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A Review

Bio-ecology and management of sorghum shoot fly, *Atherigona soccata* Rondani

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ABSTRACT

Sorghum (*Sorghum bicolor* (L.) Moench) is an important food and fodder crop in world, which ranks fourth among the major cereals after wheat, rice and maize. More than 150 insect species have been reported as pests on this crop. Among different insect pests, the shootfly, *Atherigona soccata* Rondani is a serious pest particularly in late sown crop. However, it is not uncommon to find harrowing of sorghum crop due to heavy infestation by shootfly. Looking to the seriousness of the pest, an attempt has been made to gather the information on its biology, seasonal incidence, nature of damage, alternate hosts, resistance screening techniques, resistant sources, economic threshold levels, mechanism of resistance, factors associated with resistance and management practices.

Key words : Sorghum, Shoot fly, Atherigona socata, Bio-ecology of management.

Biology and seasonal incidence:

The adult is a grey-colored small fly, which deposits small, white cigar-shaped eggs singly on the abaxial leaf surface of the seedlings parallel to midrib. After hatching in 1-2 days, the maggot enters the seedling base through the whorl and cuts the growing point. The larval period lasts for 8 to 10 days. Grown up larva is yellowish and about 6 mm in length. Pupation takes place either at the plant base or in the soil and lasts for 8 days. The entire life cycle is completed in 17 to 21 days (Sharma and Nwanze, 1997). The shoot fly populations exhibit considerable variation, normally very low from April to June, tend to increase in July and reaches peak in August. From September onwards the population gradually declines and with slight increase there will be a small peak in October and thereafter remains at a moderate level till March (Balikai, 2000). Its activity is influenced by extreme temperatures (above 35ºC and below 18ºC), and also by continuous rains. Balikai and Venkatesh (2001) reported that, rainfall received at one week after emergence and higher day temperature at two weeks after seedling emergence reduced shoot fly infestation, whereas lower afternoon relative humidity at 4 weeks after emergence increased shoot fly infestation. Karibasavaraja *et al.* (2005a) reported that, the pest was active through out the study period of four months starting from 27th to 44th standard week. Further, studies on the shootfly catches in fishmeal trap revealed that, highest peak catch of 488 flies per trap was recorded during 35th standard week. Effect of weather parameters on trap catches revealed that, the maximum and minimum temperature and rainfall had negative relationships. Maximum temperature at two and three weeks prior to trap catch had highly significant positive correlation, whereas the afternoon relative humidity at two weeks before trap catch had positive significant correlation.

Nature of damage:

Infestation normally occurs in the 1-4 weeks after seedling emergence. Maggot causes injury to the growing tip, which results in withering of central leaf popularly known as 'deadheart'. The damaged seedling is killed but may produce side tillers. However, the tillers are also attacked under high shoot fly pressure.

Alternate hosts:

During the off-season, the shoot fly survives on alternate hosts (*Echinochloa colonum* Link., *E. procera* Hubb, *Cymbopogon* sp., *Paspalum scrobiculatum* Linn., and *Pennisetum glaucum* (L.) R. Br.) and on volunteer or fodder sorghums.

Resistance screening techniques:

Adequate shoot fly density for resistance screening can be achieved by manipulating the sowing date, using infestor rows and spreading fishmeal in the field (interlard-fishmeal technique). To confirm resistance observed under field conditions and to study various resistance mechanisms a cage-screening method can be used (Sharma *et al*. 1992).

Sources of resistance:

The germplasm lines IS-1054, IS-1071, IS-2394, IS-5484, and IS-18368 were quite stable for shoot fly resistance across locations. ICSV-700, ICSV-701, ICSV-705, ICSV-714, and ICSV-717 are improved breeding lines with resistance levels comparable to original sources of resistance (Sharma *et al*. 1992). Some other resistant sources are IS-1055, IS-2123, IS-2146, IS-2165, IS-2312, IS-3962, IS-4646, IS-4664, IS-5469, IS-5470, IS-5480, IS-5604, IS-5613, IS-5619, and IS-18551. Narkhede *et al.* (2002) reported RSV-175, RSV-176, RSV-182 and RSV-290 as resistant sources, which were stable across several locations. Similarly KC-1, PGN-8, PGN-19, PGN-20, PGN-64, SEH-2, PFGS-2, PFGS-57 and PFGS-8 have been reported as resistant by Prem Kishore and Kishore (2001). Among 28 lines tested in one set, thirteen of them (ICSR -170, SPV-1156, M 148-138, SPV-1173, IS-33742, A-1, SPV-462, IS-33859, SPV-570, SPV-489, KSV-18R, IS-33843 and 5-4-1 (Muguti) were found to be promising against shootfly. While in another set of 27 lines, fifteen entries (IS-18366, IS-12611, SPV-655, SPV-1155, Afzalpur local, SPV-839, IS-4657, IS-33751, DRC-1000, BRJ-17, Selection-3, DRV-20, IS-188758, M 35-1 and 5-4-1 (Muguti)) were found to be promising against shootfly in *rabi* season (Balikai and Biradar, 2003). Out of 205 sorghum germplasm evaluated for resistance to shoot fly, eighteen genotypes (IS-2191, IS-4481, IS-4516, IS-17596, IS-18366, IS-33714, IS-33717, IS-33722, IS-33740, IS-33742, IS-33756, IS-33761, IS-33764, IS-33810, IS-33820, IS-33839, IS-33843 and IS-3388) were classed as resistant (Balikai *et al*. 1998; Balikai and Biradar, 2004).

Status of released varieties/ hybrids:

Most of the *Kharif* (CSV-2, CSV-3, CSV-4, CSV-5 CSV-6, CSV-9, SPV-462, CSV-13 and *rabi* (CSV-8R, CSV-14R, Swati) varieties and *rabi* hybrid CSH-15R show moderate level of resistance to shoot fly (<40% deadhearts).

Economic thresholds:

The ETL of 4-10, 3-9, and 6-15 per cent deadhearts in sorghum cultivars CSH-1, CSH-5 and Swarna respectively (Rai *et al*. 1978) has been estimated. For every 1 per cent increase in infestation lead to 89.1 and 30.5 kg ha^{-1} reduction in grain yield in CSH-5 and M 35-1 (Mote, 1986).

Mechanism of resistance:

Non-preference:

Significantly higher oviposition has been reported on susceptible cultivars as compared to resistant genotypes. However, Non-preference for oviposition breaks down under no-choice conditions or under high shoot fly pressure in the field.

Antibiosis:

Growth, development and survival of shoot fly is adversely affected when reared on shoot fly resistant genotypes.

Tolerance:

Some sorghum genotypes exhibit an inherent ability to produce side tillers after the main shoot is killed by shoot fly, which in turn can produce a reasonable yield if the tillers are not attacked again.

Factors associated with resistance:

Seedling vigour:

Seedling viguor is negatively associated with deadheart formation (Jayanthi *et al*. 2002).

Glossiness:

Intensity of glossiness of the leaves at the seedling stage is positively associated with resistance to shoot fly.

Leaf surface wetness:

There are genotypic differences in surface wetness of the central shoot leaf between resistant and susceptible genotypes (Nwanze *et al*. 1990).

Trichomes:

Shoot fly-resistant germplasm lines have trichomes on the undersurface of leaves (except IS-5622, which has trichomes only on the upper surface). Trichomes are absent in shoot fly susceptible lines.

Biochemical factors:

Presence of irregular-shaped silica bodies in the plant tissue from the fourth leaf onwards in shoot fly-resistant cultivars, and from the sixth leaf onwards in susceptible cultivars has been reported by Ponnaiya (1951). He suggested that the relatively late appearance of these silica bodies in the susceptible cultivars make them prone to shoot fly attack for a longer period. Percentage of nitrogen, reducing sugars, total sugars, moisture, and chlorophyll content of leaf in susceptible cultivars are higher than in resistant ones (Singh and Jotwani 1980; Patel and Sukhani 1990). Higher quantities of total amino acid content in shoot fly-resistant lines than in susceptible was observed by Khurana and Verma (1982). Susceptibility to shootfly is positively correlated with phosphorus and negatively with total phenol content (Khurana and Verma 1983). There was a positive relationship between nitrogen and phosphorus content and degree of damage by shoot fly (Bhise *et al*., 1996).

Cultural control:

Shoot fly infestation can be avoided by suitable adjustment of planting time so that the vulnerable stage of the crop does not coincide with its active period. During the rainy season, if plantings are taken within 7-10 days of the onset of the monsoon rains, the crop can escape from shoot fly infestation. In the post-rainy season, planting from September last week to October first week relatively reduces the shoot fly damage (Balikai, 1999a). Under delayed plantings in the rainy season, increased seed rate, followed by thinning and destroying the deadhearts to maintain the optimum plant stand can be adopted. From the intercropping studies, Karibasavaraja *et al*. (2005b) reported that, sorghum + garlic and sorghum + onion intercrops reduced the shoot fly incidence on main crop (sorghum) and these intercrops can be used for the management of shootfly with paired row planting of sorghum without affecting plant population.

Chemical control:

Under late plantings, the shoot fly can be effectively controlled by the application of either Carbofuran 3G or Phorate 10G (@ 20 kg ha^{-1}) at the time of planting in the seed furrows. Alternatively, shoot fly damage can be minimized by spraying with Endosulfan 35EC @ 2ml/lit of water at 7 and 14 day after seedling emergence (Balikai,1998b). Application of cypermethrin (0.05kg ai ha^{-1}) at 6 and 12 days after emergence provided adequate control of this pest. Seed treatment with imidacloprid 70 WS @ 100g/kg (Balikai, 1998a and Balikai, 1999b), imidacloprid 70 WS @ 75g/kg (Kandalkar *et al*.1999) and imidacloprid 70 WS @ 50g/kg sorghum seeds (Balikai, *et al*. 2001) were most effective in reducing the incidence. As a low cost technology for managing shoot fly, soaking seeds for 8-10 h either in CaCl2 (2%) + endosulfan (0.07%) or in endosulfan (0.07%) was developed by Balikai *et al*. (1998). Similarly seed dressing with endosulfan 35 EC @ 4ml + 20 water or chlorpyriphos 20 EC @ 4ml + 20 water per kg seeds (Balikai, 2003a) or Thiamethaxom 70 WS @ 2 g/kg seeds (Balikai, 2003b) has been suggested for shoot fly control in post rainy season. Karibasavaraja *et al*. (2005c) reported that, the seed dressing with thiamethoxam 70 WS @ 4 and 5 g ai/kg seeds proved to be best for the management of shootfly and afforded highest protection of 85.09 and 89.47 per cent respectively over control. In an IPM package, Balikai, (2003c) reported that, soil application of Carbofuran 3G @ 2 g/meter row + High seed rate of 10 kg/ha and thinning at 20 days after germination + Release of egg parasitoid, *Trichogramma chilonis* Ishi @ 5 lakh adults on 7, 14 and 21 days after germination recorded the lowest shootfly incidence of 11.5 per cent and highest grain yield of 30.0 q/ha and it was at par with Carbofuran 3G @ 2 g/meter row + Release of egg parasitoids, Carbofuran 3G @ 2 g/meter row and Carbofuran 3G @ 2 g/meter row + High seed rate of 10 kg/ha and thinning at 20 days after germination with 13.4, 14.3 and 14.4 per cent deadhearts respectively with grain yield of 28.7, 28.4 and 28.3 q/ha, respectively.

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