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RESEARCH PAPER

Population dynamics of insect pests and their natural enemies in pearl millet ecosystem

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Abstract: Field experiment was carried out at the Regional Agricultural Research Station, Vijayapura, to study population dynamics of insect pests and their natural enemies in pearl millet ecosystem. The present study revealed that, dead heart per cent (14.45%) due to shoot fly, *Atherigona approximata* (Malloch) was peak during 35th Standard Meteorological Week (SMW), per cent damage due to stem borer, *Chilo partellus* (Swinhoe) was at peak during the 37th SMW (4.55%) and highest blister beetle, *Lytta* sp. population was observed during 38th SMW (12 beetles/ 5 Ear heads). While, the maximum population of aphid *Rhopalosiphum maidis* (Fitch) and its predators, such as coccinellids *Cheilomenes sexmaculata* (Fabricius), *Harmonia octomaculata* (Fabricius) and spiders were recorded during the 34th SMW and the green lacewing *Chrysoperla zastrowi sillemi* (Ebson-petersen) population at 35th SMW. The correlation studies indicated that, dead heart per cent due to shoot fly revealed a significant positive correlation with maximum temperature (r= 0.588*) and stem borer infestation revealed a significant positive correlation with maximum relative humidity (r= 603*) and sunshine hours (r= 585*). None of the weather parameters showed a significant correlation with the incidence of blister beetle and aphid populations.

Key words: Pearl millet, Stem borer, Shoot Fly, Standard meteorological week, Vijayapura

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the most important cereal crop after rice, wheat, maize and sorghum. It is the staple food for 90 million poor people and widely grown on 30 m ha in the arid and semi-arid tropical regions of Africa (>18 m ha) and Asia (>10 m ha), accounting for half of the world's millet production. It is also used as fodder, feed in the livestock sector and industrial sector for alcohol, fuel, starch, and the processed food sector (Anon., 2018). A 100 grams of bajra contain energy (360 calories), protein (12 g), fat (5 g), minerals (2 g), fiber (1 g), carbohydrate (67 g), calcium (42 mg), phosphorus (242 mg) and iron (8 mg). It's grains also reported to have high densities of zinc and iron (Rai *et al*., 2008).

In India, pearl millet is cultivated in an area of 6.84 million ha with a productivity of 1430 kg/ha and a production estimate of 9.78 million tonnes (Anon., 2022). The major pearl millet growing states are Rajasthan, Uttar Pradesh, Haryana, Gujarat and Madhya Pradesh, which contribute 90 per cent of total production in the country (Anon., 2021). In Karnataka, it is called "Sajje" and grown in an area of 0.22 million ha with an annual production of 0.29 million tonnes having productivity of 1303 kg/ha. (Anon., 2021 b).

With the introduction of high-yielding varieties, parallel insect pest problems have also increased. The distribution and damage of insect pests is region specific. Worldwide, at least 150 insect species are recorded as feeding on millets (Nwanze and Harris, 1992); of these, 116 species have been recorded from India (Kishore, 1996). However, Prem Kishore and Solomon (1989) provided a list of approximately 25 species of potential insect pests in India's pearl millet-based cropping systems.

Natarajan *et al.* (1973) reported *Atherigona* spp. as one of the major insect pests of pearl millet in India. The stem borer, *Chilo partellus* (Swinhoe) occurs in all the bajra growing areas of the country but is found to be more dominant in Gujarat and Delhi regions. It causes losses of 20 to 30 per cent (Kishore, 1996). In the pearl millet fields in Northwest Mali, the blister beetle *Psalydolyttapilipes* (Maklin) was spotted by Grunshawa *et al.* (1994). According to Balikai (2010) in Karnataka, 26 insect pests and two non-insect pests were found feeding on pearl millet. However, important species of insect pests include grass hoppers, shoot bugs, leaf rollers, armyworms, and blister beetles. The blister beetles *viz*., *Cylindrothorax tenuicollis* (Pallas), *Psalydolytta rouxi* (Cast.) and *Mylabris pustulata* (Thunberg) assumed greater importance by recording moderate levels of incidence. A heavy infestation of these beetles at the flowering stage caused considerable damage. Adults devoured the pollen and stigma and were responsible for grain abortion and panicle sterility.

The effective pest management of pearl millet requires an understanding of the population dynamics of insect pests. Therefore, studies on the population dynamics of insect pests of pearl millet and their natural enemies were carried out.

Material and methods

The studies were carried out during *Kharif* 2022-23 at Regional Agricultural Research Station (RARS), Vijayapura. A popular pearl millet hybrid Krishna (DSBH-615), was sown during the last week of July,2022 in a plot size of 20 m^2 with plant spacing of 45 × 15 cm. Randomly selected 10 plants forming representative samples were taken, and the population of

different insect pests of pearl millet was recorded at a weekly interval right from germination till harvest of the crop by adopting standard operational procedures. The extent and nature of damage caused by various insect pests were recorded. Simultaneously, under field conditions, observations were also made on natural enemies at weekly intervals from 10 randomly selected plants. Weekly data on different abiotic parameters were recorded. Data so obtained were then subjected to statistical analysis for correlation and test of significance.

Method of observation:

1. Shoot fly: The observations were recorded on 50 plants of net plot by counting and the dead heart and the same was expressed in percentage by using the following formula.

$$\text{Per cent dead heart (\%)} = \frac{\text{Number of plants showing dead heart symptoms}}{\text{Total number of plants in each plot}} \times 100$$

2. Stem borer: At the seedling stage, plants showing parallel holes due to stem borer larvae in the leaves were considered damaged. At the ear head stage, the number of ear heads showing (empty/white ear head) damage was recorded separately. The observations were recorded on 50 plants of the net plot by counting the plants showing stem borer damage symptoms and the same was expressed in percentage by using the following formula.

$$\text{Per cent dead heart (\%)} = \frac{\text{Number of plants showing dead heart symptoms}}{\text{Total number of plants in each plot}} \times 100$$

3. Blister beetles: At the ear head stage the number of beetles present per 5 randomly selected ear heads.

4. Aphids: The aphid population was recorded as the number of aphid/3 cm^2/leaf on 10 randomly selected plants.

5. Natural enemies: The population of predators *i.e.,* coccinellids, green lacewings and spiders were counted from 10 randomly selected plants at weekly intervals and expressed as the number of natural enemies/plant.

Results and discussion

The findings of the current investigation on population dynamics of insect pests and their natural enemies in pearl millet and their correlation with weather parameters are presented in Table 1 and 2, respectively.

Shoot fly, *A. approximata* (Malloch)

The shoot fly infestation commenced at the 33rd SMW (7.27%) and continued up to the 43rd SMW (1.82%). The infestation reached its peak at 28 DAE (35th SMW) with a plant infestation of 15.45 per cent (Table 1).

Damage by maggots at the seedling stage led to the typical dead heart symptoms. The maggot migrated to the leaf whorl and cut the growing point. As a result, the central leaf dried up forming a dead heart, which can be easily pulled out and produced a rotting smell. The present findings are in line with that of Choudhary *et al*. (2018) who revealed that infestations of shoot fly began on the 31st standard meteorological week (SMW) and lasted throughout the crop season. Later, it gradually increased, reaching a peak in the 33rd (2014) and 34th (2015) SMWs with plant infestations of 16.67 and 20.00 per cent, respectively. Raghvani *et al*. (2008) stated that shoot fly infestation in pearl millet ranged from 6.4 to 13.2 per cent during the first 15 to 56 days after germination.

The data (Table 2) showed that, per cent infestation due to shoot fly revealed a significant positive correlation with maximum temperature (r = 0.588*), a non-significant positive correlation with minimum temperature (r = 0.402), morning relative humidity (r = 0.109), evening relative humidity (r = 0.066) and total rainfall (r = 0.160) and a non-significant negative correlation with sunshine hours (r = -0.163).

Dubey and Yadav (1980) who reported that, maximum temperature favoured the dead heart positively after 21 and 28 days after the emergence of the crop if the temperature was more than 30 °C, made similar observations. Anon. (2012) made similar observations, and it was found that as sunshine hours increased, the population of shoot flies decreased, whereas the population of shoot flies grows in the morning and evening as relative humidity rises.

Table 1. Population dynamics of insect pests of pearl millet and their natural enemies during *Kharif* 2022-23

Particulars			Insect Pests			Natural enemies			
Month	SMW	Stage of the crop	Shoot fly infestation (%)	Stem borer infestation (%)	Blister beetles/ 5 Earheads	Aphids/ 3 cm^2	Coccinellids	Green lacewings	Spiders
August	32	Three leaf stage	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	33	Five leaf stage	7.27	0.00	0.00	3.00	0.50	0.40	0.60
	34	Tillering stage	10.91	0.00	0.00	13.50	1.60	0.70	0.80
	35	Panicle initiation stage	15.45	2.27	0.00	6.00	0.90	1.10	0.50
September	36	Flag leaf stage	8.64	4.09	0.00	1.50	0.40	0.60	0.20
	37	Boot leaf stage	8.18	4.55	4.00	0.00	0.20	0.30	0.10
	38	Peak flowering	6.36	3.64	12.00	0.00	0.00	0.00	0.00
	39	Pollination	4.55	3.18	7.00	0.00	0.00	0.00	0.00
October	40	Milking stage	4.09	2.73	2.00	0.00	0.00	0.00	0.00
	41	Dough stage	2.73	3.86	1.00	0.00	0.00	0.00	0.00
	42	Black layer formation	2.27	1.82	0.00	0.00	0.00	0.00	0.00
	43	Maturity	1.82	0.91	0.00	0.00	0.00	0.00	0.00

SMW: Standard Meteorological Week

Stem borer, *C. partellus* (Swinhoe)

The stem borer infestations started in the fourth week of August (35th SMW) and continued up to the fourth week of October (43rd SMW) and it ranged from 0.91 to 4.55 per cent. The infestation of stem borer started with 2.27 per cent plant damage. The dead heart and defoliation due to stem borer was maximum in the second week of September (37th SMW) with 4.55 per cent, thereafter, the infestation decreased gradually, and reached lowest during the 43rd SMW (1.82%) (Table 1).

Damage due to stem borer was recorded as a series of pinholes in younger leaves, whereas in older leaves, patches of transparent leaf epidermis were seen and white ear heads are observed during the ear head stage of the crop. Similar findings were reported by Mittal and Kishore *et al*. (2006) who stated that, from the 35th to the 42nd SMW, stem borer incidence was noted, with the maximum incidence occurring in the 37th SMW. Choudhary *et al*. (2018) revealed that, stem borer infestation was observed in the 32nd SMW. During *Kharif*, stem borer damage ranged from 3.33 to 13.33 per cent which are in confirm with the present findings.

The population of stem borer revealed a significant positive correlation with maximum relative humidity (r = 0.603*) and sunshine hours (r = 0.585*) and a non-significant positive correlation with other weather parameters, *viz*., maximum temperature (r = 0.157), minimum temperature (r = 0.167) and minimum relative humidity (r = 0.350). Total rainfall (r = -0.278) showed a non-significant negative correlation with the population of stem borer (Table 2).

The research findings are in partial agreement with Raghvani *et al*. (2008) who found that stem borer and maximum temperature were negatively correlated, while morning and evening relative humidity and minimum temperature were positively correlated. Kumar *et al*. (2017) investigated that the adult population was positively correlated with weather parameters, *viz*., maximum and minimum relative humidity.

Blister beetle, *Lytta* sp.

The population of the blister beetle *Lytta* sp. started in the second week of September (37th SMW) with a population of 4.00 beetles/5 ear heads. The population increased suddenly, and the maximum population was observed during the third week of September (38th SMW) with 12.00 beetles/5 ear heads, coinciding with the peak flowering stage. Thereafter, it decreased gradually and reached a minimum of one beetle/5 ear heads during the 41st SMW *i.e*., second week of October (Table 1).

Considerable damage was caused by the heavy infestation of these beetles. Adults fed on the stigma and pollen, which were responsible for grain abortion and panicle sterility. Blister beetle incidence was seen during the flowering stage as stated by Thakur *et al*. (2008) who stated that the blister beetle is a flower feeder. Balikai (2010) reported that, blister beetles such as *Cylindrothorax tenuicollis* (Pallas), *Psalydolytta rouxi* Cast and *Mylabris pustulata* (Thunberg) assumed greater importance by recording a moderate level of incidence.

The population of blister beetles revealed a non-significant positive correlation with minimum relative humidity (r = 0.045), whereas the remaining weather parameters, *viz*., maximum temperature (r = -0.085), minimum temperature (r = -0.091), maximum relative humidity (r = -0.045), sunshine hours (r = -0.302) and total rainfall (r = -0.286), showed a non-significant negative correlation with population (Table 2).

At the flowering stage of the blister beetle, incidence was recorded in high numbers from the 3rd week of August to the 2nd week of September in black gram (Rajawath *et al*., 2021) which are similar with the present findings.

Aphid, *R. maidis* (Fitch)

The aphid population commenced in the second week of August (33rd SMW) *i.e*., 3 aphids/3 cm^2. The aphid population reached its highest of 13.50 aphids/3 cm^2 during the third week of August (34th SMW) and there after gradually decreased and

Table 2. Correlation for population of insect pests with weather parameters

Insect pests	Maximum Temperature (^{O}C)	Minimum Temperature (^{O}C)	Relative humidity		Sunshine (hrs)	Rainfall (mm)
			Maximum (%)	Minimum (%)		
Shoot fly *Atherigona approximata*	0.588*	0.402^{NS}	0.109^{NS}	0.066^{NS}	-0.163^{NS}	0.160^{NS}
Stem borer *Chilo partellus*	0.157^{NS}	0.167^{NS}	0.603*	0.350^{NS}	0.585*	-0.278^{NS}
Blister beetle *Lytta* sp.	-0.085^{NS}	-0.091^{NS}	-0.047^{NS}	0.045^{NS}	-0.302^{NS}	-0.286^{NS}
Aphids *Rhopalosiphum Maidis*	0.459^{NS}	0.255^{NS}	-0.151^{NS}	-0.142^{NS}	0.110^{NS}	-0.150^{NS}
Y	Regression linear equation					Co-efficient of determination (R^2)
Shoot fly	Y= -68.955 + 2.558 X_{1+} 1.245 X_2 - 0.085 X_3 - 0.212 X_4 - 1.099 X_5 - 0.007 X_6 + 4.341					0.553
Stem borer	Y = -9.294 + 0.894 X_1 – 1.237 X_2 +0.088 X_3 + 0.082 X_4 – 0.955 X_5 + 0.029 X_6 + 1.498					0.644
Blister beetle	Y = -14.842 + 2.705 X_1 – 3.207 X_2 + 0.150 X_3 + 0.089 X_4 -3.723 X_5 - 0.063 X_6 + 3.331					0.648
Aphids	Y = -92.690 + 0.265 X_1 + 3.536 X_2 + 0.325 X_3 - 0.314 X_4 + 1.871 X_5 - 0.091 X_6 + 3.557					0.652

*Correlation is significant at the 0.05 level;**Correlation is significant at the 0.01 level;

X_1: Maximum temperature X_2: Minimum temperature X_3: Maximum relative humidity

X_4: Minimum relative humidity X_5 : Sunshine hours X_6 : Total rainfall

reached a minimum of 1.50 aphids/3 cm^2 during the first week of September (36th SMW). Population of natural enemies *viz*., coccinellids, green lace wings and spiders was noticed to be feeding on aphids (Table 1).

The present findings are comparable to the results of Kore *et al*. (2013) who stated that, the incidence of aphid, *R. maidis* ranged from (4th week of August) 34th SMW to the 42nd SMW. Shivare *et al*. (2022) recorded the aphid *R. maidis* (Fitch) incidence when the sorghum was 26 days old and showed peak incidence during the 37th SMW with 54 aphids/leaf.

Very low rainfall and temperature range coinciding with the optimum temperature threshold levels for development, which is 10 to 35 °C might have contributed to the attainment of high population of aphids. The population of aphids revealed a non-significant negative correlation with maximum relative humidity (r = 0.151), minimum relative humidity (r = -0.142) and total rainfall (r = - 0.150). Other weather parameters, *viz*., maximum temperature (r = 0.45), minimum temperature (r = 0.255) and sunshine hours (r = 0.110), showed a non-significant positive correlation with the population of aphids (Table 2).

These results are in agreement with the statement of Chakravarty and Gautam (2004), who reported that temperature is the most important abiotic factor affecting aphid, *R. maidis* population. Relative humidity and rainfall exerted a negative and non-significant effect on the population of aphid. Patil *et al*. (2015) revealed that none of the weather parameters significantly correlated with the *R. maidis* population on maize.

Natural enemies

Coccinellids

The coccinellid activity was noticed during the 33rd SMW (second week of August) with 0.50 coccinellids/plant and persisted until the 37th SMW (second week of September) with 0.20 coccinellids/plant. Peak activity was observed on the 34th SMW (third week of August), with a population of 1.60 coccinellids/ plant (Table 1).The current observations are more or less similar with Kore *et al*. (2013) who stated that the incidence of the aphid, *R. maidis* ranged from 4th week of August (34th SMW) and to October (42nd SMW). The predators lady bird beetle and chrysoperla were active from 35th to 42nd SMW.

Green lacewings, *C. zastrowi sillemi* (Ebson-Petersen)

The number of green lacewings recorded ranged from 0.00 to 1.10 green lacewings per plant. The first observation (0.40 green lacewings/ plant) was on the 33rd SMW (second week of August), while the maximum count (1.10 green lacewings/ plant) was on the 35th SMW (fourth week of August). Later it gradually decreased and reached a minimum of 0.30 green lace wings/ plant during the 37th SMW (second week of September) (Table 1).

Hadiya and Kalariya (2017) has reported significant positive correlation between population of aphids with its natural enemies like coccinellids, spiders and green lacewings.

Spiders

The number of spiders recorded ranged from 0.00 to 0.80 spiders/plant. The first appearance (0.60 spiders/ plant) was observed on the 33rd SMW (second week of August), while the maximum count was observed on the (third week of August) 34th SMW (0.80 spiders/ plant).

Conclusion

The current study demonstrated the incidence and peak time of insect pests and natural enemies in Bajra crop ecosystem.The shoot fly, *A. approximata*, stem borer, *C. partellus* and blister beetle, *Lytta* sp. infestation reached a peak during the 35th, 37th and 38th SMW respectively. The shoot fly dead heart per cent revealed a significant positive correlation with maximum temperature and stem borer infestation revealed a significant positive correlation with maximum relative humidity and sunshine hours. The aphid, coccinellid and spiders population reached its peak during the 34th SMW. A substantial relationship was observed to exist between aphids and coccinellids. The results of this study helps to predict the level of damage caused by insect pests during the *Kharif* season. This data may be fruitfully utilized for forewarning farmers and scheduling pest management strategies.

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