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Amar Chand
Ph.D. Scholar Department of Entomology, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

SK Khinchi
Assistant Professor, Department of Entomology, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

KC Kumawat
Professor, Department of Entomology, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

Akhter Hussain
Associate Professor & Head, Department of Entomology, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

Shankar Lal Sharma
Assistant Professor, Department of Entomology, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

Corresponding Author
SK Khinchi
Assistant Professor, Department of Entomology, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University, Jobner, Rajasthan, India

Quantitative and qualitative status of insect pests of mustard, *Brassica juncea* (L.) Czern and Coss and their natural enemies

Amar Chand, SK Khinchi, KC Kumawat, Akhter Hussain and SL Sharma

Abstract
The field experiment was conducted during *Rabi*, 2019-20 and *Rabi*, 2020-21. The population of mustard aphid, *L. erysimi* first appeared in the last week of December (52nd Standard Meteorological Week) and increased gradually week after week and attained to its peak in second week of February (6th SMW) during both the years. The peak activity of aphid was observed at 26.50- 23.3 ^{0}C maximum, 4.90-5.30 ^{0}C minimum temperature and relative humidity 55.0-57.0 per cent during the two consecutive years (*Rabi*, 2019-20 and *Rabi*, 2020-21). After the peak population, the population of aphid started to decline and reached to low level in the 9th SMW near maturity of the crop during both the years. The maximum temperature had significant negative correlation and minimum temperature had non significant negative correlation, whereas, relative humidity had non-significant positive effect with aphid population during both the years *Rabi*, 2019-20 and *Rabi*, 2020-21. The occurrence of natural enemies ladybird beetle, *C. septempunctata* and syrphid fly, *X. scutellarae* with the population of aphids during both the years and the enemies *viz.*, *C. septempunctata* and X. *scutellarae* had significant positive correlation with the population of mustard aphid and population of *C. septempunctata* had non-significant negative correlation with maximum and minimum temperatures while, non-significant positive correlation with relative humidity during both the years *Rabi*, 2019-20 and *Rabi*, 2020-21.

Keywords: quantitative, insect pests, mustard, *Brassica juncea* (L.), natural enemies

Introduction
Indian mustard, *Brassica juncea* (L.) Czern and Coss (family- Brassicaceae) is one of the most important *Rabi*, oilseed crop grown in all over India. Its occupies a prestigious position in the Indian economy. *Brassica* (rapeseed-mustard) is the second most important edible oilseed crop in country after groundnut and accounts for nearly 30 per cent of the total oilseeds production in India. Rapeseed-mustard oil is superior as compared to other edible oils as it contains adequate amounts of essential fatty acids, linoleic and linolenic acid. Besides it, it has the lowest amount of harmful saturated fatty acids which are anti-nutritional factors present in other oilseed crops. Being rich source of protein, minerals, vitamin A and vitamin C, its green leaves and stems are a good source of green vegetable and fodder. The oil content in mustard seeds ranged from 35-45 per cent (Patel *et al.* 2017) [11]. The mustard cake is widely used to enrich soil fertility and reclamation of salt affected soils as it contains 5.2% Nitrogen, 1.8% Phosphorus and 1.2% Potassium. The oil is also used for making soap, softening of leather and lubrication purposes.

In India, its production is mainly confined to the major states *viz.*, Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh, West Bengal, Haryana and Punjab. The total area under mustard crop in India is 62.30 lakh hectares with an annual production of about 93.39 lakh million tonnes and an average productivity of about 1499 kg ha^{-1}. In Rajasthan, it occupies 25.00 lakh hectare area with annual production of 41.96 lakh million tonnes (Anonymous, 2018-19) [1]. It is mainly grown in the districts of Bharatpur, Alwar, Sawai Madhopur, Sri Ganganagar and Jaipur.

The low productivity of rapeseed mustard crops attributed to various abiotic and biotic factor constraints. Abiotic factors include which temperature, relative humidity, rainfall and light. Insect pests are major biotic constraints in achieving potential mustard production. The mustard is infested by more than 43 species of insect pest and out of which major pests are mustard aphid, *Lipaphis erysimi*, (Kaltenbach)., mustard sawfly, *Athalia lugens proxima* (Klug.)., painted bug, *Bagrada hilaris* (Kirk.) and leaf miner, *Phytomyza horticola* (Gourealla) (Singh *et al.* 2009).

Among the insect pest exercising heavy toll to mustard crop including 24 species insect pests in India damaging different stages of the mustard and rapeseed crop (Rai, 1976) [12].
Therefore, in order to prevent the loss caused by insect pests and to produce a quantity and quality mustard crop, it is essential to manage the insect pests population at an appropriate time with suitable measures. The population dynamics study of major insect pests is important as variation in the meteorological parameters has profound effect in determining pest status and ultimate degree of damage they may cause. The peak period of insect pest activity gives an idea that helpful in developing a more efficient pest management in order to ensure successful crop production.

Materials and Methods

The present investigations were conducted at Agronomy Farm, Department of Entomology, S.K.N. College of Agriculture, Jobner during two consecutive years, *i.e., Rabi*, 2019-20 and *Rabi*, 2020-21. The quantitative and qualitative status of major insect pests and their natural enemies of mustard, variety Pusa Bold were sown in five separate plots (3.0 x 2.4 m^2) in the first week of November with a row to row and plant to plant distance of 30 cm and 10 cm, respectively. All the recommended package of practices for raising the crop where followed. The crop was allowed for natural infestation of insect pests. The population of insect pests of mustard was recorded from five randomly selected and tagged plants from each plot at weekly interval from initiation to the harvesting of the crop.
The simple correlation was computed between the mean population of insect with weather parameters, *viz.*, maximum and minimum temperatures, average relative humidity and rainfall and their natural enemies. The correlation was also computed between weather parameters and coccinellid predators. The following formula was used for calculating correlation coefficient (Panse and Sukhatme, 1967) [10].

$$r = \frac{N \Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{N \Sigma x^2 - (\Sigma x)^2 . N \Sigma y^2 - (\Sigma y)^2}}$$

Where,
R = Simple correlation coefficient
x = Independent variable, *i.e.* abiotic component
y = Dependent variable, *i.e.* aphid population/ coccinellid predator
N = Number of observations

Results and Discussion

The quantitative and qualitative status of insect pests of mustard, *B. juncea* (L.) Czern and Coss and their natural enemies were studied during two years of *Rabi*, 2019-20 and 2020-21. The observations were recorded at the weekly interval and data have been presented in the table- 1 and 2.
Altogether total four insect-pests mustard aphid, *Lipaphis erysimi* Kalt., mustard sawfly, *Athalia lugens proxima* Klug., painted bug, *Bagrada cruciferarum* Kirk., Flea beetle *Phyllotreta cruciferae* Goeze and wasp and four natural enemies ladybird beetle *Coccinella septempunctata* Linn., Ladybird beetle *C. transversalis*, syrphid fly *Xanthogramma scutellarae* Fab and Green lace wing *C. carnea* and hony bee have been recorded. However, except mustard aphid *L. erysimi* and two natural enemies ladybird beetle, *Coccinella septempunctata* Linn. and syrphid fly *Xanthogramma scutellarae* Fab the population of other insect pests was negligible, hence not correlated with biotic and abiotic environment and recorded as minor insect pests of mustard crop .
The mustard aphid was recorded as major insect pests of mustard. The population of mustard aphid was correlated with natural enemies and meteorological parameters *viz.*, maximum temperature, minimum temperature and average relative humidity. The rainfall during the cropping season was occurred only one time, hence, not correlated, the observations were recorded at weekly interval and data have been presented in the table 1 and 2.
The population of mustard aphid, *L. erysimi* first appeared in the last week of December (52nd Standard Meteorological Week) and continued throughout the cropping season during *Rabi*, 2019-20 (table 2). Initially, the mean aphid population was recorded to be 58.00 per 10 cm terminal shoot, which increased gradually and reached to its peak (148.16 aphids/ 10 cm terminal shoot) in the second week of February (6th SMW). Thereafter, the population declined and at the time of crop harvesting, it reached at 1.73 aphids per 10 cm terminal shoot.
The infestation of aphid during *Rabi*, 2020-21 started in the last week of December (table 3). The infestation of aphid continued thereafter for a long period and disappeared in the first week of March before the crop matured. Initially, the population of aphid was recorded to be 38.10 aphids per 10 cm terminal shoot which increased gradually and reached up to 140.01 aphids per 10 cm terminal shoot in the second week of February. The population declined at the time of crop harvesting (1.20 aphids/ 10 cm terminal shoot).
The result obtained during the present investigation revealed that commencement of aphid, *L. erysimi* took place on the mustard crop in the last week of December (52th SMW) during 2019-20 and 2020-21. These results are in agreement with those of Panda *et al.* (2000), Deepak *et al.* (2002) [4], Jandial and Kumar (2007) [7], Choudhary and Pal (2009) [3], Venkateswarlu *et al.* (2011) [18], Chanchal *et al.* (2012) [2], Sahoo (2013) [13], Singh *et al.* (2018) [14] and Mishra and Kanwat (2018) who reported the appearance of mustard aphid in different weeks of December.
The observations on the population build up of *L. erysimi* revealed that during both the years, *i.e. Rabi*, 2019-20 and *Rabi*, 2020-21, the infestation commenced when the maximum temperature ranged between 22.1 to 21.7 ^{0}C, minimum temperature ranged between 2.3 to 0.7 ^{0}C and the average relative humidity during this period varied between 62.0-65.0 per cent (table 2). The peak activity of aphid was observed at 26.5 to 23.3 ^{0}C maximum and 4.9-5.3 ^{0}C minimum temperature with average relative humidity between 55.0-57.0 per cent.
The present findings of the research were partially supported by the findings of Jat *et al.* (2006) [8], Jandial and Kumar (2007) [7], Varshney *et al.* (2016) [16] and Dotasara *et al.* (2018) [5] who reported that the maximum temperature had significant negative effect and relative humidity had significant positive effect, whereas, minimum temperature and rainfall had non-significant effect on the aphid population.

Natural enemies

The quantitative survey during *Rabi*, 2019-20 and *Rabi*, 2020-21 revealed that the coccinellid predators *viz.*, ladybird beetles, *C. septempunctata*, and syrphid fly *Xanthogramma*

scutellarae were found preying aphid, *L. erysimi* on the mustard crop in both the years.

During *Rabi* 2019-20, the population of ladybird beetle, *C. septempunctata* (both beetles and grubs) appeared in the last week of December *i.e.*, 52nd SMW (4.2/ five plants) when the maximum and minimum temperatures were 0.7 ^{0}C and 21.7 ^{0}C, respectively with average relative humidity of 65.0 per cent and reached to maximum in the second week of February *i.e.*, 6th SMW (12/ five plants) on mustard crop when the maximum and minimum temperatures were 23.3 °C and 5.3 °C, respectively and relative humidity was 57.0 per cent. Thereafter, the population declined and reached at 0.60 beetles/ five plants in the first week of March (table 1).

During *Rabi* 2020-21, the population of ladybird beetle, *C. septempunctata* (both beetles and grubs) appeared in the last week of December *i.e.*, 52nd SMW (0.8/ five plants) when the maximum and minimum temperatures were 2.3 ^{0}C and 22.1 ^{0}C, respectively with average relative humidity of 62.0 per cent and reached to maximum in the second week of February *i.e.*, 6th SMW (13/ five plants) on mustard crop when the maximum and minimum temperatures were 26.5 °C and 4.9 °C, respectively and relative humidity was 55.0 per cent. Thereafter, the population declined and reached at 0.60 beetles/ five plants in the first week of March (table 2).

The data presented in table 1 & 2 revealed that the population of ladybird beetle, *C. septempunctata* was influenced by the host (prey) insect as maximum population was observed in both the years in the same period.

During *Rabi* 2019-2020, the population of syrphid fly was also first appeared in the last week of December, 2019 (52nd SMW) when maximum and minimum temperatures were 0.7 ^{0}C and 21.7 ^{0}C, respectively with average relative humidity of 65.0 per cent and continued through the crop season. Initially, the mean syrphid fly population was recorded to be 2.50 per five plants. It increased gradually and reached to maximum (5.21/ five plants) in the second week of February (6th SMW) when maximum and minimum temperatures were 23.3 °C and 5.3 °C, respectively and relative humidity was 57.0 per cent. Thereafter, the population declined and reached at 0.3 syrphid fly/ five plants in the first week of March (table 1).

During *Rabi*, 2020-221, the population of syrphid fly was also first appeared in the last week of December, 2020 (52nd SMW) when maximum and minimum temperatures were 2.3 ^{0}C and 22.1 ^{0}C, respectively with average relative humidity of 62.0 per cent and continued through the crop season. Initially, the mean syrphid fly population was recorded to be 3.0 per five plants. It increased gradually and reached to maximum (5.46/ five plants) in the second week of February (6th SMW) when maximum and minimum temperatures were 26.5 °C and 4.9 °C, respectively and relative humidity was 55.0 per cent. Thereafter, the population declined and reached at 1.20 syrphid fly / five plants in the first week of March (table 2).

The present findings are in agreement with those of Tripathi *et al.* (2005) [15], Vekaria and Patel (2005) [17] and Hugar *et al.* (2008) [6] reported that both the predators, namely coccinelid and syrphid population were maximum in the last week of January and the first week of February, respectively.

Table 1: Population dynamics of insect pests of mustard and their natural enemies in relation to meteorological parameters during *Rabi*, 2019-2020

S. No.	SMW	Date of observations	Meteorological parameters				**Mean Aphid population/ 10 cm terminal shoot	Natural enemies	
			Temperature (^{0}C)		Average relative humidity (%)	Total rainfall (mm)		Mean population/ five plants	
			Maximum	Minimum				*Xanthogramma scutellarae*	*Coccinella septempunctata*
1	52	29.12.19	21.70	0.70	65.00	0.00	58.20	2.5	4.2
2	1	05.01.20	20.70	5.80	70.00	0.00	71.33	2.6	4.6
3	2	12.01.20	20.20	4.90	67.00	0.00	88.00	2.7	7.0
4	3	19.01.20	19.70	6.00	70.00	0.00	92.16	3.4	8.2
5	4	26.01.20	23.70	5.20	61.00	0.00	96.73	4.6	9.2
6	5	02.02.20	22.70	5.00	60.00	0.00	115.33	5.0	10
7	6	09.02.20	23.30	5.30	57.00	0.00	148.16	5.21	12
8	7	16.02.20	28.20	6.60	45.00	0.00	11.2	2.0	4.5
9	8	23.02.20	27.70	11.20	57.00	0.00	6.65	1.0	3.2
10	9	02.03.20	29.20	18.10	57.00	0.00	1.73	0.3	0.6
		Maximum					-0.711*	-0.555	-0.532
		Minimum					-0.604	-0.646*	-0.579
		Relative humidity					0.407	0.179	0.146
		Aphid						0.936*	0.934*

SMW-Standard Meteorological Week,
* Significant at 5% level of significance
**Average of five replications

Table 2: Population dynamics of insect pests of mustard and their natural enemies in relation to meteorological parameters during *Rabi*, 2020-2021

S. No.	SMW	Date of observations	Meteorological parameters				**Mean Aphid population/ 10 cm terminal shoot	Natural enemies	
			Temperature (^{0}C)		Average relative humidity (%)	Total rainfall (mm)		Mean population/ five plants	
			Maximum	Minimum				*Xanthogramma scutellarae*	*Coccinella septempunctata*
1	52	30.12.20	22.10	2.30	62.00	0.00	38.1	3.00	0.80
2	1	06.01.21	21.20	10.60	73.00	10.20	97.45	3.40	3.60
3	2	13.01.21	20.40	5.80	64.00	0.00	98.05	3.80	6.50
4	3	20.01.21	24.10	5.90	61.00	0.00	99.02	4.20	8.00
5	4	27.01.21	21.90	3.10	61.00	0.00	109.1	4.66	8.60
6	5	03.02.21	25.50	4.40	53.00	0.00	113.64	4.93	9.30

7	6	10.02.21	26.50	4.90	55.00	0.00	140.01	5.46	13.00
8	7	17.02.21	28.70	9.50	53.00	0.00	22.65	2.40	4.00
9	8	24.02.21	30.50	8.70	49.00	0.00	3.04	2.20	3.00
10	9	03.03.21	31.50	10.70	45.00	0.00	1.2	1.20	0.60
		Maximum					-0.637*	-0.547	-0.238
		Minimum					-0.504	-0.668*	-0.464
		Relative humidity					0.528	0.385	0.097
		Aphid						0.952*	0.862*

SMW-Standard Meteorological Week,
* Significant at 5% level of significance
**Average of five replications

Conclusion

The infestation of aphid, *L. erysimi* on mustard commenced in the last week of December (52nd Standard Meteorological Week) and remained active throughout the crop season *i.e.*, up to first week of March and its peak in second week of February *i.e.*, 6th SMW. The occurrence of natural enemies ladybird beetle, *C. septempunctata* and syrphid fly, *X. scutellarae* with the population of aphids and the natural enemies *viz.*, *C. septempunctata* and X. *scutellarae* had significant positive correlation with the population of mustard aphid and the population of *C. septempunctata* had non-significant negative correlation with maximum and minimum temperatures during both the years (*rabi*, 2019-20 and *rabi*, 2020-21).

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