www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(1): 1007-1013

www.thepharmajournal.com
Received: 03-11-2022
Accepted: 09-12-2022

VK Bhamare
Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra, India

DS Thengade
Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra, India

ND Zatale
Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra, India

VM Doke
Department of Plant Pathology, College of Agriculture, Latur, Maharashtra, India

SV Babhare
Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra, India

VS Gambhire
Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra, India

HN Patel
Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra, India

Corresponding Author:
ND Zatale
Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra, India

Effect of weather parameters on population dynamics of sucking insect-pests and their natural enemies infesting *rabi* maize

VK Bhamare, DS Thengade, ND Zatale, VM Doke, SV Babhare, VS Gambhire and HN Patel

Abstract
The investigations conducted at Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur (VNKMV, Parbhani) during *rabi* season 2020-2021 revealed that *R. maidis* reached its peak population in 7^{th} SMW (70.8 aphids per plant) during *rabi* season. Correlation studies evidenced that none of the weather parameters had significant effect on population of *R. maidis*. *N. viridula* reached its peak population in 3^{rd} SMW (0.92 bug per plant) during *rabi* season. Correlation studies evidenced that before noon relative humidity and afternoon relative humidity had significantly direct positive effect on population of *N. viridula*, while wind speed had significantly negative effect on *N. viridula* population. *P. perpusilla* reached its peak population in 2^{nd} SMW (0.95 adult per plant) during *rabi* season. Correlation studies revealed that before noon relative humidity correlated positively, whereas wind speed correlated negatively with population of *P. perpusilla*. Spiders reached its peak population in 7^{th} SMW (5.00 spiders per quadrat) during *rabi* season. Correlation studies revealed that minimum temperature had negative relationship with population of spiders. Ladybird beetles and Earwig reached their peak population in 7^{th} SMW (20.00 beetles per quadrat) and in 5^{th} SMW (11.00 earwigs per quadrat) respectively during *rabi* season Correlation studies revealed that the weather parameters did not show any significant influence on population of ladybird beetles as well as earwigs.

Keywords: Population dynamics, abiotic factor, maize, *R. maidis*, *N. viridula* and *P. perpusilla*

Introduction

Maize (*Zea mays* L.) "Queen of cereals" belongs to the family Graminae or Poaceae is an important grain crop mainly utilized as feed, food and raw material for diverse industrial applications globally. Among cereals, maize occupies the third place after wheat and rice and is a staple food for a large segment of population worldwide (Chaudhary *et al*., 2014) [7]. Globally maize is cultivated over an area of more than 193.25 million hectares in about 165 countries with 1116.34 million tonnes of production and 5.78 tonnes per ha of productivity during 2019-2020. In India, maize is cultivated on an area of 9.72 million hectares with 28.63 million tonnes of production and 2.94 tonnes per hectare of productivity during 2019-2020. The predominant maize growing states that contributes more than 85 per cent of the total maize production in India are Karnataka, Madhya Pradesh, Bihar, Tamil Nadu, Telangana, Maharashtra, Andhra Pradesh, Rajasthan, Himachal Pradesh and Gujarat. In Maharashtra, the area under maize crop is 0.93 million hectares with 1.77 million tonnes of production and 1.90 tonnes per hectare of productivity during 2018-2019.

Maize, being a C4 plant, has a greater yield potential as compared to other cereals (Scott and Emery, 2016) [32], but attack of insect-pests at various crop growth stages from sowing to maturity poses serious limitation in full manifestation of yield potential during different seasons. There is report of 250 pests attacking maize (Mathur, 1992) [18] but only a dozen of pests is quite serious and require control measures (Siddiqui and Marwaha, 1994) [32]. Besides these many other insect-pests are reported in different parts of the country. The global climate change signifies increase in average temperature, change in the rainfall pattern and enormous climatic events. These seasonal and long term variations would influence the fauna, flora and population dynamics of insect-pests. The weather parameters are known to have direct impact on population dynamics of insect-pests and their natural enemies through inflection of developmental rates, survival, fecundity, voltinism and dispersal (Karuppaiah and Sujayanad, 2012) [10].

In this context, the present study was planned to investigate the effect of weather parameters on population dynamics of sucking insect-pests and their natural enemies infesting *rabi* maize.

Materials and Methods

The non-replicated field experiment comprising 48 quadrats each of 2.70 x 3 sq. m size was laid to investigate succession of major insect pests of *rabi* maize at the Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur (MS) during *rabi* season, 2020-21. The popular maize variety, Narendra M-909 was sown at the spacing of 45 x 30 cm in 48 quadrats on dated 6th November, 2020 for *rabi* season. The field experiment was conducted under pesticide free conditions. The succession of sucking insect pests (corn leaf aphid, sugarcane leafhopper and green stinkbug) on *rabi* maize were worked out by recording their observations on whole plant. Randomly five plants were selected from each of three quadrats twice in each meteorological week for recording incidence of sucking insect pests. The succession of natural enemies (*viz*., spiders, ladybird beetles and earwig) on *rabi* maize were worked out by recording their observations from three quadrats twice in each meteorological week. The natural enemies population will not worked out per plant due to low values which caused difficulties in its statistical analysis. The statistical analysis of the data on sucking insect pests and natural enemies population on *rabi* maize 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

The population dynamics of sucking insect-pests infesting maize was studied during *rabi* season 2020-21. During the course of investigation the weather parameters *viz.*, rainfall, minimum temperature, maximum temperature, before noon relative humidity, afternoon relative humidity and wind speed were varied from 0.5 to 6.5 mm, 11.99 ºC to 23.4 ºC, 29.4 ºC to 37.0 ºC, 42.31 to 91.2 per cent, 22.3 to 64.4 per cent, and 18.7 to 27.8 km per hr, respectively. The data pertaining to the sucking insect-pests population infesting maize in relation to weather parameters during *rabi* season 2020-21 are presented in Table 1 and depicted graphically in Fig. 1.

Sucking insect-pests of *rabi* maize

***Rhopalosiphum maidis* (Fitch)**

The first incidence of *R. maidis* was registered on *rabi* maize in 48th standard meteorological week (1.26 aphids per plants) with its peak population level (70.8 aphids per plants) in 7th standard meteorological week. At maximum level of population of *R. maidis*, the prevailing weather factors *viz*., rainfall, maximum temperature, minimum temperature, before noon relative humidity, afternoon relative humidity and wind speed were 0.00 mm, 32.9 ºC, 15.44 ºC, 65.86 per cent, 36.3 per cent and 24 km per h, respectively (Table 1).

The results of present investigation are in agreement with the findings of Choudhary *et al*. (2017) [9] who illustrated that population of *R. maidis* on barley appeared in the first week of January and reached to peak in the first week of February (114.02 aphids per tiller) and thereafter completely disappeared in the fourth week of February. Hajare (2020) [13] revealed that the first occurrence *R. maidis* on *rabi* maize was noticed in 48th SMW (148.50 aphids per plants) with its peak population level (316.90 aphids per plants) in 49th SMW. Waleed *et al*. (2020) [35] concluded that the *R. maidis* reached its peak on 29th August and 3rd October (492.33 and 156.67 aphids per sorghum plant) on the 1st and 2nd plantation at the season of 2019, respectively. Whereas, *R. maidis* reached its peak on 27th August and 10th September (456 and 158 aphids per sorghum plant) on the 1st and 2nd plantation at the season of 2020, respectively. Alam *et al*. (2020) [1] evidenced that the maximum (62.32 per cent) and significantly higher plant infestation of *R. maidis* was found on maize sown in 4th week of November.

***Nezara viridula* (Linnaeus)**

The first prevalence of *N. viridula* was observed on *rabi* maize in 50th standard meteorological week (0.40 bug per plant) with its peak population level (0.92 bug per plant) in 3rd standard meteorological week. At maximum level of population of *N. viridula*, the prevailing weather factors *viz*., rainfall, maximum temperature, minimum temperature, before noon relative humidity, afternoon relative humidity and wind speed were 0.00 mm, 31.9 ºC, 16.2 ºC, 81.47 per cent, 48.1 per cent and 19.7 km per h, respectively (Table 1).

These results are matching with the findings of Meena *et al.* (2018) [19] who revealed that infestation of *N. viridula* on cumin was noticed in first week of January at flower initiation stage to maturity of crop with an average population of 1.4 bugs per plant. Chandra and Singh (2012) exhibited that *N. viridula* was first noticed on okra at 4th SMW and reached its peak at 12th SMW. Hajare (2020) [13] exhibited that the first prevalence of *N. viridula* was registered on maize in 36th SMW (0.73 bug per plant) with its peak population level. Manjunath *et al.* (2019) [17] documented that the incidence of *N. viridula* on castor started from the second fortnight of September and continued till the end of the growth period of the crop with a peak population (0.70 per plant) during the first fortnight of December. Deole (2016) [10] showed that *N. viridula* population remain active till late vegetative period of maize during first week of March (10th SMW) on maize crop. Liljesthroem and Coviella (1999) [16] exhibited that the activity of *N. viridula* on soybean was noticed from mid-September up to mid-April.

***Pyrilla perpusilla* (Walker)**

The first occurrence of *P. perpusilla* was registered on *rabi* maize in 49th standard meteorological week (0.35 adult per plant) with its maximum population level (0.95 adult per plant) in 2nd standard meteorological week. At maximum level of population of *P. perpusilla*, the prevailing weather factors *viz*., rainfall, maximum temperature, minimum temperature, before noon relative humidity, afternoon relative humidity and wind speed were 1.00 mm, 31.9 ºC, 16.86 ºC, 82.53 per cent, 51.5 per cent and 19.9 km per h, respectively (Table 1).

The results of present investigation are in agreement with the findings of Hajare (2020) [13] who evidenced that the first incidence of *P. perpusilla* on maize was observed in 48th SMW (0.60 adult per plant) with its peak population level (0.93 adult per plant) in 1st SMW of 2020. Joshi *et al.* (2018) [15] revealed that *Pyrilla* population reached its peak in the first fortnight of October (8.13 eggs, 28.16 nymphs and 5.17 adults per leaf).

Table 1: Succession of *R. maidis*, *N. viridula* and *P. perpusilla* on *rabi* maize in relation to weather parameters during 2020-21

Month	Standard Metrological Week	Rainfall (mm)	Temperature (ºC)		Relative Humidity (%)		Wind speed (km/h)	Mean no. of insects per plant		
			Min.	Max.	Before noon	After noon		*R. maidis*	*N. viridula*	*P. perpusilla*
Nov	48	-	17.5	29.4	79.4	64.5	22.3	1.26	-	-
Dec	49	-	13.1	31.3	67.4	39.5	21.6	1.4	-	0.35
	50	-	15.6	31.2	67.7	45.2	21.4	1.6	0.40	0.41
	51	-	12.2	29.5	74.4	42.4	20	5.86	0.48	0.57
	52	-	12.8	30.5	75.4	43.6	18.4	8.0	0.55	0.66
Jan	1	-	16.5	30.4	91.2	53.4	18.7	11.73	0.62	0.80
	2	1	16.86	31.9	82.53	51.5	19.9	16.73	0.73	0.95
	3	-	16.2	31.9	81.47	48.1	19.7	24.4	0.92	0.30
	4	-	16.7	32.8	75.83	43.5	20	30.13	0.66	-
	5	1.25	15.39	31.6	76.99	37.7	23.1	60.33	-	-
Feb	6	0.5	11.99	30.9	60.24	32.5	21.7	56.06	-	-
	7	-	15.44	32.9	65.86	36.3	24	70.08	-	-
	8	6.25	14.6	30.8	72.9	39.6	25.7	41.4	-	-
	9	-	18.49	36	48.81	24.8	26.1	16.33	-	-
March	10	-	23.4	37	42.48	25.8	26.1	5.6	-	-
	11	-	19.1	36.7	42.31	22.3	27.8	1.66	-	-

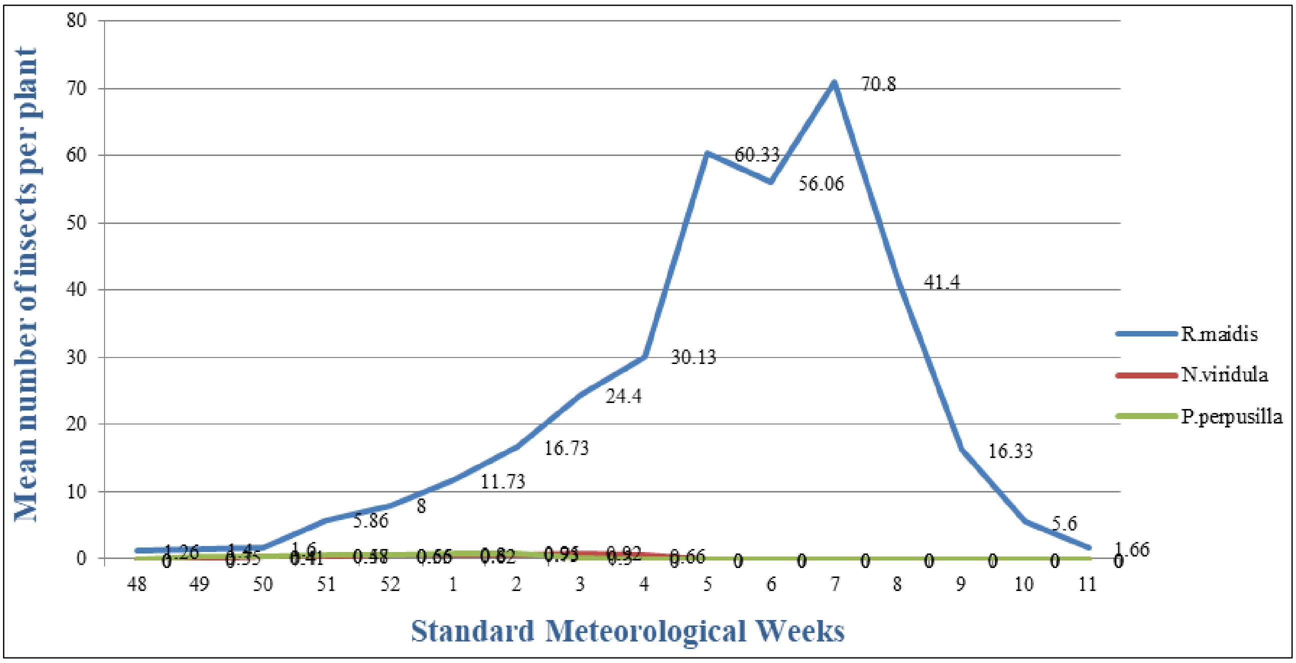

Fig 1: Succession of *R. maidis, N. viridula* and *P. perpusilla* on *rabi* maize in relation to weather parameters during 2020-21

Natural enemies on *rabi* maize

Spiders

The first occurrence of spiders was noticed on *rabi* maize in 50th standard meteorological week (1.66 spiders per quadrat) with its peak population level (5.00 spiders per quadrat) in 7th standard meteorological week. At maximum level of population of spiders, the prevailing weather factors *viz*., rainfall, maximum temperature, minimum temperature, before noon relative humidity, afternoon relative humidity and wind speed were 0.00 mm, 32.9 ºC, 15.44 ºC, 65.86 per cent, 36.3 per cent and 24 km per h, respectively (Table 2).

These results are comparable with the findings of Akshay Kumar *et al*. (2020) [3] who revealed that the population of spiders was abundant on maize between 8th to 20th SMW with its peak population during 15th and 16th SMW. Suneel Kumar *et al*. (2018) revealed that the peak activity of spiders was higher on maize during *kharif* in 41st SMW (1.22 per plant) compared to during *rabi* in 4th SMW (0.89 per plant). Saranya *et al*. (2018) showed that predatory spiders dominating in the maize ecosystem *viz*., *Lycosa barnesi*, *L. pseudoannulata*, *Pardosa birmanica, Salticus* sp. and *Hippasa lycosina.* Patra *et al*. (2013) [23] evidenced that among spider species, Araneidae and Salticidae were most prominent species observed throughout the growth period of maize.

Ladybird beetles

The first prevalence of ladybird beetles was registered on *rabi* maize in 51th standard meteorological week (1.00 beetle per quadrat) with its peak population level (20.00 beetles per quadrat) in 7th standard meteorological week. At maximum level of population of ladybird beetles, the prevailing weather factors *viz*., rainfall, maximum temperature, minimum temperature, before noon relative humidity, afternoon relative humidity and wind speed were 0.00 mm, 32.9 ºC, 15.44 ºC, 65.86 per cent, 36.3 per cent and 24 km per h, respectively (Table 2).

The results are analogous with the findings of Suneel Kumar *et al*. (2018) who stated that peak incidence of *C. transversalis* was recorded in maize during *rabi* season during 2nd and 3rd SMW (0.34 beetles per plant) and *C. sexmaculata* during 4th SMW (0.78 beetles per plant). Akshay Kumar *et al*. (2020) [3] revealed that coccinellids *viz*., *C. septempunctata*, *C. sexmaculata*, *C. tranversalis* and *Brumoides suturalis* population was observed from 7th to 19th SMW in maize. Ankita *et al*. (2021) exhibited that maximum population of coccinellid was recorded on maize during September in Zone-I (10.25 adult beetles per 30 plants and 8.25 grubs per 30 plants) and Zone-II (12.00 adult beetles per 30 plants and 10.75 grubs per 30 plants). Waleed *et al*. (2020) [35] illustrated that *Coccinella undecimpunctata*, *Scymnus pallidivestis*, *Stethorus gilvifrons* were associated with *R. maids* on sorghum. Patil *et al*. (2015) [21] showed that the population of coccinellids attained a peak in 39th SMW (5.9 per five plants) on maize. Megha *et al*. (2015) indicated that coccinellid species found in sorghum crop were *C. sexmaculata, Illeis cincta* and *Harmonia octomaculata*. Sahito *et al*. (2012) [25] evidenced that the overall seasonal mean population of seven spotted ladybird beetle, zigzag beetle, eleven spotted beetle and *Brumus* on maize was 0.44, 0.69, 0.07 and 0.50 per plant, respectively. Nyukuri *et al*. (2012) [20] illustrated that *Cheilomenes* spp. was the most ubiquitous predator (4.00 individuals per 30 aphids) in maize.

Earwig

The first occurrence of earwig was recorded on *rabi* maize in 52nd standard meteorological week (0.66 earwig per quadrat) with its maximum population level (11.00 earwigs per quadrat) in 5th standard meteorological week. At maximum level of population of earwig, the prevailing weather factors *viz*., rainfall, maximum temperature, minimum temperature, before noon relative humidity, afternoon relative humidity and wind speed were 1.25 mm, 31.6 ºC, 15.39 ºC, 76.99 per cent, 37.7 per cent and 23.1 km per h, respectively (Table 2).
More or less similar results were obtained by Boupha *et al*. (2006) [5] who revealed that earwig (*Proreus simulans*) found commonly in sweet corn. Wyckhuys and O'Neil (2006) [36] evidenced that the most abundant predators of *S. frugiperda* were ants, spiders and earwigs. Amongst them, earwigs constituted up to 70 per cent of the entire predator complex recorded from maize plants.

Table 2: Succession of spiders, ladybird beetles and earwig on *rabi* maize in relation to weather parameters during 2020-21

Month	Standard Metrological Week	Rainfall (mm)	Temperature (ºC)		Relative Humidity (%)		Wind speed (km/h)	Mean no. of insects per quadrat		
			Min.	Max.	Before noon	After noon		Spiders	Ladybird beetles	Earwig
Nov	48	-	17.5	29.4	79.4	64.5	22.3	-	-	-
Dec	49	-	13.1	31.3	67.4	39.5	21.6	-	-	-
	50	-	15.6	31.2	67.7	45.2	21.4	1.66	-	-
	51	-	12.2	29.5	74.4	42.4	20	1.66	1.00	-
	52	-	12.8	30.5	75.4	43.6	18.4	3.00	0.33	0.66
Jan	1	-	16.5	30.4	91.2	53.4	18.7	1.66	-	1.33
	2	1	16.86	31.9	82.53	51.5	19.9	1.66	-	4.66
	3	-	16.2	31.9	81.47	48.1	19.7	1.00	3.00	6.33
	4	-	16.7	32.8	75.83	43.5	20	1.33	8.33	8.00
	5	1.25	15.39	31.6	76.99	37.7	23.1	2.00	10.00	11.00
Feb	6	0.5	11.99	30.9	60.24	32.5	21.7	4.66	11.00	7.33
	7	-	15.44	32.9	65.86	36.3	24	5.00	20.00	7.00
	8	6.25	14.6	30.8	72.9	39.6	25.7	3.00	15.00	5.33
	9	-	18.49	36	48.81	24.8	26.1	1.66	6.00	2.33
March	10	-	23.4	37	42.48	25.8	26.1	-	2.33	1.66
	11	-	19.1	36.7	42.31	22.3	27.8	-	1.33	0.66

Correlation between incidence of sucking insectpests and weather parameter

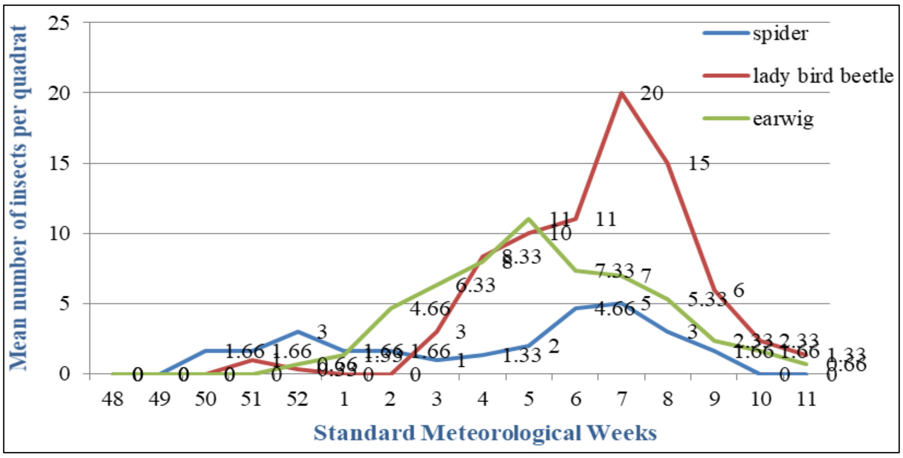

Fig 2: Succession of spider, lady bird beetle and earwig on *rabi* maize in relation to weather parameters during 2020-21

Correlation between incidence of sucking insect pests and weather parameter

***Rhopalosiphum maidis* (Fitch)**

The results in respect of simple correlations between population of *R. maidis* infesting *rabi* maize and weather parameters during 2020-21 are presented in Table 3.
The data evidenced that rainfall (r= 0.173) and before noon relative humidity (r= 0.245) exhibited positive but non-

significant correlation with population of *R. maidis*. While, maximum temperature (r= -0.046), minimum temperature (r= - 0.190), afternoon relative humidity (r= -0.011) and wind speed (r= -0.171) noticed negative but non-significant correlation with population of *R. maidis*.

These results are in consensus with the findings of Paul *et al*. (2020) who revealed that correlation analysis exhibited that population of *R. maidis* registered non-significant negative correlation with evening relative humidity and sunshine hours, while non-significant positive correlation with total rainfall.. Patil *et al.* (2015) [21] revealed that none of the weather parameters significantly correlated with *R. maidis* population on maize. Jeengar *et al* (2010) [14] showed that the abiotic factors of the environment did not show any significant influence on *R. maidis* on maize. However, Hajare (2020) [13] indicated that during *kharif* season minimum and maximum temperature exhibited significantly direct negative correlation, whereas number of rainy days, rainfall and before noon relative humidity showed significantly direct positive correlation with *R. maidis* population. While during *rabi* season, maximum temperature exhibited significantly direct negative correlation. Choudhary *et al*. (2017) [9] revealed that the maximum temperature indicated significant negative correlation and relative humidity had significant positive correlation with aphid population, other abiotic factors were non-significant.

***Nezara viridula* (Linnaeus)**

The results in respect of simple correlations between population of *R. maidis* infesting *rabi* maize and weather parameters during 2020-21 are presented in Table 3.

The data evidenced that before noon relative humidity (r= 0.624*) and afternoon relative humidity (r= 0.512*) exhibited positive significant correlation with *N. viridula* population, while wind speed (r= -0.770*) showed negative but significant correlation with *N. viridula* population. However, rainfall (r= -0.217), maximum temperature (r= -0.309) and minimum temperature (r= -0.181) registered negative but non-significant correlation with *N. viridula* population.

The results of present investigation are at par with findings of Hajare (2020) [13] who exhibited that afternoon relative humidity and before noon relative humidity registered significantly positive correlation with the population of *N. viridula* infesting maize, while minimum temperature and maximum temperature had significantly negative effect on *N. viridula* population. Manjunath *et al.* (2019) [17] revealed that none of the weather parameters exhibited significant influence on *N. viridula* population on castor. However, Endo (2016) [12] revealed that winter temperature was a useful predictor for the relative abundance of *N. viridula* in wild populations.

***Pyrilla perpusilla* (Walker)**

The results in respect of simple correlations between population of *P. perpusilla* infesting *rabi* maize and weather parameters during 2020-21 are presented in Table 3.

The data evidenced that before noon relative humidity (r= 0.566*) exhibited positive significant correlation, while wind speed (r= -0.706*) showed negative significant correlation with population of *P. perpusilla*. However, afternoon relative humidity (r= 0.488) noticed positive but non-significant correlation, while rainfall (r= -0.169), maximum temperature (r= -0.427) and minimum temperature (r=-0.294) registered negative but non-significant correlation with population of *P. perpusilla*.

The results of present investigation are in agreement with the findings of Hajare (2020) [13] who evidenced that before noon relative humidity exhibited significantly direct positive effect, while maximum temperature had significantly negative effect on population of *P. perpusilla* infesting *rabi* maize. Joshi *et al.* (2018) [15] showed that relative humidity exhibited positive effect on *Pyrilla* population. Ranju Kumari *et al.* (2018) [24] stated that relative humidity (14 hrs.) showed positive correlation with *P. perpusilla* but statistically non-significant. Patre *et al.* (2017) showed that relative humidity played significantly important role in the fluctuation of *P. perpusilla* population. Choudhary *et al.* (2015) [8] revealed that maximum and minimum temperatures had negative impact, while the relative humidity of morning and evening showed positive impact on *Pyrilla* infestation. Akhtar *et al.* (2014) [2] showed that population of *P. perpusilla* exhibited non-significant correlation with relative humidity. Regression models indicated that maximum variation in *P. perpusilla* population was contributed by temperature rather than relative humidity.

Table 3: Simple correlation of weather parameters with *R. maidis*, *N. viridula* and *P. perpusilla* infesting *rabi* maize

Weather parameter	Correlation coefficient ('r' values)		
	R. maidis	***N. viridula***	***P. perpusilla***
Rainfall (mm)	0.173	-0.217	-0.169
Maximum temperature (ºC)	-0.046	-0.309	-0.427
Minimum temperature (ºC)	-0.190	-0.181	-0.294
Before noon relative humidity (%)	0.245	0.624*	0.566*
Afternoon relative humidity (%)	-0.011	0.512*	0.488
Wind speed (km per h)	-0.171	-0.770*	-0.706*

N= 16.
*Significant at 5%.

Correlation between incidence of natural enemies and weather parameter

Spiders

The results in respect of simple correlations between population of spiders on *rabi* maize and weather parameters during 2020-21 are presented in Table 4.

The data evidenced that minimum temperature (r=-0.530*) exhibited negative but significant correlation with spiders population. However, rainfall (r=0.259) and before noon relative humidity (r=0.131) exhibited positively non-significant association with spiders population, while, maximum temperature (r=-0.276), after noon relative humidity (r= -0.101) and wind speed (r= -0.167) registered negatively non-significant correlation with spiders population.

The results are analogous with the findings of Saranya *et al*. (2018) who evidenced that the predatory spider population in the maize ecosystem had non-significant positive correlation with relative humidity at 14:22 hrs and negative correlation with maximum temperature and minimum temperature. Sidar *et al*. (2017) [29] revealed that spider population in maize had non-significant positive correlation with morning relative humidity and evening relative humidity. However, wind velocity and sun shine hours exhibited non-significant negative correlation with spider population.

Ladybird beetles

The results in respect of simple correlations between population of ladybird beetles on *rabi* maize and weather parameters during 2020-21 are presented in Table 4.

The data evidenced that rainfall (r= 0.461), maximum temperature (r= 0.069) and wind speed (r= 0.290) exhibited positive but non-significant correlation with ladybird beetles population. However, minimum temperature (r=-0.161), before noon relative humidity (r=-0.106) and after noon relative humidity (r=-0.316) exhibited negatively non-significant association with ladybird beetles population.

More or less comparable results were obtained by Nyukuri *et al*. (2012) [20] who evidenced that rainfall and relative humidity had significant effects on the abundance of *Coccinellids* on maize. Temperature had significant effect on the abundance of *Coccinellids* though at a lower level. Rainfall and relative humidity were both inversely correlated with the abundance of *Coccinellids*. On the other hand, temperature was positively correlated with the prevalence of *Coccinellids* indicating that warmer and drier conditions favoured their multiplication. Sahito *et al*. (2012) [25] illustrated that eleven spotted beetle was negatively associated with temperature while, zigzag beetle and eleven spotted beetle were negatively correlated with relative humidity. Populations of rest of the predators were positively correlated with temperature and relative humidity. Patil *et al*. (2015) [21] exhibited that none of the weather parameters significantly correlated with coccinellinds and chrysoperla population on maize.

Earwig

The results in respect of simple correlations between population of earwig on *rabi* maize and weather parameters during 2020-21 are presented in Table 4.

The data evidenced that rainfall (r= 0.283), maximum temperature (r= 0.004) and before noon relative humidity (r= 0.185) exhibited positive but non-significant correlation with earwig population. However, minimum temperature (r= -0.128), after noon relative humidity (r= -0.107) and wind speed (r= -0.018) registered negatively non-significant association with earwig population.

More or less similar results were obtained by Boupha *et al*. (2006) [5] who revealed that earwig (*Proreus simulans*) found commonly in sweet corn. Wyckhuys and O'Neil (2006) [36] evidenced that the most abundant predators of *S. frugiperda* were ants, spiders and earwigs. Amongst them, earwigs constituted up to 70 per cent of the entire predator complex recorded from maize plants.

Table 4: Simple correlation of weather parameters with spiders, ladybird beetles and earwig population on *rabi* maize

Weather parameter	Correlation coefficient ('r' values)		
	Spiders	Ladybird beetles	Earwig
Rainfall (mm)	0.259	0.461	0.283
Maximum temperature (ºC)	-0.276	0.069	0.004
Minimum temperature (ºC)	-0.530*	-0.161	-0.128
Before noon relative humidity (%)	0.131	-0.106	0.185
Afternoon relative humidity (%)	-0.101	-0.316	-0.107
Wind speed (km per h)	-0.167	0.290	-0.018

N= 16
*Significant at 5%

References

1. Alama MJ, Naharb MK, Khatunc MK, Rashidd Harun-or Md, Ahmeda KS. Impact assessment of different sowing dates on maize aphid, *Rhopalosiphum madis* infestation in Bangladesh. Sustainability in Food and Agriculture (SFNA). 2020;1(2):99-105.
2. Akhtar MF, Gogi MD, Abbas Q, Shamraiz RM, Ahmed R, Niaz T. Impact of abiotic factors on population buildup of *Pyrilla perpusilla* and *Epiricania melanoleuca* on sorghum. Journal of Entomology and Zoology Studies. 2014;2(6):77-81.
3. Akshay Kumar, Singh RS, Kripa Shankar, Vikrant & Devendra Singh. Population dynamics of major insect-pest and natural enemies on maize crop. International Journal of Current Microbiology and Applied Science. 2020;9(2):1299-1307.
4. Ankita, Sharma PK, Mehta V. Natural enemies associated with insect pests of maize in sub-tropical and sub-humid zones of Himachal Pradesh, India. Journal of Experimental Zoology. 2021;24(1):329-335.
5. Boupha BD, Jamjanya T, Khlibsuwan W, Siri N, Hanboonsong Y. Monitoring of insect pests, natural enemies of sweet corn and study on control methods in Khon Kaen University. Khon kaen Agriculture. 2006;34(1):1-11.
6. Chandra M, Singh RS. Pest complex of okra and population dynamics under Bundelkhand region, Uttar Pradesh. Annals of Plant Protection Sciences. 2012;20(2):314-317.
7. Chaudhary DP, Sandeep Kumar, Yadav OP. Maize: nutrition dynamics and novel uses. New Delhi: Springer publishers; c2014.
8. Choudhary AK, Amrate PK, Chatterjee A. Role of biotic and abiotic factors in population dynamics of sugarcane leaf hopper, Pyrilla perpusilla Walker in Madhya Pradesh, India. Environment and Ecology. 2015;33(3):1038-1043.
9. Choudhary PK, Kumawat KC, Jakhar S. Seasonal abundance of aphid, Rhopalosiphum maidis (Fitch) and its natural enemies on barley (*Hordeum vulgare* Linn) and predatory potential of major coccinellid predators on aphid (*Rhopalosiphum maidis*). International Journal of Chemical Studies. 2017;5(4):632-635.
10. Deole S. Studies on pink stem borer, Sesamia inferens Walker of maize, *Zea mays* L. with particular reference to neonate larval behaviour and its management (Doctoral Dissertation). Indira Gandhi Krishi Vishwavidyalaya, Raipur, India; c2016.
11. Deole S, Dubey VK, Rana DK. Seasonal incidence of insect pests on sweet corn and their natural enemies at Raipur, Chhattisgarh. Journal of Pharmacognosy and Phytochemistry. 2019;8(5):1351-1355.
12. Endo N. Effective monitoring of the population dynamics of *Nezara viridula* and *Nezara antennata* (Heteroptera: Pentatomidae) using a light trap in Japan. Applied Entomology and Zoology. 2016;51:341-346.
13. Hajare PB. Field life-tables and population dynamics of major insect pests of maize (Marster's thesis). Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani; 2020.
14. Jeengar KL, Srivastava AK, Ameta OP. Influence of abiotic factors of the environment on major insect pest of maize. Indian Journal of Applied Entomology. 2010;24(1):40-42.
15. Joshi B, Soni VK, Rana DK. Impact of abiotic and biotic factors on population of sugarcane leaf hopper, Pyrilla perpusilla (Walk.) at Chhattisgarh. Journal of Pharmacognosy and Phytochemistry. 2018;1:67-70.

16. Liljesthroem C, Coviella C. Population dynamics of the stink bug, Nezara viridula and *Piezodorus guildinii* and control strategies in soybean cultures. Revista de la Sociedad Entomologica Argentina. 1999;58(3-4):141-149.
17. Manjunath KL, Ganiger PC, Jahir Basha CR. Population dynamics of pests infesting castor and their natural enemies in Southern Karnataka. Journal of Entomology and Zoology Studies. 2019;7(1):238-243.
18. Mathur LML. Changing complex of maize pests in India. Proceedings National Seminar on Changing Scenario in Pest Complex. Hyderabad; c1992.
19. Meena NK, Lal G, Meena RS, Meena SR. Pest scenario of cumin (*Cuminum cyminum* L.) and population dynamics in semi-arid region of Rajasthan. International Journal of Seed Spices. 2018;8(1):80-83.
20. Nyukuri RW, Kirui SC, Wanjala FME, Odhiambo JO, Cheramgoi E. The effectiveness of coccinellids as natural enemies of aphids in maize, beans and cowpeas intercrop. Journal of Agricultural Science and Technology. 2012;A(2):1003-1010.
21. Patil VP, Rode NS, Sureja BV. Study on population dynamics of aphid, *Rhopalosiphum maidis* on maize. Bioinfolet. 2015;12(1A):143-146.
22. Paul N, Deole S, Shaw SS, Mehta N. Seasonal incidence of sucking pests *viz*., aphid, Rhopalosiphum maidis (Fitch) and leaf hoppers, Cicadulina sp. infesting maize crop at Raipur (Chhattisgarh). Journal of Pharmacognosy and Phytochemistry. 2020;9(5):101-105.
23. Patra S, Rahman Z, Bhumita P, Saikia K, Thakur NSA. Study on pest complex and crop damage in maize in medium altitude hill of Meghalaya. International Quarterly Journal at Life Science. 2013;8(3):825-828.
24. Ranju Kumari, Chand H, Paswan S. Influence of weather factors on fluctuation of *Pyrilla perpusilla* Walker population in sugarcane. International Journal of Current Microbiology and Applied Sciences. 2018;7:153-157.
25. Sahito HA, Abro GH, Talpur MA, Mal B, Dhiloo KH. Population fluctuation of insect pests and predators in maize, *Zea may* L. Wudpecker Journal of Agricultural Research. 2012;1(11):466-473.
26. Sanp RK, Singh V. Timely sowing effect on incidence of aphid, Rhopalosiphum maidis in blond psyllium, Plantaga ovata, Forsk. Journal of Agriculture and Ecology. 2018;5:83-87.
27. Saranya VSL, Samiayyan K, Prema MS. Diversity of predatory spider fauna in maize ecosystem. Journal of Biological Control. 2019;33(1):27-35.
28. Sardar SR, Bantewad SD, Jayewar NE. Seasonal incidence of Helicoverpa armigera influenced by Desi and kabuli genotype of chickpea. International Journal of Current Microbiology and Applied Sciences. 2018;6:536-541.
29. Sidar YK, Deole S, Nirmal A, Gajbhiye RK, Bisen MS. A study on the seasonal distribution of spider fauna in the maize field at Raipur, Chhattisgarh region. Journal of Entomology and Zoology Studies. 2017;5(2):1105-1108.
30. Suneel Kumar GV, Madhumathi T. Life tables of the spotted stem borer *Chilo partellus* (Swinhoe) on maize cultivars. Indian Journal of Entomology. 2019;80(4):1341-1350.
31. Scott MP, Emery M. Maize: overview. Encyclopedia of food grains. 2016;1:99-104.
32. Siddiqui KH, Marwaha KK. The vistas of maize entomology in India (1st ed.). Ludhiana, India: Kalyani Publishers; c1994.
33. Singh Gaurav, Jaglan Maha Singh. Seasonal incidence of different insect-pests in kharif maize. Journal of Pharmacognosy and Phytochemistry. 2017;7(3):3666-3669.
34. Singh G, Jaglan MS, Verma T, Khokhar S. Influence of prevailing weather parameters on population dynamics of spotted stem borer, Chilo partellus (Swinhoe) and its natural enemies on maize in Haryana. Journal of Agrometeorology. 2020;22(3):295-304.
35. Waleed A, Mahmoud Seham A, El-Dein E, Safaa, Abdel-Aziz M. Effect of biotic and abiotic factors on Rhopalosiphum maidis (Hemiptera: Aphididae) populations in corn fields at Sohag Governorate, Egypt. Egyptian Journal of Plant Protection Research Institute. 2020;3(4):1129-1138.
36. Wyckhuys KAG, O'Neil Robert J. Population dynamics of Spodoptera frugiperda Smith (Lepidoptera: Noctuidae) and associated arthropod natural enemies in Honduran subsistence maize. Crop Protection. 2006;25:1180-1.