combination with other cues with egg counts as indicators of stimulatory effects.

## 5 Conclusions

The present study indicated that volatile cues and photactic stimuli from susceptible sorghum seedlings appear to play a major role in adult attraction and the oviposition behaviour of shoot fly, but volatile blends associated with adult attraction will be reported in due course to confirm these results. An identification of the specific volatiles can provide a better understanding of what insects perceive in the environment around the sorghum plant and can also establish whether there are qualitative and/or quantitative differences in the volatile blends emanating from the leaves of sorghum plant. LWANDE and BENTLEY (1987) identified (Z)-3-Hexen-1-ol acetate as the major volatile trapped from the seedlings of *S. bicolour* (var. Serena) to elicit a behavioural response in some adult phytophagous insects. Thus, knowledge of the volatile compounds of sorghum genotypes may be useful in the study of shoot fly sorghum plant relationships especially to determine whether antixenosis might be explored as a complementary control method. Also, information on odour and phototactic stimuli on shoot fly ovipositional behaviour can be used for monitoring shoot fly populations, and may have direct implications in both breeding for resistance and management of shoot fly.

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