

Influence of weather parameters on the seasonal incidence of shoot fly (*Atherigona soccata* Rondani) on sorghum in Gujarat, India

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ABSTRACT: A field study was conducted at the Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, during the *summer*, *kharif* and *rabi* seasons of 2024-25 to investigate the seasonal incidence of sorghum shoot fly, *Atherigona soccata* Rondani and its relationship with prevailing weather parameters. The incidence of shoot fly varied significantly among seasons. During *summer*, infestation commenced in the 13th Standard Meteorological Week (SMW) with 6.67 per cent dead hearts and reached a peak of 36.67 per cent during the 15th SMW. In *kharif*, infestation began in the 28th SMW with 10.00 per cent dead hearts and attained a maximum of 43.33 per cent during the 32nd SMW, representing the highest seasonal infestation. During *rabi*, shoot fly incidence started in the 47th SMW with 3.33 per cent dead hearts and peaked at 30.00 per cent during the 50th SMW. Spider populations appeared shortly after crop establishment and fluctuated throughout the crop season. Correlation analysis revealed a significant negative association between wind speed and shoot fly infestation during *summer* ($r = -0.627^*$), while bright sunshine hours showed a highly significant negative relationship during *kharif* ($r = -0.792^{**}$). No weather parameter significantly affected shoot fly incidence during *rabi*. Multiple regression analysis indicated that weather parameters exerted a greater influence on shoot fly incidence during *kharif* ($R^2 = 0.83$) than during *summer* ($R^2 = 0.56$) and *rabi* ($R^2 = 0.42$).

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KEY WORDS: Seasons, infestation, dead hearts, abiotic factors, correlation, shoot fly, spider

INTRODUCTION

Sorghum *Sorghum bicolor* (L.) Moench is a

warm-season cereal whose origin is from Africa (Rosentrater and Evers, 2018). It is grown globally for human consumption and animals as food, feed,

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fodder, fibre and fuel or bioenergy (Padmaja, 2016). Protein in sorghum is gluten free and it is specialty food for people who suffer from diabetics (Prasad and Staggenborg 2009). In Gujarat, the overall sorghum production across all three seasons *kharif*, *rabi* and summer covered an area of 42,660ha, with a total production of 66,130 tonnes and an average productivity of 1,550kg ha⁻¹ (Anonymous, 2025). Sorghum crop production was affected (nearly 32%) with the insect pests menace in India (Borad and Mittal, 1983) of which nearly 5 per cent of the loss has been attributed to sorghum shoot fly (Jotwani, 1983). The yield of sorghum is being affected by a wide variety of biotic and abiotic constraints (Subramanyam *et al.*, 2020). Sorghum shoot fly, *Atherigona soccata* Rondani (Diptera, Muscidae) is a major pest of sorghum that mainly infest the crop during seedling stage or early crop growth stages causes dead hearts and leads to killing of entire plant. The incidence of shoot fly is known vary from region to region and season to season (Singh and Verma, 1988). Understanding the population dynamics of pests, natural enemies, and disease incidence in relation to environmental factors is imperative for developing effective pest management strategies (Singh *et al.*, 2023). In this study, the relationship between seasonal weather parameters and shoot fly incidence was analysed and multiple regression equations were developed.

MATERIALS AND METHODS

The sorghum variety GJ-43 was sown following the recommended agronomic practices. The experiment was established in a plot measuring 9m × 7.5m with a spacing of 45cm × 15cm. Observations on shoot fly incidence were recorded at weekly intervals from the 12th to 24th Standard Meteorological Week (SMW) during summer, 27th to 39th SMW during *kharif* and 46th SMW to 6th SMW during *rabi*. Shoot fly infestation was assessed based on the incidence of dead hearts. Observations were recorded from six randomly selected quadrates and five plants from each quadrate were examined for dead heart symptoms. The percentage of dead hearts was calculated.

Meteorological data corresponding to the observation periods were obtained from the

meteorological observatory of Sardarkrushinagar Dantiwada Agricultural University. The weather parameters considered included maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall, wind speed and bright sunshine hours. The relationship between shoot fly infestation and weather parameters was determined using Pearson's correlation analysis (Pearson, 1895). Further, multiple linear regression analysis was performed to quantify the contribution of individual weather variables towards variations in shoot fly incidence and to develop predictive regression models for pest occurrence. Statistical analyses were carried out using appropriate statistical software.

RESULTS AND DISCUSSION

Incidence of shoot fly during summer, 2024:

In summer incidence of sorghum shoot fly, *A. soccata*, commenced during the 2nd week after sowing (WAS) corresponding to the 13th SMW, with 6.67 per cent dead hearts. The infestation increased progressively and reached its peak (36.67% dead hearts) during the 15th SMW. Thereafter, the infestation declined gradually, with the lowest incidence (6.67% dead hearts) recorded during the 20th SMW. The population of natural enemies, particularly spiders, was first observed during the 3rd WAS (14th SMW; first week of April) with 0.03 spiders per plant. The spider population increased steadily and attained its maximum abundance (0.27 spiders per plant) during the 8th WAS (19th SMW; first week of May). Subsequently, the population declined gradually but remained active up to the 11th WAS (22nd SMW; third week of May), recording 0.06 spiders per plant (Table 1). Correlation analysis between shoot fly incidence and weather parameters (Table 2) revealed that wind speed exhibited a significant negative association with dead heart incidence ($r = -0.627^*$), indicating a suppressive effect on shoot fly activity. However, the remaining meteorological parameters did not show any significant influence on shoot fly infestation. Similarly, correlation analysis indicated that the spider population was not significantly affected by any of the weather parameters.

Incidence of shoot fly during *kharif*, 2024:

During the *kharif* 2024, infestation of sorghum shoot fly commenced during the 2nd WAS, corresponding to 28th SMW (second week of July), with 10 per cent dead hearts (Table 1). The infestation increased progressively with crop growth and reached its peak (43.33% dead hearts) during 6th WAS (32nd SMW; first week of August). Thereafter, the infestation declined gradually and reached 6.67 per cent dead hearts by the 9th WAS (35th SMW; third week of August). No shoot fly infestation was recorded beyond the 35th SMW. A single population peak of shoot fly (43.33% dead hearts) was observed during the *kharif* season. Correlation analysis (Table 2) revealed that bright sunshine hours exhibited a highly significant negative association with shoot fly incidence ($r = -0.792^{**}$). However, other abiotic factors, including rainfall, wind speed, maximum temperature, minimum temperature and relative humidity, did not exert any

significant influence on shoot fly activity. The activity of spiders, was first observed during the 3rd WAS (29th SMW; third week of July) with a population of 0.06 spiders per plant. The spider population increased gradually and attained its maximum density of 0.16 spiders per plant during the 7th and 8th WAS (33rd and 34th SMW; second and third weeks of August). Subsequently, the population declined gradually and remained active up to 11th WAS (37th SMW; second week of September), recording 0.06 spiders per plant. Correlation studies indicated that bright sunshine hours ($r = -0.598^{*}$) and maximum temperature ($r = -0.747^{*}$) had significant negative relationships with spider population. In contrast, maximum relative humidity ($r = 0.628^{*}$) exhibited a significant positive relationship with spider abundance, suggesting that higher humidity favoured spider activity and their potential role in the natural suppression of shoot fly population.

Table 1. Occurrence of *Atherigona soccata* in sorghum during summer, *kharif* and *rabi*

Summer 2024 (March – June)				<i>Kharif</i> 2024 (July – September)				<i>Rabi</i> 2024-25 (November – February)			
WAS	SMW	DH (%)	NE no/ plant	WAS	SMW	DH (%)	NE no/ plant	WAS	SMW	DH (%)	NE no/ plant
1	12	0.00	0.00	1	27	0.00	0.00	1	46	0.00	0.00
2	13	6.67	0.00	2	28	10.00	0.00	2	47	3.33	0.00
3	14	16.67	0.03	3	29	13.33	0.06	3	48	10.00	0.00
4	15	36.67	0.06	4	30	20.00	0.06	4	49	26.67	0.00
5	16	30.00	0.10	5	31	33.33	0.10	5	50	30.00	0.03
6	17	26.67	0.06	6	32	43.33	0.10	6	51	20.00	0.06
7	18	16.67	0.16	7	33	23.33	0.16	7	52	16.67	0.13
8	19	10.00	0.27	8	34	16.67	0.16	8	1	16.33	0.10
9	20	6.67	0.23	9	35	6.67	0.13	9	2	6.67	0.10
10	21	0.00	0.10	10	36	0.00	0.13	10	3	0.00	0.03
11	22	0.00	0.06	11	37	0.00	0.06	11	4	0.00	0.03
12	23	0.00	0.00	12	38	0.00	0.00	12	5	0.00	0.00
13	24	0.00	0.00	13	39	0.00	0.00	13	6	0.00	0.00
Mean		11.54	0.08	Mean		12.82	0.07	Mean		9.97	0.04

WAS: Weeks After Sowing, SMW: Standard Meteorological Weeks; DH – Dead hearts; NE – Natural enemies

Table 2. Correlation of weather parameters with *Atherigona soccata* infesting summer, *kharif* and *rabi* sorghum

Pest/ spider	Sun shine hours	Wind speed (km h ⁻¹)	Temp - Max °C	Temp - Min °C	RH (%) - Max	RH (%) = Min	Rainfall
Summer 2024							
DH (%)	-0.107 ^{NS}	-0.627*	-0.340 ^{NS}	-0.363 ^{NS}	0.055 ^{NS}	-0.091 ^{NS}	Nil
Spider	0.404 ^{NS}	-0.049 ^{NS}	0.279 ^{NS}	0.081 ^{NS}	-0.109 ^{NS}	-0.416 ^{NS}	Nil
Kharif 2024							
DH (%)	-0.792**	0.319 ^{NS}	-0.416 ^{NS}	0.161 ^{NS}	0.170 ^{NS}	0.238 ^{NS}	-0.127 ^{NS}
Spider	-0.598*	0.117 ^{NS}	-0.747**	-0.275 ^{NS}	0.628*	0.482 ^{NS}	0.401 ^{NS}
Rabi 2024-25							
DH (%)	-0.051 ^{NS}	0.103 ^{NS}	-0.240 ^{NS}	-0.371 ^{NS}	0.106 ^{NS}	-0.172 ^{NS}	Nil
Spider	-0.351 ^{NS}	0.274 ^{NS}	-0.613*	-0.545 ^{NS}	0.375 ^{NS}	0.282 ^{NS}	Nil

*Significance at 5 per cent level of significance ($r' = 0.553$); ** Significance at 1 per cent level of significance ($r' = 0.684$); DH - Dead heart (%); Spider - no/ plant

Incidence of shoot fly during *rabi*, 2024-25:

During *rabi* 2024-25 the incidence commenced during the 2nd WAS, corresponding to 47th SMW (third week of November), with 3.33 per cent dead hearts (Table 1). The infestation increased progressively with crop growth and attained its peak level of 30 per cent dead hearts during the 5th WAS (50th SMW; second week of December). Thereafter, the infestation declined gradually and reached 6.67 per cent dead hearts by the 9th WAS (2nd SMW; second week of January). No further development of shoot fly-induced dead hearts was observed after the 3rd SMW. Correlation analysis between shoot fly infestation and prevailing weather parameters (Table 2) indicated that none of the meteorological factors exhibited a significant influence on dead heart incidence during the *rabi* 2024-25 season. The activity of spiders was first recorded during 5th WAS (50th SMW; second week of December) with a population of 0.03 spider per plant. The population increased gradually and reached its maximum level of 0.13 spider per plant during the 7th WAS (52nd SMW; fourth week of December). Subsequently, the spider population declined and remained active up to the 11th WAS (4th SMW; third week of January), with a population of 0.03 spider per plant. Correlation studies between spider population and weather parameters revealed a significant negative association with maximum

temperature ($r = -0.613^*$). However, none of the other weather parameters showed any significant effect on spider activity during the cropping period.

Comparison of regression values among the seasons revealed that in *kharif* ($R^2 = 0.83$) influenced by weather parameters that is explained by the higher explanatory power of the regression model than the other two seasons like summer ($R^2 = 0.56$) and *rabi* ($R^2 = 0.42$). Natural enemies like spiders are also influenced by weather parameters during the *kharif* with higher R^2 (0.90) explanatory power than in *rabi* ($R^2 = 0.54$) and summer ($R^2 = 0.28$) shown that the weather parameters contribution towards the spider population build up and survival. All the prediction equations have given good R square value.

Shekhar (1995) studied the correlation between dead hearts and maximum temperature and reported significant negative (-ve) relationship with temperature. The present findings are in close conformity with earlier reports on the seasonal incidence of shoot fly in sorghum. Karibasavaraja and Balikai (2006) reported that shoot fly activity commenced during the 27th (SMW) with 43.10 dead hearts and increased steadily to reach a peak of 93.40 per cent during the 33rd SMW. Similarly, Keerthi *et al.* (2017) have also reported that the minimum temperature exhibited non-significant

negative correlation with dead heart formation which is consistent with the current study's findings. Likewise, Rakesh *et al.* (2022) observed the initial occurrence of *A. soccata* at 7 days after sowing (28th SMW) with maximum infestation (11.67% dead hearts) recorded during the 29th SMW. Supporting these observations, Sakshi *et al.* (2022) documented the first incidence of shoot fly during the 27th SMW with 4.12% dead hearts and remained actively till the vegetative stage (34th SMW). The highest infestation (55.43% dead hearts) was noted during the 30th SMW (23th - 29th July), followed by a gradual decline, reaching nil infestation by the 35th SMW. Similarly, Sonawane *et al.* (2022) reported the initiation of dead heart formation (12.10%) during the 28th SMW with peak infestation (15.01% dead hearts) occurring in the 31st SMW.

Among the three seasons, the highest shoot fly infestation was recorded during the *kharif* season with a mean dead heart incidence of 12.82 per cent, followed by summer (11.54%) and *rabi* (9.97%). Analysis between abiotic factors and dead heart incidence revealed that wind speed exhibited a significant and negative correlation. While, bright sunshine hours showed a highly significant negative association with shoot fly infestation in sorghum. The abundance of spiders was comparatively higher during the summer season, recording a mean population of 0.08 spiders/plant, followed by *kharif* (0.07 spiders/plant), whereas the lowest population was observed during the *rabi* season (0.04 spiders/plant). Correlation analysis with weather parameters during summer indicated that none of the abiotic factors exerted a significant influence on spider activity. In *kharif* season, spider activity showed a significant negative correlation with bright sunshine hours and a highly significant negative correlation with maximum temperature. During the *rabi* season, spider activity exhibited a significant negative association with maximum temperature, suggesting its important role in regulating spider activity.

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