Journal of Agrometeorology

ISSN : 0972-1665 (print), 2583-2980 (online)
Vol. No. 25 (3) : 458-461 (September - 2023)
https://doi.org/10.54386/jam.v25i3.2209
https://journal.agrimetassociation.org/index.php/jam

Research paper

Population dynamics of aphid and their natural enemies in mustard based on meteorological parameters using principal component analysis

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ABSTRACT

An experiment was conducted at the research farm of the Rajasthan Agricultural Research Institute, Durgapura, Jaipur, during *Rabi*, 2020–21 and 2021–22, to study the impact of meteorological parameters on the populations of the aphid, *Lipaphis erysimi* (Kalt) it's associated natural enemies coccinellids, *Coccinella septempunctata* and syrphid flies, *Xanthogramma scutellariae*. The correlation coefficients with the pooled data, showed a substantial negative correlation of aphid population with temperature (r = -0.466 and -0.582*) as well as with average relative humidity (r =0.489*). *C. septempunctata* and *X. scutellariae* had positive significant correlations with *L. erysimi* (r = 0.965* and 0.988* respectively). The most significant variables for aphid populations, according to PC1 and PC2 (initial components of principal component analysis), are biotic factors and weather parameters.

Key words: Mustard, aphid, predators, meteorological parameters, principal component analysis

Brassica juncea (L.) Czern & Coss, also known as Indian mustard, is a member of *Brassicaceae* (Cruciferae). Together with four other closely related cultivated species, *Brassica rapa, B. napus, B. carinata*, and *Eruca sativa*, it is referred as rapeseed-mustard in the trade. India is the world's top producer of oilseeds, and this sector is crucial to the country's agricultural economy. Rajasthan is the leading rapeseed-mustard producing state with the total 4.22 million tonnes production and share of 46.28 per cent compared to all India mustard production. Alwar, Bharatpur, Sri Ganganagar and Tonk are the leading mustard producing district of the Rajasthan which had accounted of area 0.27, 0.25, 0.23 and 0.23 million hectors and production 0.67, 0.53, 0.44 and 0.41 million tonnes, yield 2284, 2115, 1860 and 1740 kg ha^{-1}, respectively (Anonymous, 2021).

The primary pest of *brassica* across the major mustard planted region is *Lipaphis erysimi* (Kalt.). It's accountable to reach from 9 to 96 per cent crop production weight loss and 15 per cent oil in India. Nymphs and adults stage of aphid are destructive to mustard as these attack vegetative buds and later spread on whole plant. Due to heavy infestation, plant becomes stunted and dries up resulting in no pod formation (Vishal *et al.,* 2019). The aphids also exude honeydew on plant surfaces, which creates an ideal environment for the formation of sooty mould, it eventually inhibits photosynthesis and results in a sharp decline in output (Yadav and Singh, 2016). Kalasariya and Parmar (2018) studied the effect of weather factors on population fluctuations of mustard aphid using path co-efficient analysis. Many natural enemies, such as *Coccinella septempunctata*, *Ischiodon scutellaris*, and *Xanthogramma scutellariae*, parasitize *Lipaphis erysimi* (Kalt) in mustard fields. During their larval period, *C. septempunctata* grubs preyed on the most mustard aphids, followed by *Syrphus confrater* (Wied.), *Syrphus balteatus* (Deg.), and *Ischiodon scutellaris* (Fab.). The predator's larval stage is its most potent devourer of the *L. erysimi*. These predators might be utilised to manage *L. erysimi* on rapeseed-mustard crops in an efficient manner (Singh and Singh, 2013). Soni *et. al.,* (2021) developed models of aphid complex and its associated natural enemies in rapeseed-mustard in relation to climatic factors. Hence, and experiment was planned to study the effect of abiotic factors on insect pests of mustard and its associated natural enemies.

Article info - DOI: *https://doi.org/10.54386/jam.v25i3.2209*
Received: 29 April 2023; Accepted: 31 July 2023; Published online : 31 August 2023

MATERIALS AND METHODS

An experiment was conducted at the research farm of the Rajasthan Agricultural Research Institute, Durgapura, Jaipur, during *Rabi*, 2020–21 and 2021–22, to study the impact of meteorological parameters on the populations of the aphid, *Lipaphis erysimi* (Kalt) it's associated natural enemies coccinellids, *Coccinella septempunctata* and syrphid flies, *Xanthogramma scutellariae*. Five distinct plots of the mustard crop, variety Varuna (T-59), with a simple layout, were kept under observation to record the insect pests of mustard and its associated natural enemies. This was done in order to study the population dynamics of insect pests of mustard and their natural enemies in relation to meteorological parameters. The crop was planted on October 24 and October 27 of *Rabi* 2020–21 and 2021–22, respectively. The plot had dimensions of 4.0 x 3.0 m^2 and R x P. (30 x 10 cm).

The numbers of aphids and their natural enemies were correlated with climatic variables. Using R software (R-Studio), PCA (plotted) and stepwise liner regression were analysed.

RESULTS AND DISCUSSION

Population build-up of aphid and their natural enemies

Pooled data of two crop seasons during *Rabi,* 2020-21 and 2021-22 reveled that *L. erysimi* firstly appeared in mustard field from 52nd standard metrological week. Natural enemies like *C. septempunctata* (both larvae and beetles) and syrphid flies, *Xanthogramma scutellariae* (both larvae and adults) also firstly appeared in the mustard field from 52nd standard metrological week. The population of aphid and *C. septempunctata* hit extreme population grade in 5th and *X. scutellariae* in 6th SMW (Table 1). Number of aphid, *C. septempunctata* and *X. scutellariae* reached its peak population than after start continue to decrease to negligible number at 9th SMW. *C. septempunctata* and *X. scutellariae* eliminated after last week of February at 9th SMW. Our results are agreements to Chand *et. al.,* (2021), Mishra and Kanwat (2018) and Arvind, (2021).

Principal component analysis (PCA)

In the PC1 and PC2 correspondingly, the dimensions of the data were 61.11 and 24.68 percent (Fig. 1.) The compressible variables with negative and positive correlations on the same and opposite sides of the axis, respectively. Shorter distances between variables indicate higher degrees of significance, which is how the significance was calculated. Meteorological variables and biotic factors are the major contributors to the large fluctuation in the mean aphid population on the basis of length variations in PC1 and PC2.

Effects of abiotic factors on population build-up and natural enemies

The maximum temperature showed a non-significant and minimum temperature showed a significant correlation with

Table 1: Population dynamics of major insect pests of mustard and their natural enemies in relation to meteorological parameters in Pooled *Rabi,* 2020-21 and 2021-22.

SMW	Pooled, *Rabi,* 2020-21 and 2021-22						
	Temperature °C		Average Relative Humidity (%)	Total Rainfall (mm)	Insect pest/ five plants	Natural enemies/ five plants	
	Max.	Min.			Aphid	Coccinellids	Syrphid flies
45	30.55	13.25	40.75	0.00	0.00	0.00	0.00
46	27.80	12.75	46.75	5.50	0.00	0.00	0.00
47	27.10	13.15	42.00	0.40	0.00	0.00	0.00
48	26.95	12.15	54.25	1.60	0.00	0.00	0.00
49	27.05	11.15	54.50	0.20	0.00	0.00	0.00
50	24.15	11.35	56.00	0.00	0.00	0.00	0.00
51	22.75	6.75	45.00	0.00	0.00	0.00	0.00
52	22.00	8.35	53.25	1.60	14.18	0.48	0.90
1	20.75	11.00	69.25	7.50	55.59	2.40	1.90
2	19.15	7.95	68.25	8.30	89.37	5.20	2.70
3	21.60	7.60	64.75	0.00	114.30	6.60	3.30
4	20.70	6.85	61.75	4.60	164.05	8.20	4.00
5	24.25	8.40	54.75	0.00	191.27	11.10	4.90
6	25.00	9.50	54.25	0.00	163.70	10.62	5.00
7	27.25	11.95	48.00	0.00	81.30	7.80	2.75
8	29.45	13.15	38.50	0.00	31.90	4.30	1.30
9	29.90	13.95	42.25	0.00	1.48	0.30	0.15

Table 2: Correlation coefficient (r) between the major insect pests of mustard and their natural enemies in relation to meteorological parameters during Pooled *Rabi,* 2020-21 and 2021-22

S. No.	Particulars	Pooled *Rabi*, 2020-21 and 2021-22		
		Major insect pests	Natural enemies	
		Aphid	Coccinellids	Syrphid flies
A.	**Weather parameters**			
1.	Temperature			
	a. Maximum temperature	-0.466	-0.324	-0.465
	b. Minimum temperature	-0.582*	-0.464	-0.559*
2	Average relative humidity (%)	0.489*	0.350	0.489*
3	Total rainfall (mm)	0.113	0.00	0.113
B.	**Natural enemies**			
	Coccinellids	0.965*		
	Syrphid flies	0.988*		

*Significant at 1 per cent level, **Significant at 5 per cent level, NS = Non significant

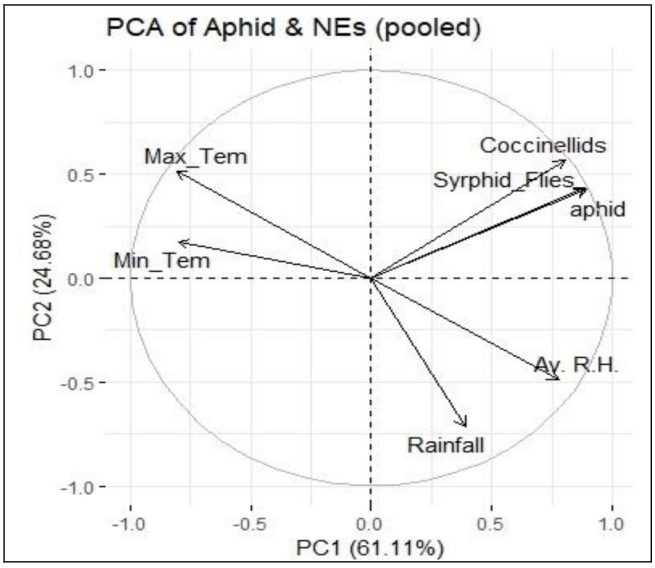

Fig. 1: Variables of the principal component analysis (PCA)

aphid (r = -0.466 and r = -0.582*). Aphid had positive correlation with average relative humidity (r = 0.489*). The current findings are also supported by the findings of Arvind, (2021), Chand *et. al*., (2021) and Dotasara *et. al.,* (2021). (Table 2). *C. septempunctata* and *X. scutellariae* had negative correlation with maximum (r = -0.324 and -0.465 respectively) and minimum temperature (r = -0.464 and -0.559* respectively). Similar findings are reported by Arvind, (2021) and Chand *et. al*., (2021). Significant correlations of *C. septempunctata* and *X. scutellariae* with aphid were found (r = 0.965 and r = 0.988, respectively). Arvind, (2021) and Chand *et. al*., (2021) also reported similar findings (Table 2).

Regression analysis

According to data from the next two *Rabi* seasons, the predicted models for the mean aphid population indicated variations in minimum temperature of 39 percent (Table 3). According to natural enemies, the numbers of syrphid flies considerably affects the mean aphid population and contribute to variations of 98 per cent. However, maximum temperature had a 98 per cent significant and non-significant impact on the population of coccinellid and

Table 3: Stepwise linear regression of aphid and their natural enemies with weather parameters

Particulars	Pooled *Rabi,* 2020-21 & 2021-22	
	Regression equations	R^2
Aphid + W.P.	$Y= 222.64^{**} -16.05T_{Min}^{*}$	0.39
Aphid + NEs	$Y= -4.29 + 36.42 SF^{***}$	0.98
Coccinellids	$Y= -5.22^{***} + 0.19^{**}T_{Max}$	0.98
Syrphid flies	$Y= 0.45 + 0.02 RH -0.05T_{max}$	0.98

W.P. = Weather parameters, NEs = Natural enemies, RH = Relative humidity, RF = Rainfall, T_{max} = Maximum temperature, T_{min} = Minimum temperature, C = Coccinellids, SF = Syrphid flies, Significant levels at, * = 1, **=0.1 and ***=0.05 %.

syrphid fly predators. Based on the stepwise regression equation, it was clear that the population of aphids and their natural enemies was influenced by meteorological characteristics. The weather has a significant impact on bug population, growth, multiplication, and distribution (Dhaliwal and Arora, 2001). The combined impacts of the environmental variables RH, temperature, and rainfall led to variations in mustard aphid of 41, 62 and 70 per cent over the course of three years, according to Sahoo, (2013) analysis using stepwise regression. Regression analysis revealed that while every meteorological component contributed to the quantity of mustard aphids, only the minimum temperature had a more significant impact than the others.

CONCLUSIONS

Coccinellid, syrphid flies, and mustard aphid started to develop in the 52nd standard metrological week (SMW) and peaked in the 5th and 6th SMW. Aphid exhibited a negative non-significant and significant association with maximum and minimum temperature respectively a positive significant correlation with relative humidity and positive correlation with rainfall. There was a substantial positive link between coccinellids and syrphid flies and the aphid *L. erysimi*. According to the findings of principal component analysis, the population of *L. erysimi* (Kalt) varied significantly in terms of temperature (maximum and minimum), relative humidity, rainfall, and natural enemies.

ACKNOWLEDGEMENT

The authors thank the Director, Rajasthan Agricultural Research Institute, Durgapura, for providing all necessary facilities and their guidance during research work.

Conflict of Interests: The authors declare that there is no conflict of interests related to this article.

Funding: Funded by the Rajasthan Agricultural Research Institute, Durgapura.

Data availability: Can't be shared.

Authors contribution: **R. V. Yadav:** Conceptualization, Methodology, Investigation, writing original draft; **V. Kumar**: Supervision; **R. Saxena**: Observed meteorological data, review and editing.

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