Biotic and abiotic factors as variables in population build-up of mustard aphid (*Lipaphis erysimi* Kalt.) in the western Gangetic planes of India

Abstract

An experiment was conducted at the Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) during *Rabi* season 2021-22. During the course of research, observations were made to study the incidence and fluctuations in population build-up of Mustard Aphid, *Lipaphis erysimi* Kalt. due to variations in abiotic factors including temperature, precipitation rates, daylight hours, humidity as well as biotic factors such as natural enemies as for example, predators like grubs and adults of lady bird beetle, *Coccinella septumpunctata* etc., The maximum aphid population 164 aphid/10 cm shoots were recorded in the third standard week of February. Appearance of grubs and adults of lady bird beetle in the first week of December and maximum population reached in synchronization with the maximum population of aphid *i.e.*, 4.12 beetle or grubs per 10 shoots in the month of February. Simple correlation studies revealed the instantaneous effects of meteorological variables on the population progression of aphids, the temperature had the biggest influence in the fluctuations of number of aphids per plant shoot. The appearance of predators was positively correlated with temperature, whereas a negative correlation with the incidence of mustard aphid was observed. Additionally, there was a positive correlation between the population of aphid and relative humidity.

Key words: Biotic, Abiotic, Natural enemies, Mustard Aphid and Lady bird beetle.

Introduction:

After groundnut, mustard is the second-most significant edible oil seed crop in India, where it makes up approximately 30 percent of all oil seed production. With two essential fatty acids, linoleic and linolenic, that are absent from many other edible oils, mustard seeds have the lowest level of toxic saturated fatty acids when compared to other seeds for oil. The lack of sulphur is covered by the leaves utilised as green vegetables. Hair oils and medicines both use mustard oil. In order to meet the nation's demand for fats and oils, more mustard must be produced.

The two most crucial elements are the optimal plant population in relation to fertilisation and the crop's effective use of nutrients. Due of the wide variety in the timing of

aphid infection and its growth, abiotic factors have a significant impact on aphid infestation. Due to the requirement for growers to use insecticides periodically, mustard aphids spread quickly, penetrate the ETL barrier, and commonly reach the EIL under favourable climatic circumstances. To establish a relationship between weather variables and aphid population, numerous studies have been conducted. According to their findings, *B. juncea* saw peak aphid activity at the end of January and the first week of March. According to **Bishnoi *et al***. (1992), who conducted a three-year simple linear regression study between the aphid population and the accompanying weather, either the mean temperature or the saturation deficiency significantly contributes to the growth of the aphid population. Rapeseed and mustard crops are grown on 24.2 million ha of land in 53 nations on all six continents, with an average yield of 1451 kg/ha and a range of 411 kg/ha to 6250 kg/ha in Algeria. This results in a total production of 35.1 million tonnes. Insect pests are the main biotic factor limiting mustard output among other biotic variables. The pests of most significance are the Bihar hairy caterpillar, *Spilarctia obliqua* Walker, the painted insect, *Bagrada hilaris* Kirk, The mustard aphid, *Lipaphis erysimi* (Kalt), and the mustard sawfly, *Athalia proxima* Klug.

Generally perceived as health-boosting spice, mustard seeds are indeed very rich in phytonutrients, minerals, vitamins and anti-oxidants. They have a high calories index, 100g of seeds provides 508 calories. The seeds are also exclusively rich in proteins, essential oils, vitamins, minerals and dietary fiber. The seeds are rich in essential oils as well as plant sterols. Mustard seeds are excellent source of essential B-complex such as niacin, thiamin, riboflavin and pyridoxin etc. These seeds also contain flavonoids and carotenoids antioxidants in addition to small quantities of vitamin- A, C, and K. The medicinal uses of mustard seeds and its oil are also well impressive. it helps to relieve muscle pain, rheumatism and arthritic pain (**Chitralekha**, **2018**).

Due to increased sowing by farmers, the country's mustard seed production is expected to climb to 110-115 lakh tons in the current *Rabi* season **(2021-22 crop year**), according to the Central Organization for Oil Industry and Trade (**COOIT**), an apex body of the edible oil industry. According to the data published by Government of India, the area covered by rapeseed and mustard seeds in the ongoing *Rabi* sowing season was 81.66 lakh hectares as of December 10th 2021, compared to 65.97 lakh hectares in the previous year's equivalent period. India is world's fourth-largest producer of oilseeds, with rapeseed and mustard accounting for 28.6 percent of total oilseed production. It is the world's third most prevalent oilseed, after soybean and palm oil. Mustard seeds and mustard oil are used in cooking. Vegetables are made from the young leaves and the oil cake it produces is used to feed livestock.

India produced a total of 109.5 lakh tones of mustard in the year 2021-22. State wise production of rapeseed and mustard in the year 2021 was topped by Rajasthan with 4.1 million tons of production in state which is 44.97 per cent share in total production of the country followed by Madhya Pradesh producing 1.31 million tonnes of rapeseed and mustard and Haryana with 1.28 million tonnes of state mustard produce. Nine oilseeds are the major source of vegetable oil in the country. Among nine major oilseeds soybean (33.5 percent), groundnut (30 percent) and rapeseed & mustard (27 percent), contribute to more than 90 percent of total oilseeds production in the country.

Various obstacles impede mustard production and quality, therefore production of rapeseed mustard is low in India compared to other nations, owing mostly to damage caused by insect pests and diseases, as well as other factors. Just like other crops, mustard is also affected by a variety of insect-pests causing a severe reduction in oil production and its quality. Some of the major pests are: Mustard sawfly (*Athalia lugens proxima* Klug), Mustard aphid (*Lipaphis erysimi* Kalt), Painted bug (*Bagrata cruciferarum* Kirk), Cabbage leaf webber (*Crocidolmia binotalis* Zeller), Flea beetle (*Phyllotreta cruciferae* Goeze), Leaf miner (*Liriomyza brassicae* Riley). Mustard aphid (*Lipaphis erysimi* Kalt.) is one of the important insect-pest, considered as a limiting factor in the cultivation of mustard crop causing 35-96 percent reduction in yield depending upon abiotic factors.

The mustard aphid *Lipaphis erysimi* (Kalt.) (*Homoptera: Aphididae*) is a key pest that attacks the crop from seedling to maturity of crop. Aphids are pearl-shaped, soft-bodied insects with a pair of cornicles (honey tubes) extending from the fifth or sixth abdominal segment. There are four phases of nymphs (instars). Female aphids are wingless and have a yellowish green, grey green, or olive-green body with a white waxy bloom. The abdomen of the winged, female adult aphids is dusky green, with dark lateral stripes dividing the body segments and dusky wing veins. Male aphids range from olive green to brown in color.

Aphid outbreaks usually begin in December and last until March. The favorable temperature is below 20 degrees Celsius. Growth of insects is accelerated by cloudy and cold conditions. In a year, about 45 generations are completed. However, it is too detrimental to crops during the reproductive phase, resulting in yield reductions of 35.4 to 96 per cent in favorable conditions and up to 66.87 per cent oil content. Aphids also secrete honeydew, which is harmful to plants encourage the formation of sooty molds, which turn the stems and leaves black, and photosynthesis is disrupted. The mustard aphid invasion occurs in the field from December to February. Both the nymph and the adult suck the cell sap from the plant's leaves,

flowers, vulnerable stems, and pods, generating economic damage. Yellowing, curling, and ultimately withering of leaves appear as a result of extensive infestation, resulting in fragile pods and little seeds in the pods. The aphids feed on the sap from the leaves, causing the leaves to curl, the plant to fail to grow pods, and the immature pods to fail to mature and yield healthy seeds. Mustard aphids have the potential to rapidly grow their population and spread in a favorable environment in a short period of time. All control measures, with the exception of chemical control, are resource efficient (**Sahoo, 2012**). Chemical insecticides, on the other hand, are toxic not just to natural aphid enemies such as *Diaeretiella rapae*, *Chrysoperla zastrowi* a*Rabi*ca, coccinellids, and syrphid flies, but also to humans, pollinators, pest resurgence, insect resistance development, and residues in oil and cake (**Nagar *et al*., 2012**). As a result, chemical treatment is only used as a last resort to keep the aphid population under control in a limited period of time.

The relation of life cycle and emergence of aphids depends greatly on the environmental conditions viz., temperature, sunlight, humidity, rainfall etc. The peak of aphid population is observed when the temperature is favorable around 23ºC and relative humidity at 54.75 per cent. The aphid population reduces decelerating as the plant reaches to maturity due to unavailability of plant sap. During this time these insects host over *Phalaris minor* weed in the nearby areas.

Lady bird beetle, one of the mustard aphid's bio-agents, is an important predator, since the majority of them, *Coccinella septempunctata*, and Syrphid flies, are predaceous on aphids, coccids, adelgids, and aleyrodids. Predaceous species account for 90% of the known 4200 Coccinellid species (**Iperti and Paoletti, 1999**), with 119 predaceous species found in India. *Micraspis discolour* (Fabricius) is the only one that is indigenous to India (**Agarwal and Ghosh, 1988; Gautam, 1994**). The beetle is considerd sexually dimorphic (**Omkar and Pervez, 2000**), and it feeds on a wide variety of aphid prey, allowing it to effectively manage aphids biologically. The beetle as well as its grub feeds on all the stages of mustard aphid and thus helping in keeping the population under check.

MATERIALS AND METHODS

The investigation was carried out under control conditions at the crop research center at Sardar Vallabhbhai Patel university of agriculture and technology Meerut, U.P. during *Rabi* 2020-21. Meerut which is situated at besides NH-58. The area lies between 29^0 17`N Latitude and 77^0

42`E longitude at an altitude of 237 meter above mean sea level. The total geographical area of Meerut district is 2564 km^2. The city falls under western plain zone of Uttar Pradesh Sub-region of upper Gangetic plains. The climate in this area is subtropical and semi-arid, with hot summers and bitterly cold winters. The mean maximum temperature of this region is about 43 ^oC to 45 ^oC is not uncommon during summer while very low temperature (1-2 ^oC) accompanied by frost may be experienced during December-January and the winter is quite cold Frost usually appears around the end of December and lasts until the beginning of January. The monsoon season typically begins in the third week of June and ends until late September. Some major 1fluctuations were seen due to western disturbances which lead to heavy rainfall in the month of January and February. The monsoon generally begins in the last week of June and ends by the end of September. In this region, the total precipitation and its distribution are around 863 mm. The daily meteorological data pertaining to rainfall, relative humidity and temperature during the experimental period were obtained from meteorological observatory of Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut – 250110 (U.P.).

The maximum temperature was recorded on 44^{th} standard week and minimum temperature was recorded on 4^{th} standard week during experiment time. The highest rainfall was recorded on 2^{nd} standard week which might have disrupted the aphid population. The soil of the experimental field had a sandy loam texture, neutral to saline in reaction, low in organic carbon and available nitrogen, medium available in phosphorus and potash. Agronomic practices such as field preparation planking, and sowing of seeds were done in October in 3 replication and 21 plots each of size 4×3 m^2. The space of 45×15 cm was managed between plants within a row and between two rows. Irrigation was provided 40 days after sowing for better growth and establishment of seedlings. Interculture operations of thinning and weeding were done 35 days after sowing.

OBSERVATION TO BE RECORDED

To study the seasonal abundance of aphids in relation to biotic and abiotic factors, separate experimental plots of mustard of size 4x3 m^2 were conducted at CRC, S. V. P. University of Agriculture and Technology, Meerut in order to record the changes in population of mustard aphid due to biotic and abiotic causes. The crop was raised by following all the recommended agronomic practices except for pest management and the plots were kept completely exposed to natural conditions without any barrier or protection. Ten plants were randomly selected from each plot to take observational data on population dynamics of mustard

aphid and all the prevailing insects. The observation was taken from top 10 cm of the twig from selected plant. The meteorological data were also recorded and evaluated during the entire period of crop beginning from the sowing of seeds to harvesting. A track of all the insects prevailing in the area are recorded before the emergence of aphid. The weather parameters *i.e.*, day and night correlation calculation and regression studies to know the influence of weather parameters on the population of mustard aphid temperature, relative humidity values and rainfall were collected till maturity of the crop.

Table 1: Weekly meteorological data during crop season *Rabi*, 2021-22

S. No.	S W	Date	Meteorological Parameters						
			Temperature (^{0}C)			Relative Humidity (%)			Rainfall (mm)
			Maximum	Minimum	Mean	Morning	Evening	Mean	
1.	44	Nov 1-7	30.06	14.86	**22.46**	72.00	50.14	**61.07**	0.00
2.	45	Nov 8-14	28.73	12.86	**20.80**	76.86	48.00	**62.43**	0.00
3.	46	Nov 15-21	29.01	13.86	**21.44**	76.43	49.71	**63.07**	0.00
4.	47	Nov 22-28	28.11	11.00	**19.56**	80.57	46.86	**63.72**	0.00
5.	48	Nov 29- Dec 5	26.76	9.71	**18.24**	81.57	46.29	**63.93**	0.00
6.	49	Dec 6-12	23.07	11.64	**17.36**	84.29	48.14	**66.22**	0.90
7.	50	Dec 13-19	22.40	9.36	**15.88**	83.43	39.43	**61.43**	0.00
8.	51	Dec 20-26	20.74	7.17	**13.96**	82.43	38.43	**60.43**	0.00
9.	52	Dec 27- Jan 2	20.00	6.49	**13.25**	88.63	49.50	**69.07**	2.50
10.	1	Jan 3-9	20.6	7.5	**14.05**	84.6	61.1	**72.85**	9.9
11.	2	Jan 10-16	17.7	5.3	**11.50**	91.9	80.6	**86.25**	67.5
12.	3	Jan 17-23	16.2	4.7	**10.45**	92.6	71.1	**81.85**	3.7
13.	4	Jan 24-30	16.6	5.3	**10.95**	91.6	67.9	**79.75**	33.9
14.	5	Jan 31- Feb 6	20.1	6.0	**13.05**	88.6	67.0	**77.80**	18.4
15.	6	Feb 7-13	20.5	7.3	**13.90**	85.9	64.1	**75.00**	4.5
16.	7	Feb 14-20	24.3	8.3	**16.30**	82.6	57.4	**70.00**	0.0
17.	8	Feb 21-27	25.9	9.9	**17.90**	82.7	50.3	**66.50**	0.7
18.	9	Feb 28- Mar 6	26.0	10.5	**18.25**	88.6	53.1	**70.85**	31.5
19.	10	Mar 7-13 Mar 6	30.3	13.4	**21.85**	76.0	43.0	**59.50**	0.0

RESULTS AND DISCUSSION

During the entire course of experiment, observations were recorded and inferences were drawn with the help of tabular presentation representing the trends in aphid population due to weather

factors i.e., abiotic factors *viz*., maximum, minimum temperature, relative humidity of morning and evening periods and rainfall and biotic factors such as presence of natural enemies in this case, coccids.

The data presented in table revealed that the aphid population was maximum during 7th standard week between 14-20 February 2022 *i.e.,* 164 aphids per 10 cm apical shoot when the prevailing maximum and minimum temperature was 24°C and 18°C, average humidity was 70 percent and no precipitation was recorded whereas minimum population was observed on 49th standard week *i.e*., between 6th to 12th December when the maximum temperature was 23.07°C and minimum temperature was 11.64°C with relative humidity at 66.22 per cent and 0.90 mm precipitation.

Correlation between aphid and predator was found positively correlated (r = 0.921) which implies that the population of *coccinelids* increased with increasing population of mustard aphids. All the stages of *Coccinella septumpunctata* were seen in the field emerging from 51st standard week upto the crop harvest. These predator grubs as well as adult feed on nymphal instars of mustard aphid colonies vigorously leading to a significant decrease in number of mustard aphids.

The aphids started to appear from 48th standard week onwards. The observations were recorded from 10 randomly selected plants in three large size plots. The mustard aphid population remained active throughout the plant growth period and reached up to a maximum population of 206 aphids per 10 cm of apical shoot. The aphid population started declining as the plant approached maturity and came at low level as 28 aphids per 10 cm of apical shoot. This indicated that availability of succulent plant is essential for aphid infestation. Aphid population started emerging during 49th standard week and started increasing acceleratively reaching ETL level in the 3rd standard week and started fluctuating due to unfavourable environmental conditions. This shows that weather parameters are highly influential on mustard aphid population. On 49th week, the population was found 49 aphids per 10 cm apical shoot. The correlation between aphid population and weather parameters was calculated through correlation coefficient (r) which appears negative non-significant (r = -0.422) for maximum temperature and negative significant (r = -0.533) for minimum temperature. Correlation coefficient between average relative humidity and mustard aphid population was found positive and significant (r = 0.547) and correlation coefficient between aphid population and rainfall it was calculated positive and non-significant (r = 0.223). Additionally, the correlation between aphid population and its predator *coccinellids* was calculated r = 0.921

which indicates that both were positive significantly correlated. These findings are supported by **Dwivedi *et al.*, (2018)** as they too observed that the **270** aphids/10cm shoot in the first week of February and the fourth week of March.

Synchronization in the appearance of mustard aphid predators *Coccinella* spp. and syrphid larvae population was maximum 11.25 beetles/ 10 plants. Correlation studies were conducted between meteorological variables showed that the temperature had major role in increase in aphid population. Positive correlation was observed between the population of aphid and relative humidity. **Rahul *et al.*, (2020)** observed that aphid population appeared in first week of January and attained a peak during 7^{th} standard week when the meteorological parameters as maximum and minimum temperature was 23.8°C and 8.8°C respectively and relative humidity was 85%. **Sreedhar *et al.*, (2021)** explained that mustard aphid appeared during month of January with 0.75 aphids/ top 10 cm apical shoot and these aphids persisted in the field up to March. Correlation studies revealed that mustard aphid population was positively correlated with maximum and minimum temperature and negatively correlated with average relative humidity and positive correlation with rainfall. **Zia *et al.*, (2019)** concluded that mustard aphid appeared naturally from 3^{rd} standard week and lasted up to 11^{th} standard week. His study also revealed that the population of aphids reached its peak in 7^{th} standard week and showed significant positive correlation with maximum temperature and negative correlation with relative humidity.

Conclusions

The present investigation on Biotic and abiotic factors as variables in population build-up of mustard aphid Lipaphis erysimi Kalt. in the western Gangetic planes of India conducted at crop research centre of Sardar Vallabhbhai Patel university of agriculture and technology, Meerut in Rabi season of 2021-22 during which the effect of weather parameters on the population of mustard aphid was recorded and correlation between both was derived through correlation coefficient (r). Relationship between mustard aphid population and predators (Coccinellids) was also recorded the effective correlation coefficient was worked out to know the effect of predator population on aphids. As a statistical conclusion to the experiment, we determined that the correlation coefficient (r), which shows a negative non-significant connection, was used to calculate the relationship between the aphid population and weather conditions. (r = -0.422) for maximum temperature and negative significant (r = -0.533) for minimum temperature. Correlation coefficient between average relative humidity between

mustard aphid was found positive and significant (r = 0.547) and between aphid population and rainfall it was calculated to be positive and non-significant (r = 0.223). Correlation between aphid population and its predator coccinellids was calculated r = 0.921 which indicates that both were positive significantly correlated. Based on the aforementioned results, we can conclude that favourable climate conditions are necessary for aphid growth because they cannot endure extremely high temperatures and humidity levels. Since both the grub and adult stages of coccinellid beetles feed on aphid colonies, the presence of natural enemies like predator coccinellids also helped to control the population's growth.

Table 2: Effect of metreological parameters and predators on aphid population

SW	DATE	No. of aphid/10 cm apical shoot	Population of lady bird beetle	Temprature °C		Average Relative humidity (%)	Rainfall (mm)
				Maximum	Minimum		
44	Nov 1-7	0	0	30.06	14.86	61.07	0.00
45	Nov 8-14	0	0	28.73	12.86	62.43	0.00
46	Nov 15-21	0	0	29.01	13.86	63.07	0.00
47	Nov 22-28	0	0	28.11	11.00	63.72	0.00
48	Nov 29- Dec 5	0	0	26.76	9.71	63.93	0.00
49	Dec 6-12	8.12	0	23.07	11.64	66.22	0.90
50	Dec 13-19	11.34	0	22.40	9.36	61.43	0.00
51	Dec 20-26	26.00	0.27	20.74	7.17	60.43	0.00
52	Dec 27- Jan 2	40.00	0.84	20.00	6.49	69.07	2.50
1	Jan 3-9	27.00	1.35	20.60	7.50	72.85	9.90
2	Jan 10-16	52.00	2.67	17.70	5.30	86.25	67.50
3	Jan 17-23	64.00	2.89	16.20	4.70	81.85	3.70
4	Jan 24-30	86.00	3.07	16.60	5.30	79.75	33.90
5	Jan 31- Feb 6	118.00	3.41	20.10	6.00	77.80	18.40
6	Feb 7-13	135.00	4.12	20.50	7.30	75.00	4.50
7	Feb 14-20	164.00	3.72	24.30	8.30	70.00	0.00

8	Feb 21-27	126.00	2.61	25.90	9.90	66.50	0.70
9	Feb 28- Mar 6	78.00	1.21	26.00	10.50	70.85	31.50
10	Mar 7-13 Mar 6	28.00	0.43	30.30	13.40	59.50	0.00

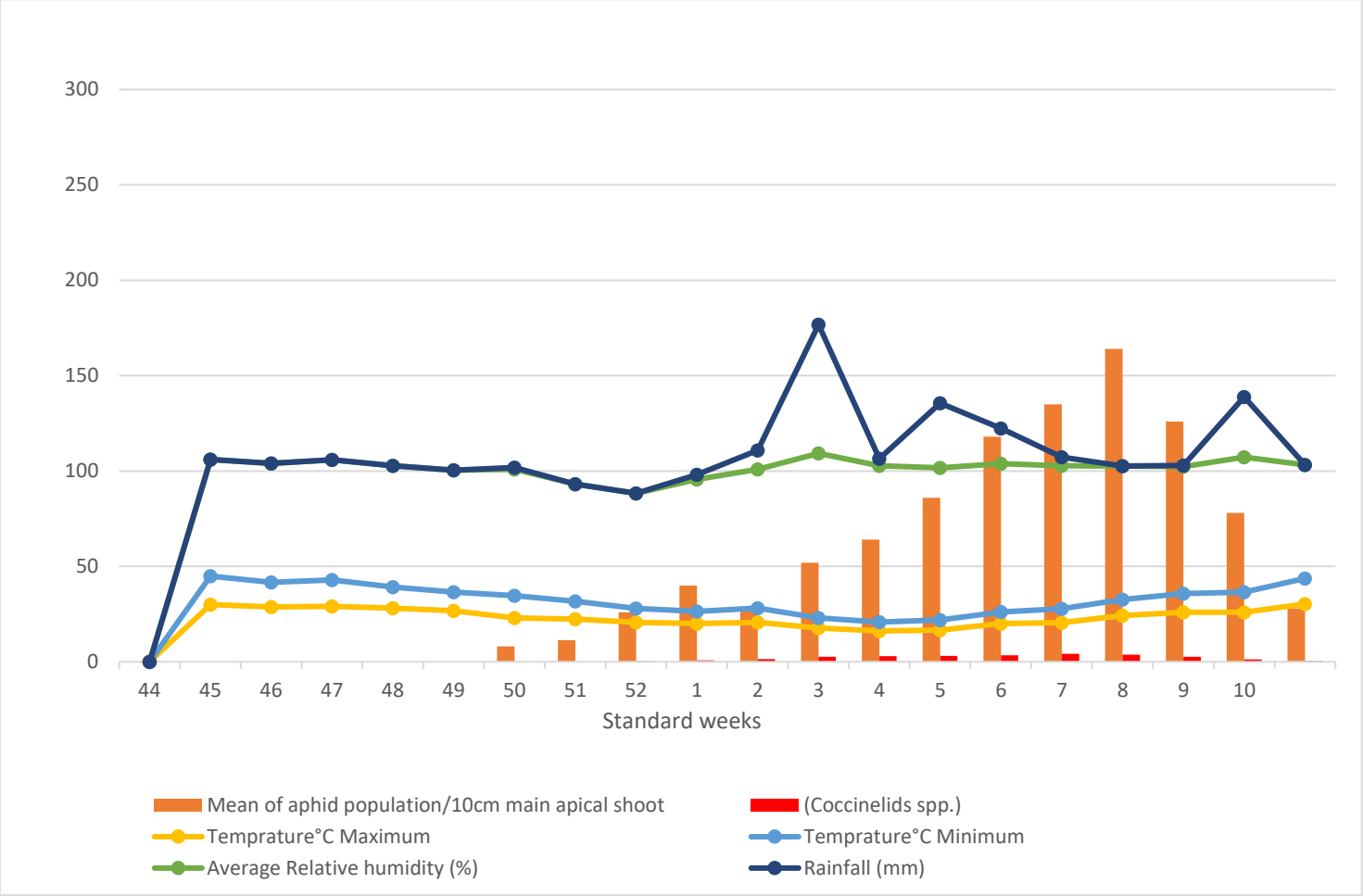

Fig. 1: Effect of biotic (*coccinellids*) and abiotic factors on aphid population growth

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Fig 2: Aphid infested plant of mustard

Fig 3: **Grub of lady bird beetle *Coccinela septumpunctata* feeding on aphids.**

Fig 4: Adult lady bird beetle feeding on aphids.

Fig 5: Control of mustard aphid through natural enemy ladybird beetle.