

Biology, Ecology and Management of Sorghum Shoot Fly (*Atherigona soccata*): Challenges and Prospects

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OPEN ACCESS

Keywords

Shoot fly, Sorghum, Dead heart, Pest, Management

How to cite this article:

Solanki, N., Harshana, A., Devi, H. D. and Mishra, P. K. 2026. Biology, Ecology and Management of Sorghum Shoot Fly (*Atherigona soccata*): Challenges and Prospects. *Vigyan Varta* 7 (05):16-22.

ABSTRACT

Sorghum bicolor is an important cereal crop used for both grain and fodder. However, its productivity is greatly constrained by insect pests, with over 150 species recorded. Among which the sorghum shoot fly is one of the most destructive during the early crop stage. The pest attacks young seedlings and damages the central growing point, leading to the formation of “dead heart” symptoms, which results in poor plant population and significant reduction in grain as well as fodder yield. Considering the economic importance of this pest, article presents a comprehensive information regarding its life cycle, ecology, damaging symptoms, alternate host plants, economic threshold levels, yield losses and management strategies, along with the major challenges and limitations associated with its control.

INTRODUCTION

S*orghum bicolor* is a major cereal grown in many parts of the world. In India, it is widely cultivated for both food and animal feed, and it ranks fourth among cereal crops after rice, wheat and maize (Dehinwal *et al.*, 2016). Sorghum is affected by many types

of insect pests at different stages of its growth, which reduce both grain and fodder yield. More than 150 insect species have been recorded as pests of this crop (Jotwani *et al.*, 1980; Sharma, 1993). Among the many insect pests that attack sorghum, the shoot fly,

Atherigona soccata (Order: Diptera; Family: Muscidae), is one of the most serious at the early seedling stage. It damages young plants and leads to heavy losses in both fodder and grain yield, making it one of the major pests of sorghum. This insect mainly attacks sorghum during the early seedling stage and causes the most severe damage during the rainy season (Singh *et al.* 2017). Severe attack at the booting stage causes the upper leaves to curl and prevent the panicle emergence, which can lead to yield losses of up to 41% in India (Subbarayadu *et al.*, 2002). This pest can survive on other cereal crops and different weeds. Considering its adverse effects on plant population and grain yield, significant research has been undertaken to develop effective management strategies for sorghum shoot fly. Several approaches are available for its control, including early sowing, use of higher seed rates, thinning and removal of seedlings showing dead heart symptoms, seed treatment or soil application of insecticides, as well as intercropping and crop rotation practices. However, the adoption of a well-planned insect pest management program is essential to reduce losses and ensure the appropriate use of insecticides.

Biology

The sorghum shoot fly completes its life cycle in four stages:

Egg: Females lay small, white, elongated, cigar shaped eggs singly on the underside of young sorghum leaves (3rd–6th leaf) within 1–4 weeks after emergence. A single female may produce up to 75 eggs during her lifespan, which hatch in 2–5 days (Deeming, 1972).

Maggot (Larva): The newly emerged larva moves to the central whorl and they damage the growing point. This feeding injury causes the central leaf to wilt and dry, producing the typical “dead heart” symptom (Padmaja *et al.*, 2010). The larval stage lasts 8–10 days

and includes 4–5 instars. Mature larvae are yellowish and about 6 mm long.

Pupa: Pupation occurs at the base of the affected seedling or in the surrounding soil. The pupal stage continues for about 5–7 days before adult emergence.

Adult: The adult fly is small, dark to greyish brown, and similar to housefly but is nearly half its size. Males are comparatively smaller than females, and the abdomen shows six distinct black spots. Adults live for around 12 days on sorghum plants. The complete development from egg to adult takes about 17–21 days, (Sharma and Nwanze, 1997) and under favorable conditions, the insect can produce up to 10 generations annually.

Ecology / Seasonal Incidence

The populations of shoot fly are highly fluctuating, very less from April to June and generally increases in the month of July onward and maximum number of flies appears during the month of August (Balikai, 2000). Its behavior is driven by extreme temperatures (hotter than 35°C and colder than 18°C), as well as by constant rain. Therefore, the activity of shoot fly became higher at early stage of crop growth, remained high as it stays in the grand growth phase and decreased when the crop becomes to be matured (Rai & Mulatu, 2012). The highest occurrence of shoot fly during the *kharif* season has been documented in August, whereas in the rabi season, it was seen in October to November (Pawar *et al.*, 2015). Fly infestations typically peak in crops sown during the post-rainy season of September–October.

Alternate Hosts

In the off-season, sorghum shoot fly lives on other plants instead of sorghum. These plants include *E. procera*, *Echinochloa colonum* Link., *Cymbopogon* species, *Paspalum*

scrobiculatum. It can survive on volunteer and fodder sorghums crops.

Nature of damage

Infestation usually takes place within one to four weeks after the emergence of seedlings. The larvae feed on the growing point of the plant, leading to the drying of the central leaf, a condition known as “dead heart.” The affected seedlings often die, although they may sometimes produce side tillers. In cases of heavy infestation, these tillers are also attacked. While a few tillers may develop into productive panicles, they are often subjected to further damage by insects feeding on panicles and by birds. Early infestation of the crop can greatly decrease the overall plant population.



Fig. 1 Dead heart



Fig. 2 Affected plant producing side tillers

Yield losses

In India, insect pests are responsible for causing approximately 32% loss in sorghum production, as reported by Borad and Mittal (1983), with about 5% of this damage

attributed specifically to the sorghum shoot fly (Jotwani, 1983). Among the various pests, *Atherigona soccata* is considered one of the most serious at the seedling stage of the crop. It can reduce fodder yield by nearly 68.6% and grain yield by about 75.6% (Kahate et al. 2014). The severity of infestation increases with delayed sowing, sometimes reaching up to 90% (Rao and Gowda, 1967). The yearly economic losses caused by this pest are estimated to be more than US\$100 million according to ICRISAT (1992).

Economic Threshold Levels

The economic threshold levels (ETLs) differ depending on the cultivar, geographical region, and season. In India, the ETLs for sorghum shoot fly have been reported to range from 4–10% dead heart incidence in CSH 1, 3–9% in CSH 5, and 6–15% in Swarna (CSV 1) (Rai et al., 1978). However, under conditions where improved management and higher inputs are applied, damaged plants can often compensate for early injury through the development of productive tillers, thereby reducing the overall impact on grain yield.

Management

Different management strategies have been developed to control sorghum shoot fly.

Cultural Control

- Cultural methods are important for reducing shoot fly infestation and include practices such as proper sowing time, optimum seed rate, and intercropping.
- Adjusting the planting time helps prevent the most susceptible stage of the crop from overlapping with the peak activity of the pest.
- Early sowing, particularly during the second week of June, combined with a higher seed rate of about 10 kg/ha and

removal of dead heart plants at around 28 days after emergence, is effective in minimizing damage (Shekharappa and Bhuti, 2007).

- In cases of delayed sowing during the rainy season, increasing the seed rate followed by thinning and removal of affected plants helps maintain the desired plant population.
- Intercropping sorghum with crops like garlic or onion has also been shown to reduce shoot fly incidence. Such systems, especially when combined with paired row planting, help manage the pest without adversely affecting plant density (Karibasavaraja *et al.*, 2005).



Fig. 3 Intercropping (sorghum + cowpea)

Physical Control

Several types of traps are employed to manage sorghum shoot fly populations. Among these, fishmeal traps are widely used for attracting and capturing adult flies.

Host Plant Resistance

A number of sorghum genotypes have shown resistance to shoot fly infestation. Varieties such as ICSB 425, ICSB 42, and IS 2312 exhibit resistance mainly due to leaf glossiness, which discourages oviposition by the pest (Kalpande *et al.*, 2015).

Biological Control

- The conservation of natural enemies plays a significant role in managing shoot fly. Important biological control agents include parasitoids and predators such as *Trichogramma chilonis*, *Trichogrammatoidea simmondsi*, *Neotrichoporoides nyemitawus*, coccinellid beetles, spiders, and lacewings.
- Additionally, the release of egg parasitoids like *Trichogramma chilonis* at a rate of 1,00,000 individuals per hectare, around 10–15 days after crop emergence, has been found effective in controlling the pest population.

Use of botanicals

- Botanical insecticides play an important role in the eco-friendly management of sorghum shoot fly. Application of neem oil and karanj oil at a 2% concentration, sprayed at 7, 14, and 21 days after emergence of crop significantly reduced egg laying by the pest and effectively decreased the formation of dead hearts in the crop (Joshi *et al.*, 2016).
- The combined use of neem seed kernel extract (NSKE) with cow urine and panchgavya has shown effectiveness comparable to chemical insecticides, while remaining environmentally safe (Shrinivas *et al.*, 2009).
- Similarly, azadirachtin 1500 ppm, a neem-derived formulation, helps in lowering oviposition and reducing dead heart incidence caused by the shoot fly (Parteti *et al.*, 2014).

Chemical Control

- Chemical methods, particularly seed treatments, are effective in managing sorghum shoot fly infestation. Treatment of

seeds with thiamethoxam 30 FS at 5 ml per kg or imidacloprid 600 FS at 7 ml per kg has been reported to provide good control of the pest (Sandhu, 2016).

- Even at lower dosages, such as thiamethoxam 70 WS at 2 g per kg and imidacloprid 70 WS at 5 g per kg, satisfactory control of the pest can be achieved (Kumar and Prabhuraj, 2007).
- The use of thiamethoxam 70 WS at 3 g per kg of seed has shown high efficacy against shoot fly (Daware *et al.*, 2012).

Challenges

- Climate Variability - Variations in temperature, rainfall, and relative humidity strongly affect shoot fly population build-up and seasonal incidence. Irregular weather patterns can alter pest peaks and reduce the reliability of timely sowing as a control strategy (Balikai and Venkatesh, 2001).
- Carry-Over on Alternate Hosts - The pest survives during the off-season on grasses and volunteer sorghum, maintaining infestation pressure across seasons.
- Dependence on Cultural practices, such as early sowing and higher seed rate, is effective but may not always be practical due to unpredictable rainfall, labour limitations, or irrigation constraints.

Future prospects

- Improved Biological Control Strategies - Advancements in biological control offer promising opportunities for managing sorghum shoot fly. The mass production, conservation, and augmentative release of parasitoids, particularly *Trichogramma* species, can enhance natural pest suppression.

- Weather-Based Pest Forecasting - Prediction models using climatic data can guide farmers in adjusting sowing dates and management decisions.
- Strengthening IPM - Integration of cultural, resistant varieties, biological control, botanicals, and need-based chemicals remains the most sustainable strategy.

CONCLUSION

Sorghum shoot fly (*Atherigona soccata*) is one of the primary factors limiting sorghum productivity, because it damages the crop at the early seedling stage and multiplies rapidly under favorable conditions. Its survival on alternate hosts and sensitivity to sowing time and weather make management challenging. Sustainable control depends on adopting an Integrated Pest Management (IPM) approach that combines timely sowing, resistant varieties, biological control, eco-friendly botanicals, and limited use of chemicals. Future prospects lie in strengthening biological control, improving pest forecasting systems, and promoting eco-friendly management technologies.

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