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Shoot fly complex: A significant threat to cereals, and their management

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Abstract
Shoot Fly, *Atherigona* spp. (Rondani) is a Dipteran fly belonging to House fly family, Muscidae. This is a very serious concerned and considered as a major pest of Sorghum, Maize, Wheat, and other Millets, mainly associated with the major and minor cereal crops. The *Atherigona* genus contains many species that are primarily specialized to each crop. This pest was reported to be a serious pest in spring maize which causes heavy plant loss. Also it possesses a significant threat to sorghum production worldwide. It was reported to cause up to 60% plant loss and around 21% grain yield loss depending upon the crops. The major damage caused by the pest drying and withering of the central shoot, which mainly leads to the ultimate reduction in economic yield of the crop. As an internal borer fly causes severe reduction in grain as well as stalk yield of every potential cereal host plants. In a very advanced research, it has demonstrated that the Shoot fly has already developed cross-resistance against the several systemic insecticides. Rather than trying to control the flies, we need to manage them in order to reduce such significant crop losses. That's why the concepts of Integrated Pest management has arrived and been implemented to reduce the pest population up to Economic Threshold Level (ETL). Several control approaches become harmoniously coordinated and applied to keep the safe environment for the beneficial insects as well as also to control the target pests. In this literature, the level of incidence, shoot fly complex attacking on different crops and their viable IPM strategies will be discussed briefly in a short course.

Keywords: Shoot fly, integrated pest management, cereals, chemical insecticides etc.

Introduction
Sorghum shoot fly, *Atherigona soccata*, is one of the important pests of post rainy season Sorghum. They attacked mainly the crops sown in September-October temperature above 35 °C, as because below 18 °C reduces shoot fly survival. Shoot Fly belongs from the family Muscidae whose larvae feed on the central growing shoots. The Muscidae family is well-known for House flies or Stable Flies, contain almost 4,000 described species in over 100 genera. Most species are not synanthropic. Adults can be predatory, hematophagous, saprophagous, or feed on a number of types of plant and animal exudates, and the immature stage maggots are mainly act as borer, Phytophagous and sometimes they remain inactive. Maggots are considered as the main damaging stage of field crops. They are Acephalous and Apodous sometimes present as Eucephalous (E.g. Wriggler). The Acephalous maggots bear black coloured pointed Cephalopharengeal skeleton at the apical portion of the body, through that only they bore into the stem of crops and feed the internal content. There are approximately 200-250 species present under *Atherigona* genus, within that some aren't described till now and very few are considered as massive agricultural pest. The every species having their own specific host plant, except *A. falcata* which was recorded on 17 hosts, including sorghum. Mainly all the species are attacked the Gramineae family mostly. But the mostly preferred hosts of this shoot fly complex are Maize and Sorghum, and other minor millets. All crops belonging to the Gramineae (Poaceae) family have hollow pseudo stems that concurrently contain hollow nodes and internodes. Due to that, the maggots can easily bore into the shoot system of the main crops and cause hindrance in the sap flowing. In India, the shoot fly, *Atherigona soccata*, is considered the most severe pest, particularly in Rajasthan, where it causes significant damage to seedlings by killing the central shoot.

On the other hand, the adult flies are used to oviposit on the under surface of leaves, but their damaging site is mostly the tender shoots and midrib of the leaves. As they're prevalent in every parts of the plant, only the systemic insecticides can't manage them uniformly. We've to take some extra agronomical measures simultaneously before the massive attack by the pest. The use of Botanicals, natural enemies and resistant cultivars along with some mechanical traps collectively consider very effective strategy to manage this particular pest. Farmers and agricultural experts in sorghum-growing areas often employ integrated pest management (IPM) approaches that combine multiple strategies, including cultural practices, resistant varieties, biological control, and judicious use of pesticides or botanicals when necessary. The main agenda of these IPM strategies are- 1) To manage the particular pests, not directly destroy their life cycle, 2) To save the beneficial natural enemies and 3) To bring down the pest population below the ETL level. But it's important to note that specific management practices for insect pests may vary depending on the region, local conditions, pest populations and the availability of the natural resources of that particular region. For efficient management of the pest incidence, it's necessary to adopt the integrated strategy by keeping the environment safe and conservative.

Shoot Fly Complex of Cereal Crops

The *Atherigona* genus includes more than 220 species can be distinguished from other genera by the following characters, e.g. angular head, with long very sunken face and antennal flagellomere, almost reaching lower facial margin in lateral view; arista bare; thoracic setae very reduced in size, prealar absent, wing veins, except costa, bare; hind tibia without posterodorsal seta (calcar) in apical half. *Atherigona* species are uniform in general appearance, small (body length: 5.0–7.0 mm), yellowish grey in general coloration. Among the different species, the discrimination between the arrangements of cross-veins, are the right way to identification.

The genus *Atherigona* [Family:- Muscidae, Order:- Diptera] includes the following species along with their potential host plants:-

Table 1: The genus *Atherigona* [Family:- Muscidae, Order:- Diptera] includes the following species along with their potential host plants

Sl. No.	Species Name	Associated Crops	Damage Potential
1.	*A. soccata* Rondani	Maize, Wheat, Sorghum, Ragi in India, Kodo in Nepal	84-91%
2.	*A. approximata* Malloch	Pearl Millet, Finger Millet	33-42%
3.	*A. simplex* Thompson	Proso millet, Kodo Millet	56-61%
4.	*A. atripalpis* Malloch	Fox tail Millet, Korle in AP	26-34%
5.	*A. falcata* Thompson	Barnyard Millet, Sorghum, Pearl Millet, Finger Millet, Kutki, Shavan, Buckwheat millet	78-86%
6.	*A. pulla* Wiedmann	Little Millet, Kodo Millet	16-20%
7.	*A. punctate* Karl	Proso Millet, Graminaceous wild hosts	9-13%
8.	*A. oryzae* Karl	Paddy, Wheat, Sorghum	15-23%
9.	*A. reversura*	Other Graminaceous wild hosts.	-
10.	*A. culicivora*	Bamboo Shoot fly feeding on mosquito larvae	-
11.	*A. orientalis*	Pepper, Damaged plant parts, Faeces	56-67%

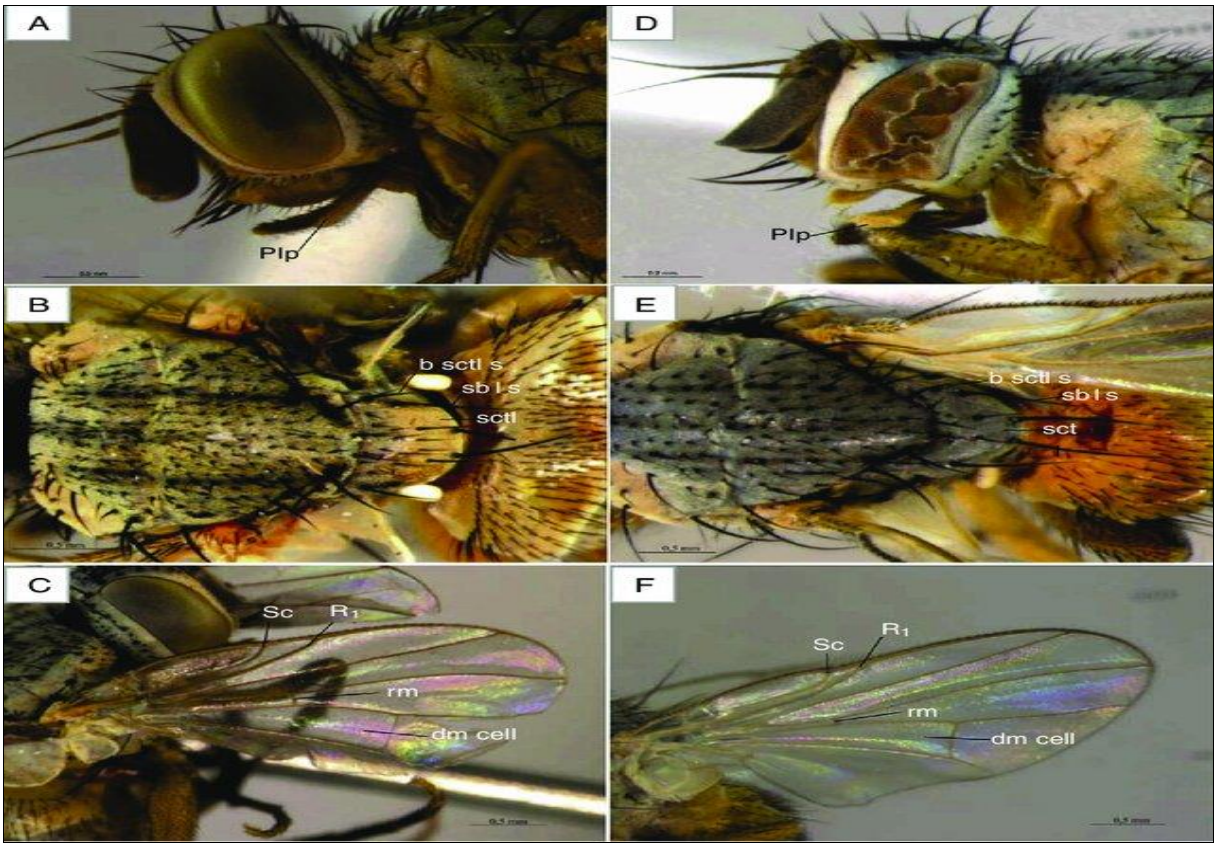


Fig 1: The characteristic Features to identify the Atherigona genus among the other genus in Muscidae

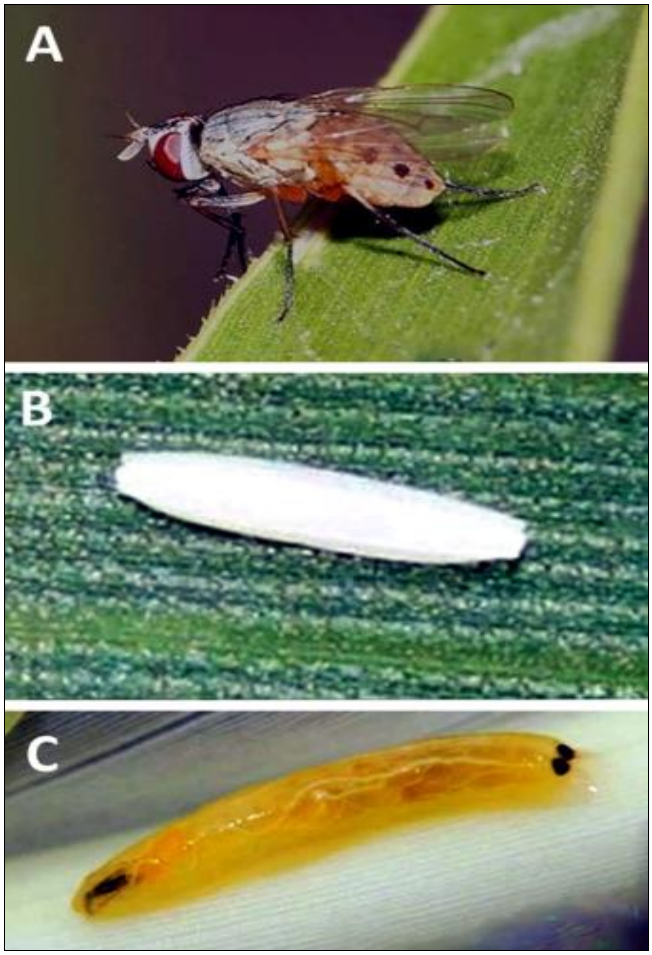


Fig 2: Biology of Shoot Fly (*A. socatta*)

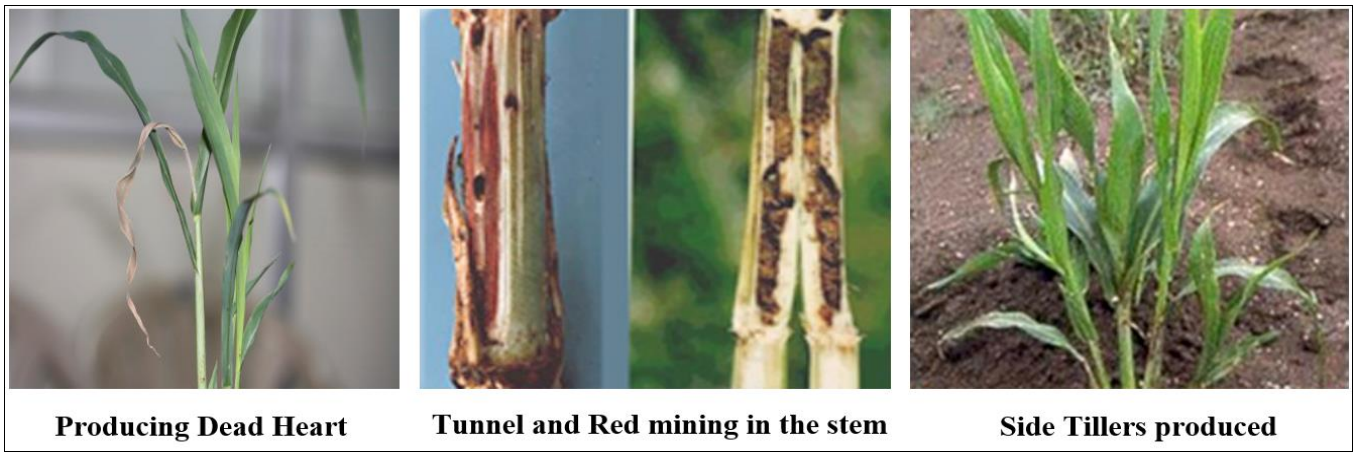
- **Biology of Shoot Fly (*A. socatta*):-**
- **Eggs:** They are cigarette shape, white coloured laid generally singly parallel to the midrib on the under surface of the 3rd to 5th leaf. Incubation period within 2-5 days.
- **Maggot:** Yellow in colour migrate to the dorsal surface of the leaf, enter the space between the leaf sheath and the axis and make a clean cut with the help of Cephalopharengeal skeleton present in dorsal part of maggot body. The larval period lasts for 6 - 10 days.
- **Pupa:** Pupation takes place inside the stem and the adults emerge in about a week. Pupal period- 6-8 days.
- **Adult:** The adults are dark brown and similar to domestic housefly, but nearly half the size with the males smaller than the females. Adult flies are little smaller and greyish brown in colour with 6 black spots on the abdomen. The adults usually live for 10 to 20 days.
- They complete their life cycle quickly when, Temperature remains -25-30 °C Relative Humidity- more than 60% and erratic rainfall occurred, but Continuous rain fall decrease pest incidence.

Damage Symptoms

- The early instar larvae migrate to the upper side of the leaf and reach the growing point where the larvae cut the growing point. As a result, the central leaf dries up forming a dead heart, which can be pulled out easily and produces a rotting foul smell.
- In case high humidity during the rainy season, they are moving to the older plants (>30 days after seedling emergence), in those plants, shoot fly do not produce the typical dead heart symptoms, rather they damaged leaf becomes thin and papery, wrapping around the other leaves. The plants may fail to grow normally.
- Late infestations may also damage the panicle in the formative stage, resulting in rotting or drying up of a portion of the panicle affected by shoot fly damage.
- The damaged plants tend to produce the side tillers.

Favourable Temperature (Epidimeology of Pest Attack)

- Mainly damage started at seedling stage (5 to 30 days after seedling emergence or 3-4 weeks after sowing).
- Damage incidence is prominent in late kharif and early Rabi season, mainly during post rainy season, crops which are sown in September-October.
- Infestation is especially high when sorghum planting is staggered due to erratic rainfall.
- The late sown crops generally suffer greater shoot fly damage because of high humidity and moderate temperature.



- **Integrated Management of Shoot Fly Damage**

The following key components of IPM are really indispensible for managing the Sorghum Shoot Fly:-

a) Cultural Control

- **Planting time:** Early sowing of sorghum immediately after the receipt of South West or North East monsoon to minimise the shoot fly incidence, because The manipulation of planting time helps to minimize pest damage by producing asynchrony between host plant and the pest.

- **Proper Plant Spacing:** Plant spacing may influence the population and damage of many insect pests by modifying the micro-environment of the crop or affecting health, vigour and strength of the crop plants. That's why maintain the proper recommended plant spacing is very important, follow the Plant to plant spacing should be-10-15 cm and Row to row spacing will be 45 cm.
- **Growing Resistant Varities:** Genetically modified resistant varieties are more tolerant than any natural control, that's why cultivate the resistant varieties of Shoot Fly like Co-1, CSH 15R, Maldandi and Hagari, M35-1, Swati, SPV 491, IS - 18551, 5566, ICSV 700, ICSV 705, Phule Yashoda.
- **Seed Rate:** Adoption of appropriate seed rate ensures proper stand, spacing and crop canopy that ensure the healthy crop stand. To control the incidence of shoot fly, Use higher seed rate (12.5 kg/ha).
- **Fertilizer Management:** High levels of nitrogen fertilizers significantly increase the incidence of most of the insect pests, so must follow the recommended dosages of N: P: K- 40:40:0 Kg/ha and for Hybrid cultivars, we should use the N: P: K- 80:40:20 Kg/ha. Also we need to apply the well rotten FYM @ 12.5 t/ha.
- **Water Management:** Proper and judicious irrigation methods should be followed to avoid the excess moisture and dry condition in fields. So on an average 6-9 irrigations should be given, each of 5-6 cm depth is necessary. Total water requirement of Sorghum is 500-600 mm. Another thing during the application of irrigation, we've to keep in mind that the critical stages of irrigation, e,g in case of Sorghum the critical stages are-Germination, Knee high stage (30-35 DAS), Flag leaf stage (50- 55 DAS), Flowering stage (70-75 DAS), Grain formation stage (100-105 DAS).
- **Sanitation or Clean Cultivation:** Clean cultivation is often recommended as a way to eliminate the overwintering sites for pest populations. Here also, we must have to remove the shoot fly damaged seedlings at the time of thinning or raise nursery and transplant only healthy seedlings.
- **Crop Rotation:** we shouldn't follow the monocropping of the cereal crops, as the incidence of shoot fly is more prominent in the cereals, so we can rotate the cereals with various pulses and groundnut (oilseed crops), then it produces the environment less favourable for survival of shoot fly during the off season.

b) Mechanical Control

a) We've to remove the shoot fly damaged seedlings at the time of thinning or raise nursery and transplant only healthy seedlings. We've to rid off the infested shoot that harbouring the puparium of the shoot fly.

b) We've to pull out and destroy plants showing dead hearts at the time of thinning and Gap filling.

c) Set up the TNAU low-cost fish meal trap @ 12/ha till the crop is 30 days old.

c) Biological Control

- Release of natural enemies like Egg parasitoids such as *Trichogramma toideasimmonalsi*, *Trichogramma chilonis*, *Neotrichoporoides nyemitawus* and predators such as spiders, coccinellids, lacewings etc to keep the shoot fly populations in check.
- Release of *Trichogramma chilonis* @ 1,00,000 per ha on 10-15 days old crop.

d) Chemical Control

- We've to spray the required amount of the insecticides at a correct crop stage, shouldn't use the blanket application as well as during the reproductive and fruiting stage of crops. Always the farmers should follow the proper chemical spraying methodologies.
- Spraying of Methyl demeton 25 EC 12 ml/ha, Dimethoate 30 EC 12 ml/ha in 120 m^2 nursery area.
- In Main field, we can spray Methyl demeton 25 EC 500 ml/ha, Dimethoate 30 EC 500 ml/ha, Neem Seed Kernel extract 5%.
- Also Soil application of granular pesticides e.g. phorate 10 G 18 kg/ha or carbofuran @ 33.3 kg /ha at the time of sowing is quite beneficial. Also we can apply during vegetative stage at the leaf whorl.
- We can spray either of Fenvalerate 20EC @100ml/ha, Cypermethrin 10EC @ 100ml/ha or deltamethrin 2.8EC @ 200ml using 150 liters of water to the crops 2-3 weeks after sowing as soon as borer injury to the leaves is noticed.

Conclusion

Shoot fly becomes a very significant threat now a days mainly in the cereals. It causes an irreplaceable damage both in terms of quality and quantity. By Understanding its distribution, life cycle, and nature of damage it is very crucial to identify and formulate the most effective management strategies. For sketching the proper integrated management strategies practically in the field the study of the ecology of the insect is basic principal theory. After understanding the crop behaviour, insect ecology and environmental impact, we should integrate the suitable and reasonable management strategies to bring down the pest population under EIL and to keep safe the crop ecology for the further enhancement of natural enemies.

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