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Research article

Weather-dependent trends of *Atherigona soccata* Rondani infestation in sorghum

Ritu Bhall[1], Bajrang Lal Sharma[1*], Sunita Yadav[1], G. Shyam Prasad[2], Kapil[1] and Penumajji Ganesh Kumar[1]

[1]CCS Haryana Agricultural University, Hisar-125004, India
[2]ICAR-Indian Institute of Millets Research, Hyderabad-500030, India
[*]Corresponding author email: bl_antela@rediffmail.com

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Abstract

This study provides a comprehensive analysis of the population dynamics of the sorghum shoot fly (*Atherigona soccata* Rondani) during the *Kharif* season of 2020 at CCS HAU, Hisar. The research revealed a dramatic surge in the shoot fly population, escalating from 135 flies per trap to 243 flies per trap between the 29th and 38th weeks of the calendar year. The peak infestation, with 243 flies per trap, occurred in the third week of September, coinciding with the 38th Standard Meteorological Week (SMW), underscoring a critical period of pest activity. Our analysis identified significant correlations between shoot fly populations and key climatic variables. A robust positive correlation was observed with the lowest temperature (r = 0.65**), evening humidity (r = 0.61**), and highest temperature (r = 0.35*), as well as average wind speed (r = 0.33*). Conversely, morning humidity (r = 0.38) and rainfall (r = 0.30) were found to be less influential, with their correlations not reaching statistical significance. Notably, the number of sunshine hours exhibited an inverse relationship (r = -0.01) that was statistically insignificant. These findings provide crucial insights into the climatic factors driving shoot fly infestations, highlighting the importance of temperature and humidity in pest management strategies. Understanding these dynamics is essential for optimizing control measures and mitigating crop damage in sorghum cultivation.

Keywords: *Atherigona soccata*, Climatic factors, Correlation, Pest management, Population dynamics, Sorghum

Introduction

Sorghum bicolor (L.) Moench, commonly known as Jowar in India, is a crucial cereal crop belonging to the Poaceae family and is believed to have originated in North East Africa. This versatile crop is vital for food security and livestock feed, especially in the semi-arid tropics where it serves as a primary source of sustenance for impoverished and food-insecure populations (Rao *et al*., 2010). In India, sorghum is predominantly cultivated for its fodder, with Haryana being a major region where it is grown extensively. However, sorghum cultivation faces significant challenges from insect pests, which contribute to substantial crop losses. Insect pests are responsible for approximately 32% of the total sorghum crop losses in India (Borad and Mittal, 1983). Among these, the sorghum shoot fly (*Atherigona soccata* Rondani) is a particularly destructive pest, accounting for around 5% of the total losses (Jotwani, 1983). The shoot fly poses a severe threat to sorghum crops, especially those sown late in the season.

The sorghum shoot fly is notorious for infesting crops during their early growth stages, specifically between 5 and 30 days after emergence. Infestations can reach up to 80%, leading to significant yield reductions up to 80 to 90% for grain and 68% for fodder (Chikkarugi *et al*., 2009; Kahate *et al*., 2014). The pest's feeding behavior results in the formation of dead hearts and, in severe cases, can cause total crop failure (Nwanze *et al*., 1990). The impact of *A. soccata* varies with agro-climatic conditions, as different environments influence the occurrence and intensity of pest damage. Furthermore, weather conditions play a critical role in shaping the distribution and population dynamics of this pest (Meena *et al*., 2013). Understanding the interaction between weather parameters and pest activity is essential for developing effective pest management strategies. A comprehensive regional analysis of *A. soccata* population dynamics will provide valuable insights into the timing and intensity of pest outbreaks. This knowledge is crucial for designing targeted interventions and optimizing pest management practices to mitigate losses and enhance sorghum production.

Materials and Methods

Study location and experimental details: The population dynamics of *Atherigona soccata* Rondani were studied during the *Kharif* season of 2020 at the Research Area of the Forage Section, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar (29.1492° N, 75.7217° E, 215 m above sea level). The sorghum variety 'Swarna' was sown in August on a 50 × 20 m plot, replicated three times.

Monitoring of shoot fly population: From April to December 2020, adult shoot flies were monitored using fishmeal traps. Each trap consisted of a plastic jar with entry holes and a transparent collection jar. Traps were maintained by replacing fishmeal weekly and sprinkling water twice daily to retain bait freshness (Plate 1).

Data recording: Observations were made on the number of flies trapped, eggs per five plants (at 7, 14, and 21 DAE), and per cent dead hearts (at 14, 21, and 28 DAE). Concurrent meteorological data were recorded to study the influence of weather on pest activity.

Calculation of dead heart percentage: The percentage of dead hearts was calculated based on the number of symptomatic (dead heart) plants relative to the total number of plants per plot. Thus Per cent dead hearts due to shoot fly was calculated as (number of plants with dead hearts per plot/ total number of plants per plot) × 100.

Statistical analysis: Data were statistically analyzed using OPSTAT software to determine correlations between shoot fly populations and various weather parameters such as temperature, humidity, rainfall, sunshine hours and wind speed.

Plate 1. Fishmeal trap placed in the field

Plate 2. Adult of *Atherigona soccata*

Results and Discussion

Observations were made on the seasonal incidence of shoot fly in terms of the number of eggs per five plants, per cent dead heart formation and the number of adult flies in the trap catches on the sorghum dual-purpose variety Swarna.

Effects of weather parameters on shoot fly eggs: The number of eggs deposited by the shoot fly, in conjunction with weather conditions, was meticulously monitored over a three-week period from August 27 to September 16. The observations revealed a notable increase in egg production by the shoot fly from the 35th to the 37th standard meteorological week (SMW). Specifically, at 21 DAE, the recorded number of eggs was 19.78, which decreased to 8.04 at 14 DAE and further to 5.09 at 7 DAE (Table 1). This surge in egg deposition during the specified period can be attributed to the heightened presence of shoot flies, as indicated by the fishmeal traps, which captured between 209 and 237 flies from the 35th to the 37th SMW (Plate 2). This correlation suggests that increased shoot fly activity is a significant driver of elevated egg-laying rates, highlighting the importance of monitoring pest populations for effective management.

Effects of weather parameters on dead hearts: The percentage of dead hearts was meticulously recorded over a three-week period, from 14 to 28 DAE, alongside the corresponding weather parameters (Plate 3). Notably, there was a marked increase in the dead heart percentage between the 36th and 38th SMW. Specifically, at 14 DAE, the average dead heart percentage was 21.40%, which rose to 44.30% by 21 DAE, and further escalated to 53.30% by

Plate 3. Shoot fly dead hearts

Plate 4. Dead heart, along with a maggot

28 DAE (Table 1) Dead hearts along with maggot presence were observed in infested plants (Plate 4). These findings are consistent with Vadariya's (2014) observations, which documented that sorghum shoot fly infestation commenced in the first week post-germination, with an initial dead heart incidence of 25.00%. The infestation intensified rapidly, reaching 39.00% dead hearts by the second week after germination. This progression underscores the accelerating impact of pest activity on sorghum, highlighting the critical need for timely intervention strategies.

Seasonal activity of sorghum shoot fly: The shoot fly population was recorded from the 16th to the 52nd standard week. The population increased tremendously from 29th (16th - 22nd July) to 38th standard week (17th- 23rd Sep), i.e., 135 flies per trap to 243 flies per trap, respectively. After that, a sharp decline in the population was observed up to the 52nd standard week (24th Dec-31st Dec) with no flies in the trap. The peak shoot fly catch (243 flies per trap) was recorded during the third week of September (38th SMW) when maximum and minimum temperature, morning and evening relative humidity, sunshine hours, wind velocity and rainfall, were 37.6, 24.7°C, 87, 47.9%, 7.6 hrs/day, 3.9 km/hr, and 7 mm, respectively. During the study period, a total of 2924 flies were caught with a weekly average of 79 per trap (Fig 3). The above findings are similar to those of Kulkarni *et al.* (1978), who found a high incidence of shoot fly in August, which was also supported by Reddy and Davies (1979), who reported a peak in fly catches in August-September. Taneja *et al.* (1986) also reported that the shoot fly population began to rise in July, peaked in August-September, and began to decline at temperatures above 35°C. These differences in the peak might be due to the differences in the cropping patterns in different locations and due to the weather parameters.

Correlation of shoot fly (in trap catches) with abiotic factors: An analysis was conducted to elucidate the relationship between various weather parameters, namely maximum and minimum temperatures, morning

Table 1. Impact of weather parameters on egg laying patterns and on dead heart formation of sorghum shoot fly (*Atherigona soccata*)

Standard Week	DAE	Egg counts*	*Percent DH	Temperature (°C)		Relative humidity (%)		Average wind speed (km/h)	Bright sun shine (hours)	Rainfall (mm)
				Max.	Min	Morning	Evening			
35	7	5.09	--	33.9	25.6	90.3	63.5	7.5	6.8	0.0
36	14	8.04	21.40	34.2	25.1	93.5	66.6	3.4	5.1	32.5
37	21	19.78	44.30	36.3	24.9	88.5	49.3	3.0	8.3	0.0
38	28	--	53.30	37.6	24.7	87	47.9	3.9	7.6	7.0

* Mean of three replications; DAE: Day after emergence; DH: Dead hearts

and evening relative humidity, sunshine hours, wind velocity, and rainfall, with fishmeal trap catches. Statistical evaluations employing simple correlations were performed (Figs 1, 2, 3). The correlation analysis revealed a significant positive association with maximum temperature (r = 0.35*), minimum temperature (r = 0.65**), evening relative humidity (r = 0.61**), and average wind speed (r = 0.33*). Conversely, morning relative humidity (r = 0.38) and rainfall (r = 0.30) displayed non-significant correlations with adult shoot fly populations, while sunshine hours (r = -0.01) exhibited a non-significant negative correlation (Table 2). These findings concur with the observations of Mote and Kadam (1986), who reported that average temperatures between 25 and 27°C and relative humidity were positively associated with adult shoot fly activity. Comparable patterns of correlation between weather parameters and shoot fly incidence have been documented under diverse agro-climatic conditions (Keerthi *et al*., 2021; Bhuyan and Kumar, 2023). Furthermore, Kumari *et al*. (2021) demonstrated that environmental conditions markedly influence the biochemical mechanisms governing resistance to shoot

Table 2. Correlation coefficient of sorghum shoot fly in trap catches with weather parameters

Weather parameters	*Number of shoot fly adults in trap catches*
Maximum temp. (°C)	0.35*
Minimum temp. (°C)	0.65**
Morning RH (%)	0.28NS
Evening RH (%)	0.61**
Average wind speed (km/hr)	0.33*
Bright sunshine (hours)	-0.01NS
Rainfall (mm)	0.30NS

*(p <0.05); **(p <0.01); NS: Non-significant

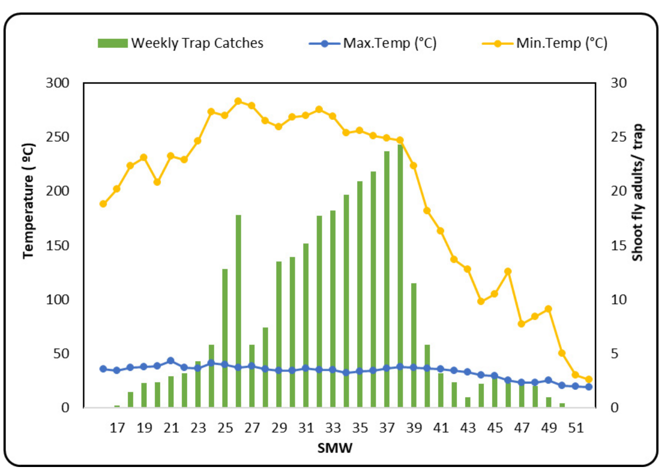

Fig 1. Population of shoot fly (adults trapped/week) in relation with maximum and minimum temperature

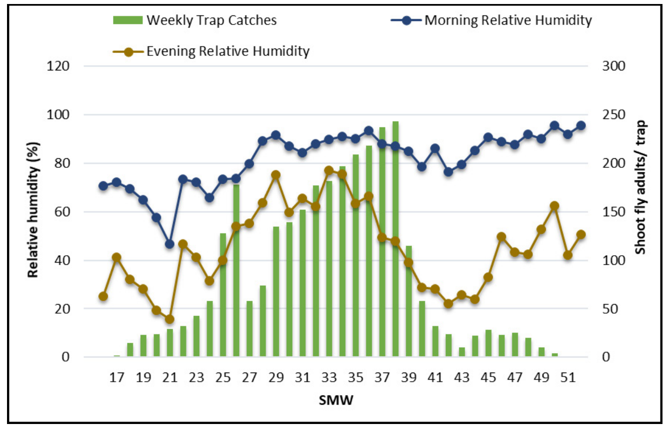

Fig 2. Population of shoot fly (adults trapped/week) in relation with morning and evening relative humidity

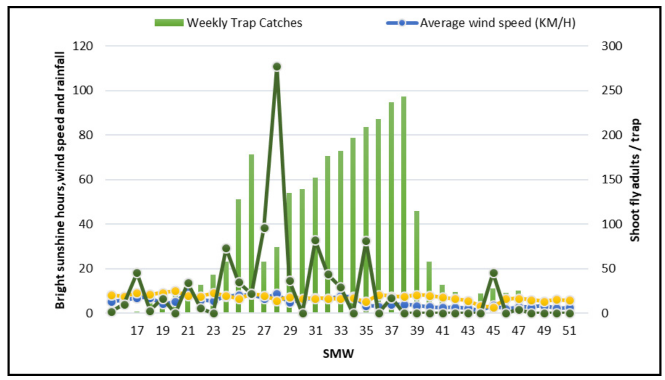

Fig 3. Shoot fly population (adults trapped/week) in relation to sunshine hours, wind speed and rainfall

fly, while Prasad *et al*. (2015) reported that the stability of multiple-resistant sorghum lines is closely linked to prevailing temperature and humidity regimes, underscoring the integral role of climatic variables in modulating pest incidence. Likewise, Kumar et al. (2015) observed that higher maximum and minimum temperatures, coupled with elevated evening relative humidity, enhanced shoot fly activity, and Saxena *et al*. (2022) also established a positive association between adult fly density and minimum temperature. In contrast, the present findings regarding rainfall are in agreement with those of Kandalkar *et al*. (2001), who reported a non-significant correlation between rainfall and shoot fly incidence. Kumar *et al*. (2015) further noted a negative relationship between rainfall and egg population, suggesting that inconsistent and insufficient precipitation during the study period may have limited its influence on pest dynamics.

Conclusion

This research presents valuable insights into the population dynamics of the shoot fly (*A. soccata* Rondani) in sorghum fields. Throughout the study, the shoot fly exhibited continuous activity, consistently impacting sorghum crops. The substantial increase in egg deposition during specific weeks and the correlation between meteorological factors and shoot fly populations highlight the complex interplay between weather conditions and pest dynamics. These findings lay the foundation for more effective pest management strategies in sorghum cultivation, emphasizing the need for further research and the integration of these insights into agricultural policies. By contributing to the understanding of shoot fly behavior and its response to environmental factors, this study can facilitate informed decision-making among farmers and researchers, ultimately aiding in the mitigation of the impact of shoot fly infestations on sorghum yields.

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