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Effect of weather factors on seasonal incidence of sorghum shoot fly, *Atherigona soccata* Rondani on *rabi* sorghum in Maharashtra region of India

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Abstract
The study was carried out at the Post Graduate Experimental Field of Department of Agricultural Entomology, College of Agriculture (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani), Campus Latur, Dist. Latur, Maharashtra, India during 2020-21.This study evaluate that maximum number of egg laying by *Atherigona soccata* (2.9 eggs per plant), maximum number of dead heart (17 dead heart plants per quadrat) and maximum per cent dead heart (14 per cent dead heart) per quadrat were observed during 51th SMW during *rabi* season. The wind speed (r = -0.562*) was exhibited negatively significant with mean number of eggs per quadrat. However maximum temperature (r = -0.511*) and (r = -0.510*) showed negative significant correlation with mean number of dead heart and per cent of dead heart per quadrat, While wind speed (r = -0.590*) and (r = -0.585*) also exhibited negatively significant correlation with mean number of dead heart and per cent dead heart per quadrat, respectively.

Keywords: Correlation, dead hearts, eggs, maximum temperature, minimum temperature, negative significant, positive significant, quadrate, standard meteorological weeks, wind speed

Introduction
Sorghum (*Sorghum bicolour* (L.) Moench an ancient crop belongs to the family Poaceae is a warm-season cereal of African origin, which was first cultivated in the region of Ethiopia or Chad over 5000 years ago and spread to India by 4000 years (Rosentrater and Evers, 2018). Sorghum is the world's fifth most important cereal after maize, rice, wheat and barley (Balakrishna *et al*., 2019) [4]. In India, the area under sorghum crop is 4.09 million ha with the production of 3.47 million tonnes and the average yield of 849 kg per ha (FAOSTAT, 2020) [7]. At global level, important sorghum insect pests include leaf-sucking species, leaf-feeding species, stalk or stem borers, pests of the panicle and of the stored grain (Okosun *et al*., 2021) [13]. Sorghum is ravaged by a number of insect pests *viz*., shoot fly (*Atherigona soccata* Rondani), stem borers (*Chilo partellus* Swinhoe and *Sesamia inferens* Walker), armyworms (*Mythimna separata* Walker and *Spodoptera frugiperda* J.E. Smith), aphids (*Melanaphis sacchari* Zehntner and *Rhopalosiphum maidis* Fitch), midge (*Contarinia sorghicola* Coquillett), head caterpillars (*Helicoverpa armigera* Hubner), hairy caterpillars (*Orgyia* sp., *Olene mendosa* Hubner and *Somena scintillans* Walker), shoot bugs (*Peregrinus maidis* Ashmead) and green stink bug (*Nezara viridula* (Linnaeus) in Maharashtra. Among them shoot fly, *Atherigona soccata* is considered a most serious insect pest of sorghum and the maximum damage of shoot fly observed in early stages of the crop and maximum damage caused within four week just after the germination of the crop. (Keerthi *et al*., 2017). The research experiment were conducted to assess the peak time period of egg laying, causing number of dead heart and per cent dead heart to know the relationship between weather parameters and incidence of shoot fly during *rabi* season.

Material and Methods
The field experiment comprising forty-eight quadrat each of 2.70 x 3.00 sq. m size was laid to investigate the population dynamics of sucking insect pests on *rabi* sorghum at the Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur Maharashtra during *rabi* season, 2020-2021. The popular sorghum variety Parbhani Moti was sown at the spacing of 45 x 15 cm in 48 quadrat with all recommended package of practices recommended

by VNMKV, Parbhani (Anonymous, 2018) [3] in *rabi* season. The observations of egg count were taken on 14 days old crop, while dead hearts and Per cent dead heart were taken on 21st and 28th day after sowing from the randomly selected quadrat. At each observation, three quadrat of sorghum were carefully examined twice in a week. The per cent dead heart from each quadrat was calculated with the help of formula.

% Dead heart per quadrat = Number of plants with dead hearts per plot / Total number of plant per quadrat X 100

The statistical analysis of mean number of eggs per plant, mean number of dead heart and per cent dead heart on *rabi* sorghum and weather parameters were carried out by simple correlation and multiple regression using WASP 2.0 software developed by ICAR Research Complex, Goa.

Results and Discussion

In this present investigation the eggs load of *A. soccata* was first time recorded in 49th SMW (0.75 eggs per plant) which drastically increased and it attained peak in 51th SMW (2.9 eggs per quadrat). However, the maximum level of the mean number of dead heart (17 dead hearts) and per cent dead hearts (14 per cent) per quadrat was observed during 51th SMW, respectively. (Table.1)The data revealed that the wind speed (r = -0.562*) exhibited negative significant with the mean number of eggs of *A. soccata* per plant, while the maximum temperature (r = -0.511*) and wind speed (r = 0.590*) observed negative significant with the mean number of dead heart per quadrat. The similar trend were founds in the per cent dead heart per quadrat, where the maximum temperature (r = -0.510*) and wind speed (r = 0. 0.585*) observed negatively significant during *rabi* season. The multiple-regression of weather parameters had profound influence on seasonal occurrence of *A. soccata*. (Table. 2) The coefficient of determination (R^2) value of mean number of eggs per plant, mean number of dead heart and mean number of per cent dead heart per quadrat was 0.450, 0.533 and 0.531 and showing that different weather parameters accounted 45.0, 53.3 and 53.1 per cent variability in the mean no. of eggs per plant, mean no. of dead heart and mean no. of per cent dead heart during *rabi* season, respectively. (Table.3).

The results of present investigation are in concurrence with the findings of Shid *et al*. (2021) [15] who revealed that Lowest dead hearts per cent caused by shoot fly at 28 DAE were recorded by the test entries RSV-2394, RSV-2388 and RSV-2395 were 14.41%, 15.38%, 15.72% respectively. Balikai and Venkatesh (2019) [5] illustrated that the observations on dead hearts caused by *A. soccata* were recorded on 28th day after emergence of *rabi* sorghum. Kundra *et al*. (2019) [10] recorded the lowest percentage of shootfly eggs in the genotype IIMR LM7012 (10.78%) and it remained at par with BG 1 (12.77%) which were however, not better than DLM95 (16.26%). Abdi (2017) [1] monitored seasonal incidence and observed during *rabi* season when the maximum temperature was between 28-30ºC the infestation was very high and causing 38% dead heart in sorghum. Matti *et al*. (2017) evidenced that the maximum level eggs (1.95±0.37) per plant during 46th standard week, However maximum per cent dead hearts also noticed in late planting during *rabi* season followed by normal and least in early sown crop. Mohammed *et al*. (2016) [12] demonstrated that maximum level of ovipostion (2-3 shoot fly eggs/plant) was observed in the genotypes CSV 15 and Swarna, while the maximum per cent of dead hearts (3.96–53.05%) also recorded in the postrainy season. Agav *et al*. (2007) found that the population dynamics of sorghum shoot fly showed significant positive correlation with meteorological parameters studied while dead hearts formation was not correlated. Deshpande *et al*. (2003) [6] who revealed that new genotypes SP 15050, SP 15003 and SP 15047 being recorded 26, 27 and 27 per cent dead hearts with 1.2,0.7 and 1.4 eggs per plant during *rabi* season. Gahukar (1987) [8] showed that correlations between relative humidity and fly numbers were present at all sites. Maximum temperature did not favours fly abundance.

Table 1: Mean number of eggs per plant, mean number of dead heart and per cent dead heart per quadrat in relation to weather parameters during *rabi* season 2020-21

Month	Standard Meteorological Weeks	Rainfall (mm)	Temperature (ºC)		Relative Humidity (%)		Wind speed (Km per h)	Mean no. of eggs per plant	Mean no. of dead heart per quadrat	Percent dead heart Per quadrat
			Min.	Max.	Before noon	After noon				
November 2020	48	0	17.5	29.4	79.4	64.5	22.3	0	0	0
December 2020	49	0	13.1	31.3	67.4	39.5	21.6	0.75	7.5	6
	50	0	15.6	31.2	67.7	45.2	21.4	2.1	12	10
	51	0	12.2	29.5	74.4	42.4	20	2.9	17	14
	52	0	12.8	30.5	75.4	43.6	18.4	1.4	15	12.5
January 2021	1	0	16.5	30.4	91.2	53.4	18.7	1.2	6.5	5
	2	1.00	16.86	31.9	82.53	51.5	19.9	0.9	4.5	3.75
	3	0	16.2	31.9	81.47	48.1	19.7	0.4	2	1.6
	4	0	16.7	32.8	75.83	43.5	20	0	0	0
	5	1.25	15.39	31.6	76.99	37.7	23.1	0	0	0
February 2021	6	0.5	11.99	30.9	60.24	32.5	21.7	0	0	0
	7	0	15.44	32.9	65.86	36.3	24	0	0	0
	8	6.25	14.6	30.8	72.9	39.6	25.7	0	0	0
	9	0	18.49	36	48.81	24.8	26.1	0	0	0
March 2021	10	0	23.4	37	42.48	25.8	26.1	0	0	0
	11	0	19.1	36.7	42.31	22.3	27.8	0	0	0

Table 2: Simple correlation of weather parameters with mean number of eggs per plant, mean number of dead heart and per cent dead heart caused by *A. soccata* per quadrat on *rabi* sorghum

Weather parameters	Correlation coefficient ('r' values)		
	Mean no. of eggs per quadrat	No. of dead heart per quadrat	Percent dead heart per quadrat
Rainfall (mm)	-0.216	-0.280	-0.227
Maximum Temperature (°C)	-0.437	-0.511*	-0.510*
Minimum temperature (°C)	-0.478	-0.483	-0.479
Before noon relative humidity (%)	0.335	0.307	0.299
Afternoon relative humidity (%)	0.308	0.270	0.266
Wind speed (km/ h)	-0.562*	-0.590*	-0.585*

Table 3: Multiple regressions of weather parameters with mean number of eggs per plant, mean number of dead heart and per cent dead heart caused by *A. soccata* per quadrat on *rabi* sorghum

S. No	Correlated factors	Multiple regression equation	Intercept (a)	R Square value	Multiple Correlation Coefficient (R)	Standard Error
1	Mean no. of eggs	Y=21.025+ (-0.041) x B1 + (0.134) x B2 + (-0.415) x B3 + (-0.032) x B4 + (-0.044) x B5 + (-0.235) x B6 + 0.854	21.025	0.450	0.671	0.854
2	Mean no. of dead heart	Y=132.263+ (0.046) x B1 + (0.354) x B2 + (-1.979) x B3 + (-0.310) x B4 + (-0.166) x B5 + (-1.890) x B6 + 5.200	132.263	0.533	0.730	5.200
3	Per cent dead heart	Y=108.914+ (0.074) x B1 + (0.267) x B2 + (-1.592) x B3 + (-0.267) x B4 + (-0.125) x B5 + (-1.579) x B6 + 4.301	108.914	0.531	0.729	4.301

B1- Rainfall (mm)
B2- Maximum temperature (°C)
B3- Minimum temperature (°C)
B4- Before noon relative humidity (%)
B5- Afternoon relative humidity (%)
B6- Wind speed (km per h)

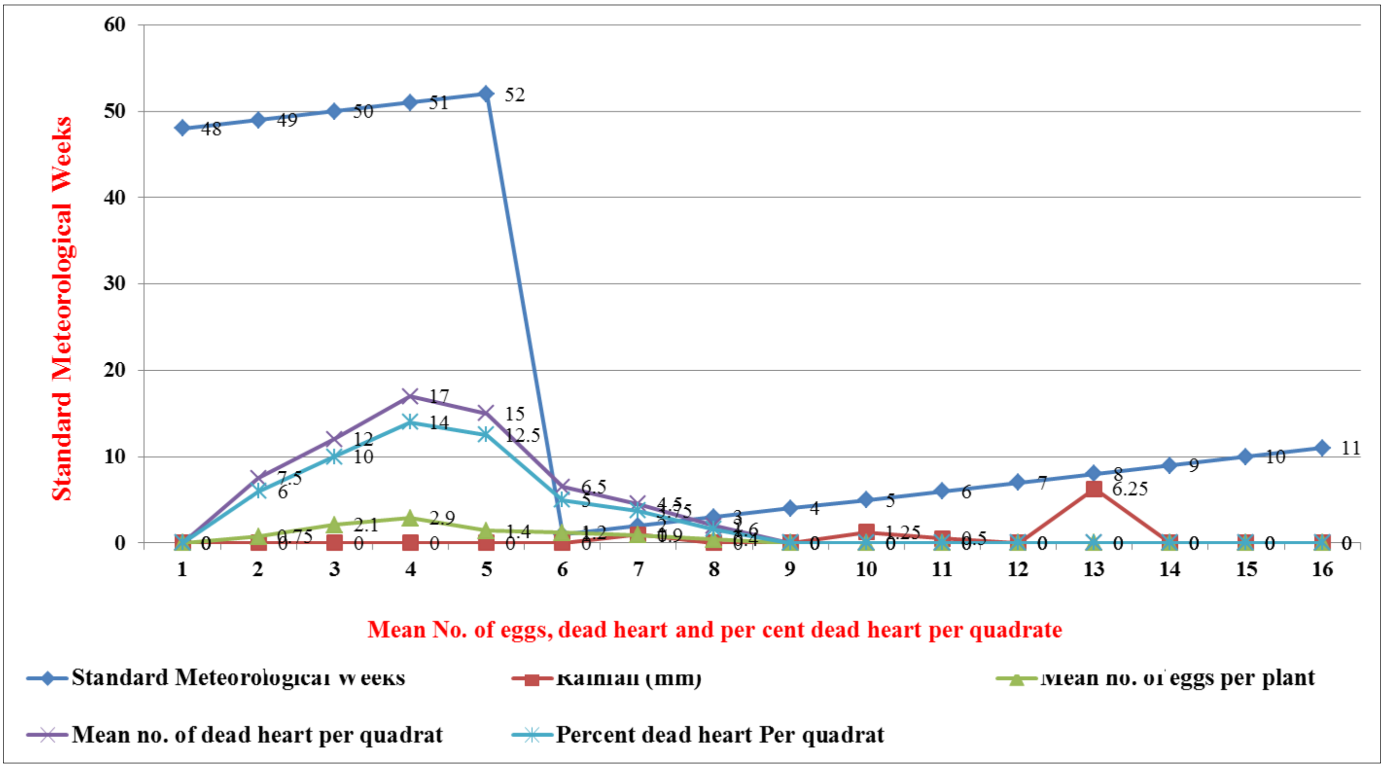

Fig 1: Mean number of eggs per plant, mean number of dead heart and per cent dead heart per quadrat in relation to rainfall during *rabi* season 2020-21

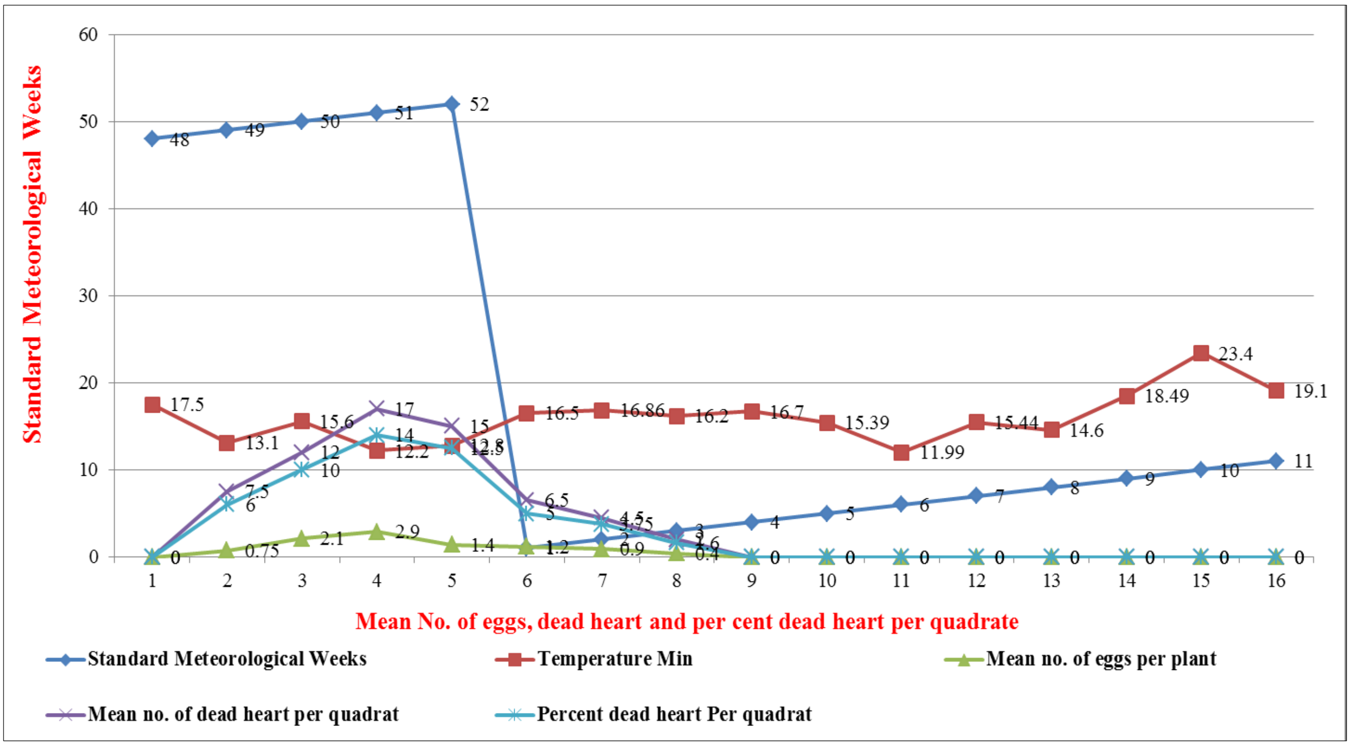

Fig 2: Mean number of eggs per plant, mean number of dead heart and per cent dead heart per quadrat in relation to minimum temperature during *rabi* season 2020-2021

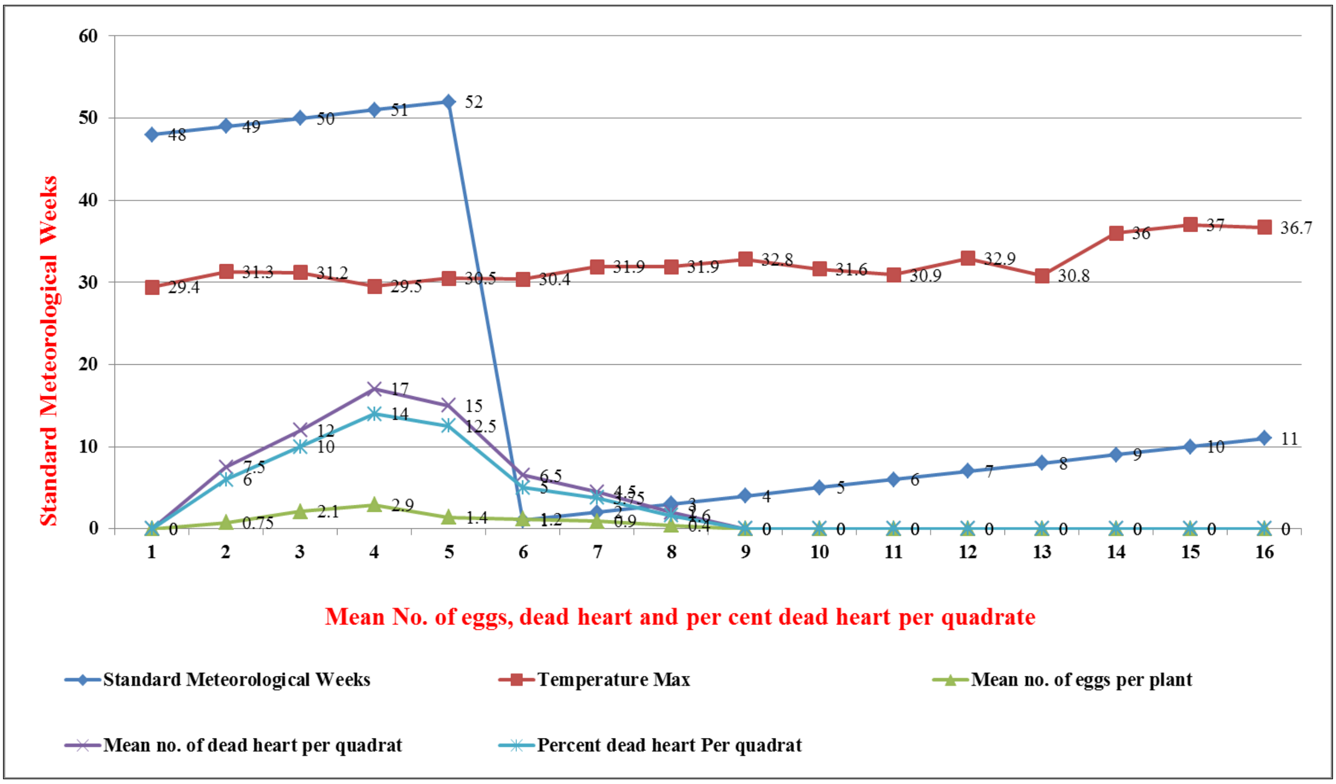

Fig 3: Mean number of eggs per plant, mean number of dead heart and per cent dead heart per quadrat in relation to maximum temperature during *rabi* season 2020-2021

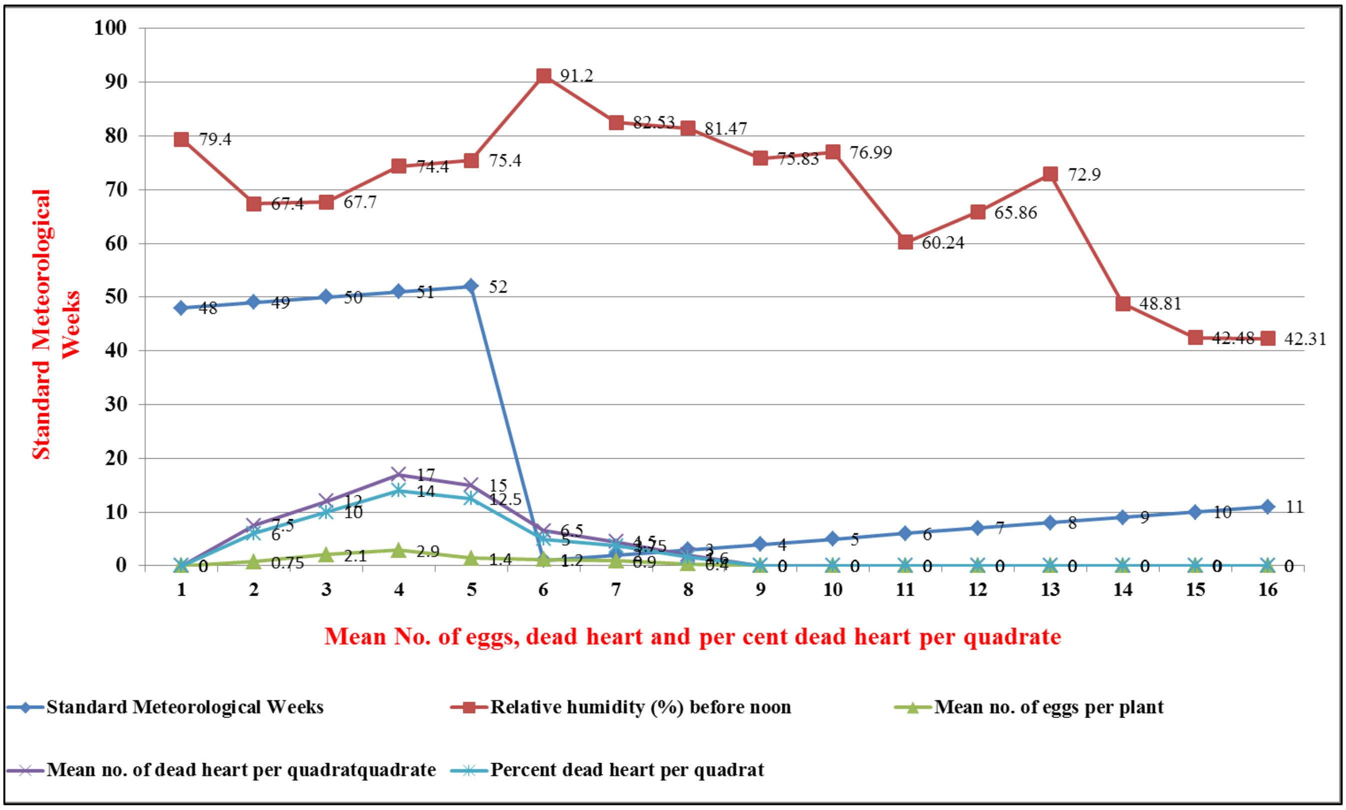

Fig 4: Mean number of eggs per plant, mean number of dead heart and per cent dead heart per quadrat in relation to before noon relative humidity during *rabi* season 2020-2021

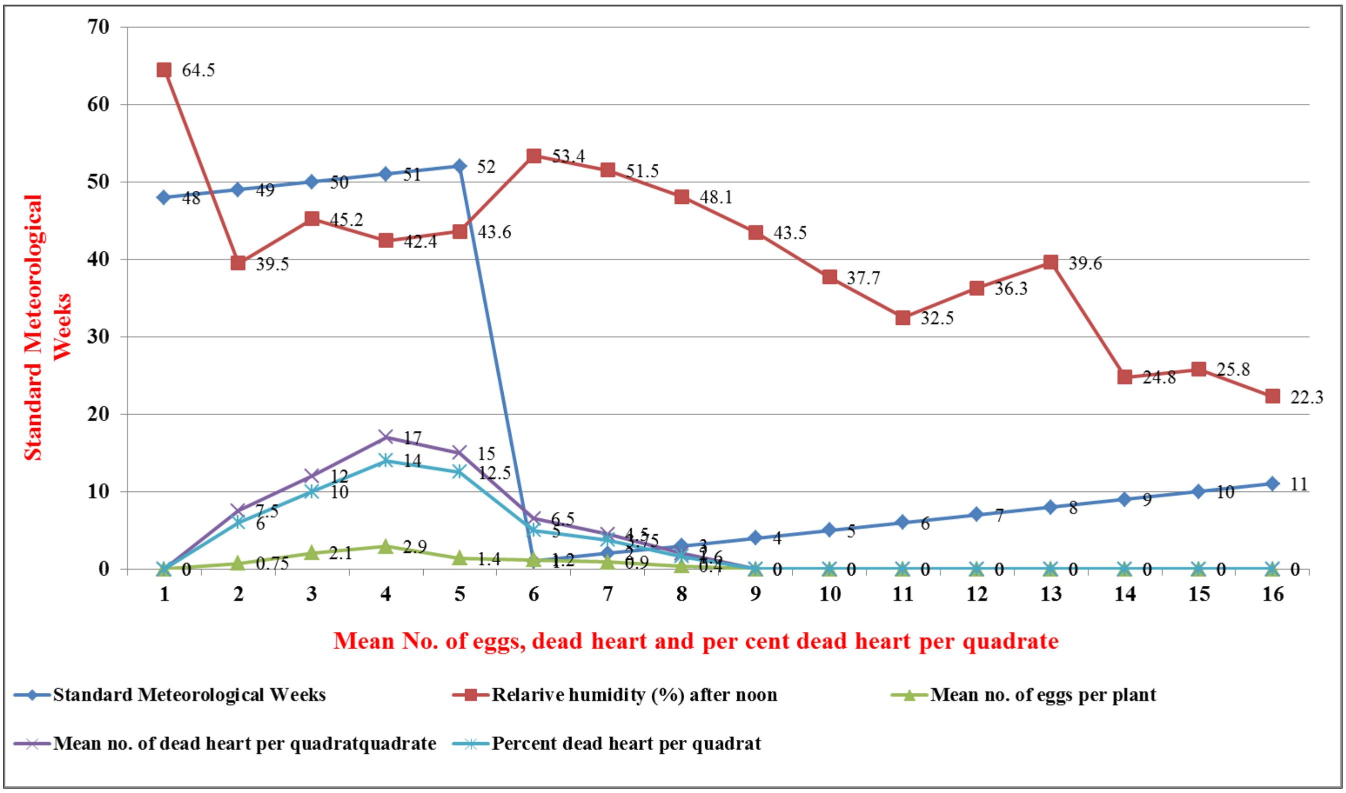

Fig 5: Mean number of eggs per plant, mean number of dead heart and per cent dead heart per quadrat in relation to after noon relative humidity during *rabi* season 2020-2021

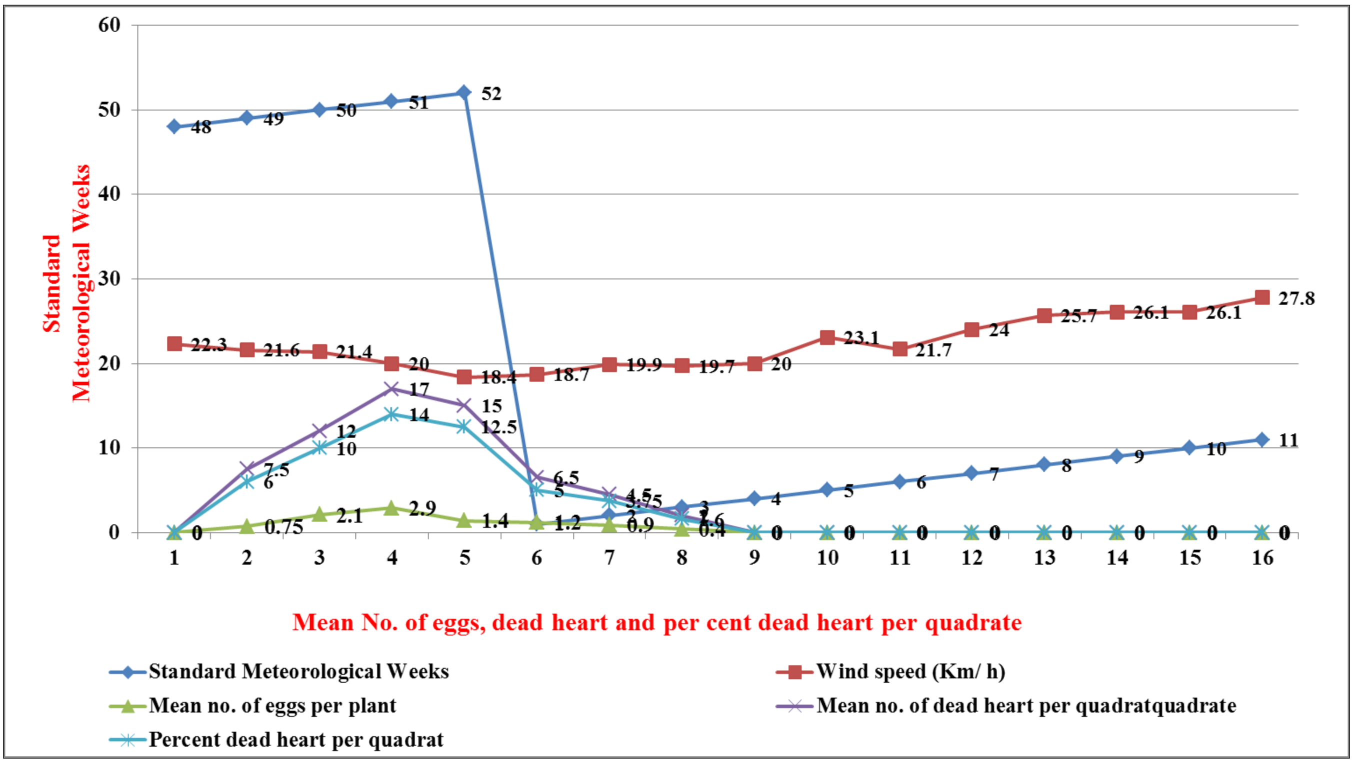

Fig 6: Mean number of eggs per plant, mean number of dead heart and per cent dead heart per quadrat in relation to wind speed relative humidity during *rabi* season 2020-2021

Fig 7: Eggs of shoot fly on young seedlings of sorghum

Fig 8: Dead heart symptoms in young seedlings of sorghum

Fig 9: Field view of damaged caused by shoot flies during *rabi* season 2020-21

Conclusion

The current study showed that the maximum level of attack and infestation caused by *A. soccata* within four to five weeks after the sowing of the crop. In this study the maximum level of mean number of eggs per plant, dead heart and per cent dead heart was recorded in 51^{th} SMW and the various weather parameters like wind speed and maximum temperature were recorded negatively significant with mean number of eggs dead heart and per cent dead heart per quadrat. The results of this study were developed for prediction of level of damage caused by *A. soccata* during the *rabi* season. This data may be fruitfully utilized for forewarning farmers.

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Conflict of interest: None

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