Sorghum Entomolo
Progress Report 4

S6 0749

# Observations on oviposition of sorghum shoot fly, *Atherigona soccata* Rond. (Diptera: Muscidae)

J.C. Davies and K.V. Seshu Reddy



ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
ICRISAT Patancheru P.O.
Andhra Pradesh 502 324, India

# Observations on oviposition of sorghum shoot fly, *Atherigona soccata* Rond. *(Diptera: Muscidae)**

J.C. Davies and K.V. Seshu Reddy

ABSTRACT

Observations on oviposition on sorghum plants by *Atherigona soccata* Rond. at ICRISAT Center, near Hyderabad, India, confirmed its high rate of incidence particularly during postrainy season. Eggs were normally laid on the under surface of the fourth or fifth leaf, usually one egg per plant was laid. The number of eggs laid was highest per unit area at high plant densities--10 mm or less between plants. At these densities more plants were laid on, and this applied to both main plants and tillers. There was a very high correlation between the number of plants laid on and the number showing dead heart symptoms. Very few plants at low densities escaped attack. Soil type did not affect oviposition. It was concluded that, for maximizing shoot fly build-up for screening for resistance in sorghum, dense plant populations should be sown in the spreader rows, but for material under test spacings of 200 mm or more were optimal.

## INTRODUCTION

*Atherigona soccata* Rond. is the principal species of shoot fly attacking *Sorghum bicolor* (Linn.) Moench in Africa and Asia (Nye, 1960; Blum, 1967; Jotwani *et al.*, 1970; Seshu Reddy and Davies, 1977). Eggs are laid on young seedlings and the larvae which emerge cause typical "dead heart" symptoms. As part of a research project aimed at identifying sorghum cultivars with resistance to shoot fly, detailed studies on maximizing oviposition on plant material under test were carried out.

## MATERIALS AND METHODS

The observations on general oviposition were carried out by examining tens of thousands of sorghum seedlings for shoot fly eggs. The seedlings were grown on various plots, 0.1 ha to 6 ha in size in the experimental blocks for agronomic and breeding trials at ICRISAT Center during 1974 to 1977. Sowings were made at various times of the year on both Alfisols and Vertisols. The former is shallow, light reddish brown soil of pH 5.5 to 7.0 well leached and drained and the latter is of dark grey and calcareous, low in organic matter and poorly drained, with a pH of 7 to 8.5.

Data on the effect of plant density on shoot fly oviposition were obtained by sowing experiments in both soil types at periods of heavy shoot fly incidence. In the first season (rainy season, 1975) three randomised blocks were sown utilising five spacings of 10, 25, 50, 100 and 200 mm,

*Approved as Journal Article No. 82 of the International Crops Research Institute for the Semi-Arid Tropics.

with an interrow spacing of 0.75 m. Each count plot consisted of one row of 6 m, replicated five times. The requisite plant densities were obtained by thinning to stand within 7 days following germination. Comparable plant densities were obtained at all the three sites. The same plant densities were used in a subsequent rainy season of 1977 with the addition of one treatment where two rows of sorghum at the 10 mm spacing were sown on each ridge. In the trial sown in 1977 plots consisted of five rows, 75 cm apart and 5 m in length and each treatment replicated four times. All plants in plots were counted and examined.

## RESULTS

### General Oviposition

Data on shoot fly egg distribution typical of far more extensive counts are given in *Table 1*. These show that the number of plants with eggs as a proportion of those examined is highest in the postrainy season, and that in the rainy season there is a clear tendency for the number of plants with eggs to increase as sowing is delayed. Both these observations confirm previous observations in India.

A single egg is most commonly laid on a plant, where shoot fly populations are deliberately fostered, multiple oviposition was common. Individual plants with more than 10 eggs were very infrequent, and in four seasons of counting at ICRISAT Center, the maximum number of eggs found on a seedling was 20. A striking feature of these data was that considerable differences in oviposition levels could occur within short distances, even when sowing dates were the same. There were no consistent differences in oviposition related to soil type.

Observations were made on oviposition site, using a known susceptible hybrid, CSH-1. The leaf and site chosen for oviposition were noted *Table 2*. Eggs were very seldom laid on the first leaf and clearly the fourth and fifth leaves were preferred for oviposition. The third and sixth leaves were frequently chosen. On 385 plants examined, 444 eggs were laid, 274 of them on the mid-leaf undersurface and 130 towards the base of the leaf blade, again on the undersurface. Almost no eggs were laid towards the tip and none were observed on the upper leaf surface, although this has been recorded rarely in other counts.

Oviposition was infrequent on seedlings of many cultivars older than 6 weeks, but it was confirmed in this study that on the CSH-1 hybrid, eggs were laid as late as 10 weeks and that larvae emerging from such eggs were able to become established and sever the growing tip. On some cultivars it was observed that *A. soccata* was able to lay eggs on nodal tillers up to 3 m from ground level and that larvae from these eggs developed normally into adults.

Table 1. Number of sorghum plants with and without eggs of *Atherigona soccata* at ICRISAT Center on two soil types at various dates (counts taken 14-30 days from seedling emergence).

| Soil type | Emergence date | Totals of plants with egg number | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | >10 | examined |
| Vertisol | 1/7/74 (K) | 13,037 | 858 | 141 | 35 | 8 | | | | | | | 14,079 |
| Alfisol | 4&6/7/74 (K) | 27,195 | 222 | 5 | 2 | | | | | | | | 27,424 |
| Vertisol | 18/7/74 (K) | 9,076 | 1,930 | 568 | 146 | 57 | 9 | 3 | 3 | | | | 11,792 |
| Alfisol | 20/7/74 (K) | 3,514 | 1,264 | 699 | 424 | 279 | 176 | 116 | 45 | 61 | 1 | 3 | 6,582 |
| Alfisol | 11/8/74 (K) | 2,290 | 726 | 386 | 169 | 92 | 18 | | | | | | 3,681 |
| Vertisol | 22/9/74 (R) | 909 | 519 | 172 | 42 | 8 | | | | | | | 1,650 |
| Vertisol | 16/12/74 (R) | 531 | 339 | 135 | 68 | 14 | 9 | 4 | | | | | 1,100 |
| Vertisol | 19/7/75 (K) | 3,872 | 902 | 171 | 40 | 10 | 3 | 2 | | | | | 5,000 |
| Alfisol | 19/7/75 (K) | 1,545 | 242 | 13 | | | | | | | | | 1,800 |
| Vertisol | 30/7/75 (K) | 1,730 | 903 | 436 | 265 | 132 | 90 | 32 | 6 | 6 | | | 3,600 |
| Alfisol | 2/8/75 (K) | 1,211 | 497 | 294 | 102 | 53 | 23 | 20 | | | | | 2,200 |
| Total Number of Plants | | 64,910 | 8,402 | 3,020 | 1,293 | 653 | 328 | 177 | 54 | 67 | 1 | 3 | |

K = Rainy (kharif) season
R = Postrainy (rabi) season

## Effects of Intrarow Spacing on Oviposition

It is important, for screening work, to determine which plant densities maximize egg numbers and which are best for screening for oviposition nonpreference and resistance. In routine screening work, it had been observed that when few plants emerged in a test row, fewer plants than expected had eggs laid on them. In three experiments in the rainy season of 1975, the number of seedlings with eggs increased significantly at higher plant densities ($P > 0.001$) and the correlation coefficients between number of plants and number with eggs were high in all three trials (0.97, 0.95, and 0.94) *Table 3*. However, when these data were converted to percentage plants with eggs, the trend was reversed; attack was maximized at the 200 mm spacing. Subsequent 'dead heart' counts clearly reflected these findings--the number of plants with 'dead hearts' was significantly higher at high plant densities, but the percentage was again the reverse.

These findings were confirmed in the trial carried out in the rainy season of 1977, when significantly more eggs were laid per unit area at high plant densities, but the percentage of plants with eggs was greatest at low plant densities. Very few plants were free of eggs at this spacing and larvae established in almost all plants, since there was an extremely close relationship between the number of plants with eggs and the number of 'dead hearts' (Fig. 1). At the 200 mm intrarow spacing, 78 of the 79 plants with eggs developed 'dead hearts', but even at the 10 mm (two-row) spacing the relationship was close--1,181 plants with eggs, 1,173 with dead hearts. A study of the total number of eggs laid on these plots shows that at the 200 mm spacing only 121 eggs were laid while at the latter some 2,240 were laid on an area of the same size. The mean number of eggs laid, on plants selected for oviposition was nevertheless higher on the 200 mm spacing--1.5 compared to 1.2 per plant. This observation was confirmed by analysis of the percentage of plants having multiple egg numbers which clearly showed that multiple egg numbers were more common at the low plant densities.

Data from this experiment showed that far more tillers per plot were produced at the denser spacings, but that the number per plant was higher at the wider spacings. More eggs were laid on tillers per plot at the denser spacings and the larvae produced from these eggs gave correspondingly high numbers of dead hearts; however, the ratio of eggs to dead hearts produced was obviously higher at the low plant densities *Table 4*.

## DISCUSSION

The results are of relevance in the context of resistance screening and breeding programmes for *Atherigona soccata*. To maximize shoot fly increase in susceptible spreader-row sowings, spacings of 10 mm or less between plants will maximize both egg numbers and numbers of dead hearts, thus ensuring maximum shoot fly challenge to plant material under test.

Table 2. The number of *Atherigona soccata* eggs laid on leaves of sorghum at ICRISAT Center, July 1974.

| Plants examined (no.) | Germination date | Leaf number together with number of eggs detected | | | | | | | | | | | | | Total eggs laid |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | |
| 2989 | 6/7/74 | 13 | 23 | 37 | 51 | 74 | 60 | 18 | 18 | 5 | 6 | 3 | 4 | 0 | 312 |
| 3072 | 6/7/74 | 3 | 7 | 37 | 62 | 77 | 68 | 38 | 54 | 42 | 39 | 14 | 10 | 4 | 455 |
| 385 | 19/7/74 | 2 | 16 | 96 | 180 | 100 | 40 | 8 | 2 | 0 | 0 | 0 | 0 | 0 | 444 |

Table 3. Number and arc sine percentage of sorghum seedlings with *Atherigona soccata* eggs at three sites and five plant spacings (ICRISAT Center, rainy season 1975).

| Spacing (mm) | Mean number and percentage seedlings with eggs per plot | | | | | |
|---|---|---|---|---|---|---|
| | Experiment No. 1 | Trans %[a] | Experiment No. 2 | Trans % | Experiment No. 3 | Trans % |
| 10 | 217 | 60.7 | 247 | 48.1 | 234 | 35.3 |
| 25 | 159 | 67.7 | 202 | 67.6 | 148 | 54.9 |
| 50 | 113 | 74.7 | 114 | 78.9 | 100 | 76.4 |
| 100 | 59 | 78.2 | 45 | 78.4 | 45 | 76.4 |
| 200 | 39 | 79.4 | 32 | 85.4 | 32 | 88.0 |
| SE | ± 10.1 | 3.90 | ± 10.9 | 4.02 | ± 9.3 | 2.91 |
| P | 0.001 | 0.05 | 0.001 | 0.001 | 0.001 | 0.001 |

[a]Arc sine transformation used for analysis of data.

Table 4. The relationship between tiller production, plant density, and oviposition by *A. soccata* at ICRISAT Center, rainy season 1977.

| Spacing | Mean tiller number per plot | | | |
|---|---|---|---|---|
| | Total | With eggs | With dead hearts | Mean No. eggs |
| 10 mm (2 rows) | 2511 | 909 | 495 | 1009 |
| 10 mm | 1267 | 449 | 256 | 484 |
| 50 mm | 521 | 309 | 229 | 354 |
| 100 mm | 320 | 190 | 145 | 219 |
| 200 mm | 195 | 117 | 91 | 145 |
| SE | ± 129.4 | ± 75.1 | ± 59.3 | ± 90.7 |
| P | 0.001 | 0.001 | 0.001 | 0.001 |
| LSD (P<0.05) | 398.7 | 458.6 | 182.7 | 279.5 |

Since more tillers per unit area are also produced at these high densities and more dead hearts are obtained, maximum shoot fly production is ensured. Data indicate that a high proportion of plants oviposited on will produce dead hearts at all densities.

When using percentage data in assessing material for shoot fly resistance, spacing between plants should be not less than 200 mm to obtain repeatable results, since escapes, (i.e., plants which are not laid on) are far less frequent at wider spacings. At spacings closer than 100 mm, the percentage of plants attacked is reduced, making selection of definitel resistant plants more difficult.

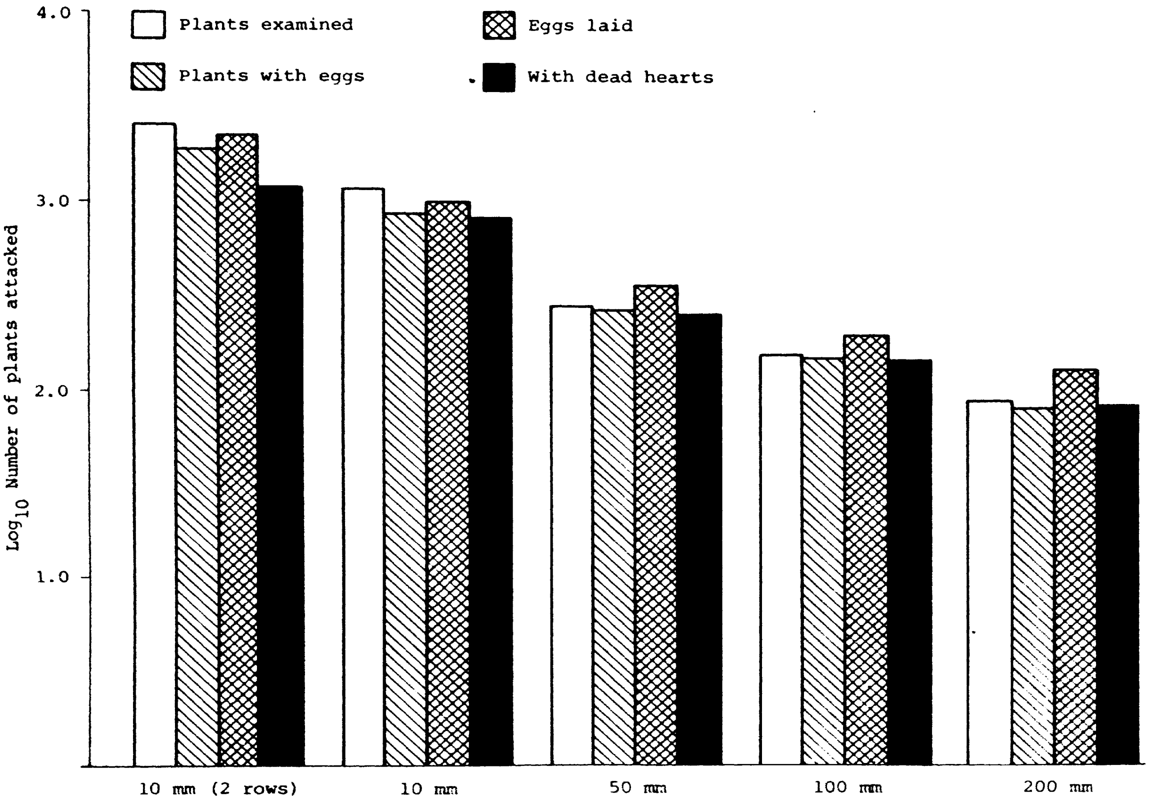
Data on oviposition sites confirmed that eggs are normally laid on the lower surfaces of leaves, particularly the mid-leaf area (Ponnaiya, 1951; Langham, 1968), and that generally only one egg per plant is laid (Soto, 1974). The observation that the third to seventh leaves are preferred for oviposition (Ponnaiya, 1951; Soto, 1974) were strongly supported.

These data indicated that reduction in potential stand losses by shoot fly are possible by sowing thickly and roguing out of plants prior to the development of the second generation of shoot fly within the crop. These observations confirmed those made elsewhere (Swaine, and Wyatt, 1954; Davies and Jowett, 1966) that early sowing reduced the level of attack. Data indicate that a slight delay in sowing results in greatly increased oviposition.

## ACKNOWLEDGEMENTS

We gratefully acknowledge the assistance of our technical field staff in the tedious counting involved in these studies and the helpful comments of Dr. W. Reed, on the draft manuscript.

Figure 1. Mean $\log_{10}$ plants examined and numbers attacked by *A. soccata* at six plant densities (ICRISAT Center, 1977 - Mean of four replicates)



## REFERENCES


BLUM, A. (1967). Varietal resistance of sorghum to the sorghum shoot fly (*Atherigona varia* var. *soccata*). Crop Sci. 7, 461-462.

DAVIES, J.C. and JOWETT, D. (1966). Increases in the incidence of *Atherigona indica infuscata* Emden (*Diptera-Anthomyiidae*) on sorghum due to spraying. Nature 209, 104.

JOTWANI, M.G., MARWAHA, K.K., SRIVASTAVA, K.M. and YOUNG, W.R. (1970). Seasonal incidence of shoot fly (*Atherigona varia soccata* Rond.) on Jowar hybrids at Delhi. Indian J. Entomol. 32, 7-15.

LANGHAM, R.M. (1968). Inheritance and nature of shoot fly resistance M.Sc. Thesis. Ahmadu Bello University, Zaria, Nigeria.

NYE, I.W.B. (1960). The insect pests of graminaceous crops in East Africa. Booklet, Colonial Research Studies No.31, H.M.S.O., London pp 48.

PONNAIYA, W.B.X. (1951). Studies on the genus sorghum. II. The cause of resistance in sorghum to the insect pest *Atherigona indica* M. Madras Univ. J. 21, 203-217.

SESHU REDDY, K.V. and DAVIES, J.C. (1977). Species of shoot fly *Atherigona* sp. present in Andhra Pradesh. PANS 23, 379-383.

SOTO, P.E. (1974). Ovipositional preference and antibiosis in relation to resistance to a sorghum shoot fly. J. Econ. Entomol. 67, 265-267.

SWAINE, G. and WYATT, C.A. (1954). Observations on the sorghum shoot fly East African Agricultural and Forestry J. 20, 45-48.