



E-ISSN: 2278-4136

P-ISSN: 2349-8234

[www.phytojournal.com](http://www.phytojournal.com)

JPP 2021; 10(1): 879-884

Received: 21-10-2020

Accepted: 02-12-2020

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## Population dynamics of mustard aphid (*Lipaphis erysimi*) with relation to some micro-meteorological parameters

**P Debnath and S Pal**DOI: <https://doi.org/10.22271/phyto.2021.v10.i1m.13446>**Abstract**

Mustard variety B9 and B54 were cultivated during *rabi* seasons of 2019-20 at Jaguli instructional farm of Bidhan Chandra Krishi Viswavidyalaya to find out the population dynamics of aphid, *Lipaphis erysimi* with relation to some micrometeorological factors and their infestation level on mustard. The aphid population in the mustard ecosystem showed fluctuation throughout the crop growing period and reached to the peak during mid of February. Among the plant parts inflorescence had significantly higher level of infestation compared to leaf and siliqua. The accumulated growing degree days, air temperature within plant canopy and leaf area index had significant positive correlation with the abundance of aphid population while relative humidity within plant canopy and surface soil moisture had significant negative correlation. The multiple linear regression analysis showed that different microclimatic parameters combinedly contributed 86- 94% variation on the incidence of aphid.

**Keywords:** Aphid, growing degree days, micro-meteorology, mustard, infestation, population dynamics

**Introduction**

India is the third largest producer of oil seeds in the world and accounts for 19% of world's area and 9% of the global production (Sinha, 2003) [26]. Rapeseed and mustard (*Brassica* sp.) are the second most important oil seed crop in the country after groundnut. In India rapeseed and mustard are cultivated in an area of 56 lakh ha with a production of 66 lakh tonnes and with an average yield of 1182 kg/ha (DACNET, 2009-10) [7]. However, this productivity of mustard is comparatively low as compared to other countries. Among the various factors which are responsible for reducing the yield of mustard, insect pests attack are the major ones. Mustard aphid, *Lipaphis erysimi* (Kalt) (Homoptera: Aphididae) is the most serious pest of this crop and is considered to be the limiting factor in the successful cultivation of mustard causing 35 to 73 percent reduction in yield (Rohilla *et al.*, 1987) [21]. It is therefore, essential to keep this pest under control for getting profitable harvest. Mustard aphid is a cosmopolitan insect and found on both of the leaf surfaces and in leaf folds of developing heads, on inflorescence and on silica (Nelson and Rosenheim, 2006) [19]. Nymph and adult aphids suck saps from leaf, stem, inflorescence and pod and as a result the infested plant shows stunted growth, curled and mottled leaves, withered flower and deformed pod (Begum, 1995) [3]. In nature the distribution and abundance of living organisms determined by combine effect of different components of ecosystem (Sinha *et al.*, 1989) [25]. Several studies have indicated that weather factors and plant microclimatic factors like within canopy air temperature and relative humidity, surface soil moisture plays an important role on appearance and multiplication of aphid (Kumar *et al.*, 1999 and Adak *et al.*, 2012) [14, 1]. Daily accumulated temperature in relation to aphid population has been studied by many researchers (Khan and Jha, 2010) [13]. Aphid population depends on the growth of the crops and it was found that growths of the crop are linearly related with growing degree days (Rao *et al.*, 2013) [20]. A number of studies have investigated the effect of microclimate on survival and development rate of aphid population mostly in relation to temperature accumulation only under controlled conditions but not in field conditions. Therefore, to ensure an effective and economical management of this pest the current study focuses on the effect of the plant microclimate viz, within canopy air temperature and humidity, surface soil moisture, accumulated growing degree days (AGDD), humid thermal ratio (HTR) and leaf area index (LAI) on incidence of aphid population.

**Materials and methods**

The research was carried out at Jaguli instructional farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia during *Rabi*, 2019-20 crop season.

The land was well prepared by ploughing followed by laddering and fertilizer application as per the recommended dose (N:P:K – 100:50:50) was done to ensure proper growth of mustard. The soil of the experimental site was sandy loam to loam in texture with pH (6.8 – 6.9). Two cultivars of *Brassica napus* viz. B54 and *Brassica campestris* viz. B9 were sown on 25<sup>th</sup> November following randomized block design (RBD) with three replications having plot size of 3 x 3 m and spacing between row to row and plant to plant as 30cm and 10cm, respectively. All the recommended agronomic practices and intercultural operations like gap filling, thinning and hand weeding were adopted. No insecticides were sprayed in the plot. The plants kept under surveillance for the incidence of the mustard aphid from three weeks after germination and continues till harvesting. The appearance of the aphid and its subsequent development was recorded from top 10 cm twigs on 10 plants in each replication at weekly interval and were averaged to get the mean value. During inspection, the total number of leaves, inflorescence and siliqua as well as the number of infested leaves, inflorescence and siliqua of the plants were counted and percent infestations were calculated. Air temperature and relative humidity within crop canopy were measured with the help of a digital pocket weather tracker at different crop heights (0 cm, 30 cm, 60 cm, 90 cm and top of canopy) at around 2.00 pm (i.e., time of occurrence of daily maximum temperature). Surface soil moisture was taken with the help of a digital moisture meter at morning and evening time and then averaged. The daily weather parameters viz. temperature (maximum and minimum), relative humidity (maximum and minimum) were collected from AICRP on Agro-meteorology, Directorate of Research, BCKV. From the meteorological parameters some derived meteorological parameters viz. accumulated growing degree days (AGDD) and humid thermal ratio (HTR) were calculated which affect the crop and pest population growth. Gowning degree days (GDD) was calculated by considering base temperature as 5.0 °C following Chakravarty and Sastry (1983) [5]. Growing degree days (GDD) were accumulated from the date of sowing to each phenological stage for estimating AGDD.

$$AGDD = \sum(T_{Max} + T_{Min})/2 - T_{base}$$

Where, Humidity Thermal Ratio (HTR) is calculated by dividing mean relative humidity and mean temperature.

$$HTR = Rh_{mean} / Temp_{mean}$$

The records on bio-physical trait i.e., leaf area index (LAI) was calculated in each phenological stage by using the formula given by Watson (1947) [30].

$$LAI = \text{Leaf area} / \text{land area}$$

For the data analysis arithmetic means of all the weekly observations on the intensity *L. erysimi* were calculated which were further transformed into square root values. The mean infestation level on leaf, inflorescence and siliqua were analyzed by analysis of variance and followed by Tukey HSD posthoc test. The simple correlation coefficient was worked out between the abiotic factors and the aphid population. The multiple regression analysis was carried out to develop a functional relationship between the microclimatic parameters and the aphid population. The statistical analyses were

performed by using Microsoft excel 2010 and IBM SPSS 20.0 software.

## Results and Discussion

**Population dynamics of mustard aphid:** The first appearance of *L. erysimi* was noticed in field on 3<sup>rd</sup> standard meteorological week (SMW) i.e. 15<sup>th</sup> January in B9 while in B54 the pest was noticed from 4<sup>th</sup> SMW i.e. 22<sup>th</sup> January (Table1, Table2, Figure1 and Figure 2) with its initial intensity of 7.33 aphids/ top 10 cm twig/plant and 9.98 aphids/ top 10 cm twig/plant respectively. The intensity of aphid increased in ensuing weeks and reached its peak during mid of February at this time the crop was in silica formation stage. The highest mean abundance of aphid in variety B9 was noticed on 12<sup>th</sup> February with 65.03 aphids/ top 10 cm twig/plant when accumulated growing degree days (GDD) was 994.05, humid thermal ratio (HTR) was 4.64, plant canopy temperature was 21.84°C, plant canopy humidity was 54.15%, soil surface moisture content was 58.21%, leaf area index was 2.63. While in B54 the highest population level was observed on 19<sup>th</sup> February with 87.67 aphids/ top 10 cm twig/plant when accumulated growing degree days (GDD) was 1107.35, humid thermal ratio (HTR) was 4.04, plant canopy temperature was 24.17 °C, plant canopy humidity was 50.15%, soil surface moisture content was 50.72%, leaf area index was 1.52. After 2<sup>nd</sup> - 3<sup>rd</sup> week of February the aphid population drastically reduced when pods started to mature and the pest population may not get sufficient amount of food to sustain their life. The aphid population showed significant variations during different crop growth stages and their infestation on different plants parts of mustard crop also differed. The mean infestation level of leaf, inflorescence and siliqua ranged from 7.85 to 33.8% in B9 (Figure 3) while it ranged from 11.2 to 38.1% in B54 (Figure 4) in overall crop growing period. Among the plant parts, inflorescence revealed significantly higher level of infestation compared to leaf and siliqua.

The present findings are in agreement with Das *et al.*, 2019 [8] who found the activity of mustard aphid population of late sown crop in between 1<sup>st</sup> to 8<sup>th</sup> SMW. Analogously Shahoo (2012) observed the appearance of mustard aphid from last week of December and 1<sup>st</sup> week of January in the year 2009-10 and 2011-12 respectively. According to Uttam *et al.*, 1993 [29] the mustard aphid population reached at peak in mid of February. The results of the present study got ample support from the findings Basiva *et al.* (2018) [2] who observed that, the mustard aphid infestation started from flowering stage and remain up to maturity of crop. Analogously, Hasan and Singh 2010 [12] and Goyal *et al.*, 2017 [10] noticed the flowering stage of mustard are the most vulnerable stage for *L. Erysimi* infestation. According to Kundu and Pant (1968) [16] both flowering and pod initiation stages are mostly favoured by the aphids. The present findings are in tune with the reports of Mandal *et al.*, 2018 [17] who found Inflorescence had significantly higher level of aphid infestation compared to mustard siliqua and leaf. The results of the current study are in line with the findings of Tharranum *et al.*, 2017 [27] who found the aphid population increased exponentially with increase in GDD. Chakravarty and Gautam, 2002 [4] clearly indicates that development stages of the aphids can be effectively expressed as a temperature sum or degree-day. According to Rao *et al.*, 2013 [20] AGDD required for initial and peak appearance of aphid is 839 and 1382 respectively at Mohanpur, West Bengal. According to Goyal *et al.*, 2017 [10] the aphid population are highly sensitive to the microclimatic

condition (temperature and relative humidity) within plant canopy. Similarly Narjary *et al.* 2013<sup>[18]</sup> reported the appearance of aphid in mustard depends on crop phenology and prevailing weather parameters within crop canopy. The findings can be compared with Gundappa *et al.*, 2016<sup>[11, 23]</sup> who clearly indicates that HTR is a useful tool for understanding the population dynamics of sucking pest viz. thrips in mango. These findings are in tune with the reports of Dhaliwal 2002<sup>[9]</sup> who found mustard aphid population reached their peak when HTR value was between 3 to 4 however, Tharrnum *et al.*, reported aphid population occur in HTR value of 1.5 - 4 range in different agroclimatic zones. The findings can be partially compared with the findings of Chang *et al.*, 2008<sup>[6]</sup> who noticed atmospheric relative humidity and soil moisture content can change water balance of insect's body which affects individual's development and population occurrence.

**Correlation between mustard aphid and micro-meteorological parameters:** To know the association between aphid population and different microclimatic parameters correlation was worked out and presented in Table 3. The results revealed that air temperature within plant canopy ( $r = 0.615$  and  $r = 0.745$  for variety B9 and B54 respectively) and growing degree days ( $r = 0.659$  and  $r = 0.614$  for variety B9 and B54 respectively) had significant positive correlation with the incidence of aphid population while, humid thermal ratio had non-significant positive correlation. Relative humidity percentage within plant canopy ( $r = -0.710$  and  $r = -0.635$  for variety B9 and B54 respectively) and surface soil moisture percentage ( $r = -0.846$  and  $r = -0.724$  for variety B9 and B54 respectively) showed significant negative correlation with aphid population. Seasonal incidence of aphid population is highly correlated with the leaf area index with the value of correlation coefficient  $r = 0.961$  and  $r = 0.924$  for variety B9 and B54 respectively. The influence of plant canopy temperature, growing degree days, humid thermal ratio, relative humidity

percentage within plant canopy, surface soil moisture percentage and leaf area index on aphid population was worked out through multiple regression analysis (Table 4 and 5). From the regression analysis it was observed that the combined effect of these micro-meteorological parameters had the most influence on aphid population. Which contributed 86% and 94% variation in aphid population in variety B54 and B9 respectively.

The findings of the present experiment can be compared with the findings of Gundappa *et al.* (2016)<sup>[11, 23]</sup> who reported that thrips infestation in mango are closely related ( $R^2 = 0.94$ ) to humid thermal ratio. Similarly, Roy (2003)<sup>[22]</sup> and Narjary *et al.*, 2013<sup>[18]</sup> found mustard aphid population are positively correlated with humid thermal ratio. In anethetical to this study Dhaliwal (2002)<sup>[9]</sup> reported that with increasing HTR the peak aphid population decreased. The results obtained in the present investigation in relation to aphid population and GDD are support the findings of Tharrnum *et al.*, 2017<sup>[27]</sup> who observed GDD as a common variable influencing aphid population, whose correlation coefficients ranged between 0.795 to 0.982 in different brassica varieties. However, Das *et al.*, 2019<sup>[8]</sup> observed GDD had significant negative correlation with the aphid population in mustard. The results in relation to leaf area index (LAI) and aphid population are falling in the line of Kumar *et al.*, 2012<sup>[15]</sup> who found there is a significant and positive correlation between aphid infestation and LAI and if severe aphid infestation occur then LAI may be reduced up to 67 - 94%. The result of the present investigation are more or less in conformity with Shidi *et al.*, 2019<sup>[24]</sup> who found that the infestation of *O. lybicus* are negatively correlated with humidity in date palm plantation and relationship of *O. lybicus* infestation with humidity was greater than that for temperature at the same time. While, Goyal *et al.*, 2017<sup>[10]</sup> observed that aphid population was negatively correlated with mean profile temperature and positively correlated with mean profile relative humidity in mustard.

**Table 1:** Population build up of *L. erysimi* on Brassica species B9

SMW	Date of observation	No. of Aphids* /top 10 cm twig/plant	GDD	HTR	Plant canopy temp (°C)	Plant canopy Humidity (%)	Surface soil moisture (%)	LAI
51	17.12.19	0.0 (0.10)**	284.95	3.13	21.15	64.13	64.28	0.24
52	24.12.19	0.0 (0.10)	362.05	5.20	18.31	66.04	70.26	0.32
1	01.01.20	0.0 (0.10)	451.13	4.75	18.58	68.21	69.14	0.48
2	08.01.20	0.0 (0.10)	534.20	3.02	18.83	78.20	68.36	0.62
3	15.01.20	7.33 (2.64)	653.03	3.79	19.03	60.34	64.35	0.85
4	22.01.20	12.07 (3.47)	720.14	4.17	21.32	56.17	62.51	1.24
5	29.01.20	17.34 (4.16)	807.95	3.91	20.26	55.08	60.25	1.72
6	05.02.20	35.02 (5.91)	900.50	4.32	20.31	58.42	56.43	2.01
7	12.02.20	65.03 (8.06)	994.05	4.64	21.84	54.15	58.21	2.63
8	19.02.20	53.66 (7.32)	1107.35	4.04	23.52	52.04	54.32	2.01
9	26.02.20	28.6 (5.35)	1227.45	3.68	23.17	62.47	57.39	1.48
10	05.03.20	15.3 (3.92)	1374.80	3.54	23.72	56.21	56.35	1.26
11	12.03.20	8.01 (2.83)	1509.55	3.14	24	53.03	56.12	1.13

\*Mean of three replications \*\*figures in parenthesis are square root transformed values

**Table 2:** Population build up of *L. erysimi* on Brassica species B54

SMW	Date of observation	No. of Aphids* /top 10 cm twig/plant	GDD	HTR	Plant canopy temp (°C)	Plant canopy Humidity (%)	Surface soil moisture (%)	LAI
51	17.12.19	0.0 (0.10)**	284.95	3.13	20.24	65.17	58.32	0.15
52	24.12.19	0.0 (0.10)	362.05	5.20	18.42	68.02	65.18	0.23
1	01.01.20	0.0 (0.10)	451.00	4.75	17.38	67.25	76.15	0.31
2	08.01.20	0.0 (0.10)	534.2	3.02	17.52	75.13	63.49	0.46
3	15.01.20	0.0 (0.10)	653.13	3.79	20.04	58.35	67.25	0.63
4	22.01.20	9.98 (3.15)	720.08	4.17	19.32	54.04	65.63	0.95

5	29.01.20	14.34 (3.78)	807.95	3.91	20.23	53.16	62.34	1.32
6	05.02.20	43.31 (6.59)	900.50	4.32	22.31	56.45	59.02	1.68
7	12.02.20	84.30 (9.18)	994.05	4.64	23.43	53.04	54.64	2.14
8	19.02.20	87.67 (9.36)	1107.35	4.04	24.17	50.15	50.72	1.52
9	26.02.20	30.32 (5.50)	1227.45	3.68	23.53	61.28	57.75	1.24
10	05.03.20	14.56 (3.83)	1374.80	3.54	24.32	55.13	55.24	0.98
11	12.03.20	8.74 (2.83)	1509.55	3.14	24.89	52.09	55.02	0.84

**Table 3:** The correlation between aphid population and abiotic factors

Variety	GDD	HTR	plant canopy temp	Plant canopy humidity	soil RH	LAI
B9	0.659*	0.162	0.615*	- 0.710*	- 0.846**	0.961**
B54	0.614*	0.176	0.745*	- 0.635*	- 0.724*	0.924**

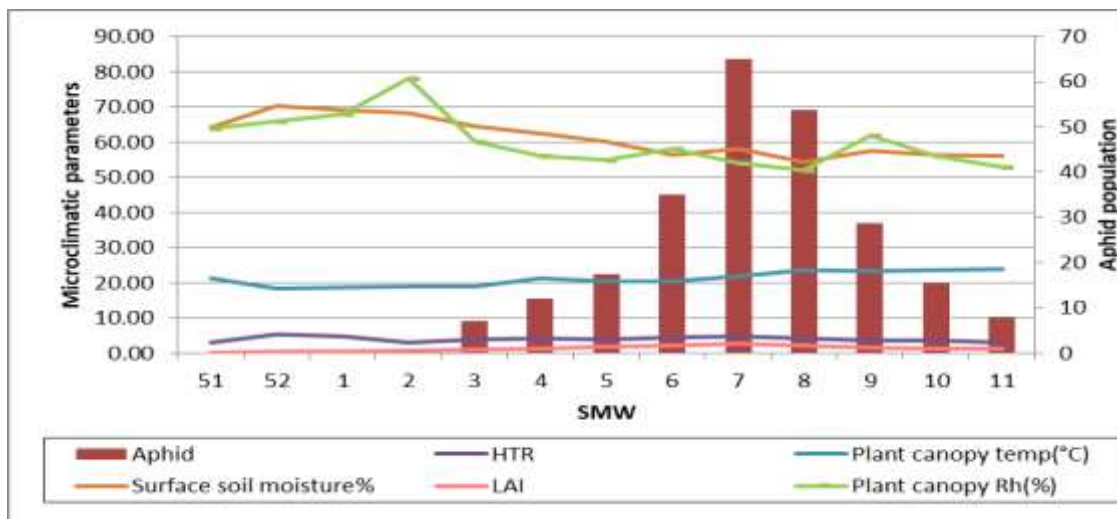
\*significant at 5% level \*\*significant at 1% level

**Table 4:** The linear multiple regression analysis between *L. erysimi* population and abiotic factors

Variety	Multiple Regression	GDD (x <sub>1</sub> )	HTR (x <sub>2</sub> )	Plant canopy temp (°C) (x <sub>3</sub> )	Plant canopy Humidity% (x <sub>4</sub> )	Surface soil Moisture% (x <sub>5</sub> )	LAI (x <sub>6</sub> )
B9	Coefficient	-0.02	0.46	0.49	-0.28	-0.08	3.36
	Standard error	0.01	1.37	0.55	0.62	0.16	0.51
	T value	-0.79	0.33	0.87	-1.24	-0.52	1.55
	F value	22.03					
	R <sup>2</sup>	0.94					
	Regression equation	Y= - 6.61- 0.02 X <sub>1</sub> + 0.46 X <sub>2</sub> + 0.49X <sub>3</sub> - 0.28X <sub>4</sub> - 0.08 X <sub>5</sub> +3.36X <sub>6</sub>					

**Table 5:** The linear multiple regression analysis between *L. erysimi* population and abiotic factors

Variety	Multiple Regression	GDD (x <sub>1</sub> )	HTR (x <sub>2</sub> )	Plant canopy temp (°C) (x <sub>3</sub> )	Plant canopy Humidity% (x <sub>4</sub> )	Surface soil Moisture% (x <sub>5</sub> )	LAI (x <sub>6</sub> )
B54	Coefficient	-0.05	0.32	0.56	- 0.12	-0.04	4.68
	Standard error	0.01	0.98	0.68	0.35	0.11	0.79
	T value	-0.92	0.31	0.95	- 0.72	-0.69	5.44
	F value	16.46					
	R <sup>2</sup>	0.86					
	Regression equation	Y= - 6.32 - 0.05 X <sub>1</sub> + 0.32 X <sub>2</sub> + 0.56X <sub>3</sub> - 0.12X <sub>4</sub> - 0.04 X <sub>5</sub> +4.68X <sub>6</sub>					



**Fig 1:** Aphid population dynamics with relation to different microclimatic parameters in variety B9



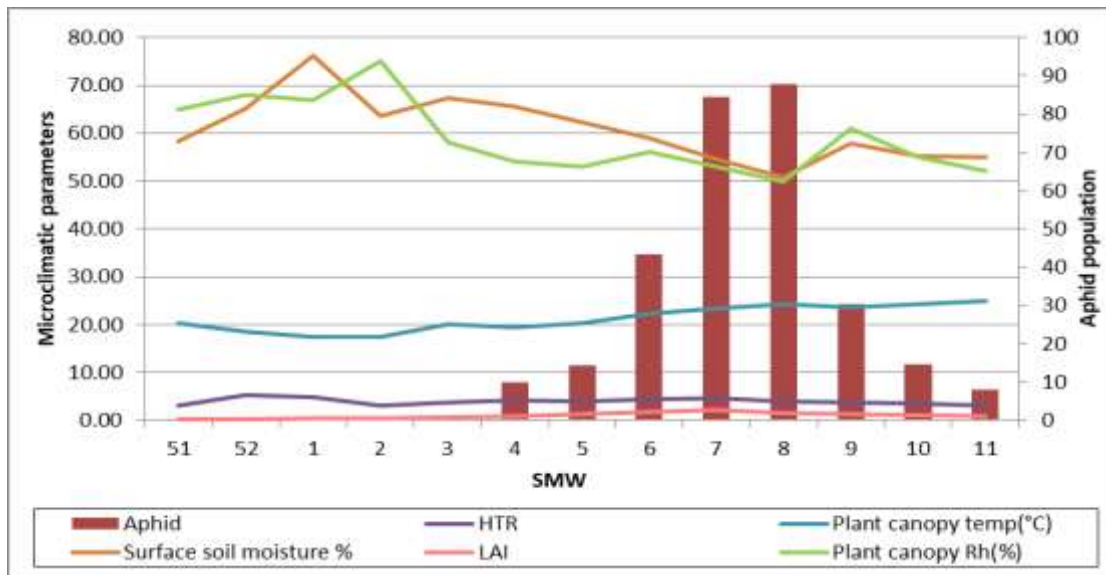


Fig 2: Aphid population dynamics with relation to different microclimatic parameters in variety B54

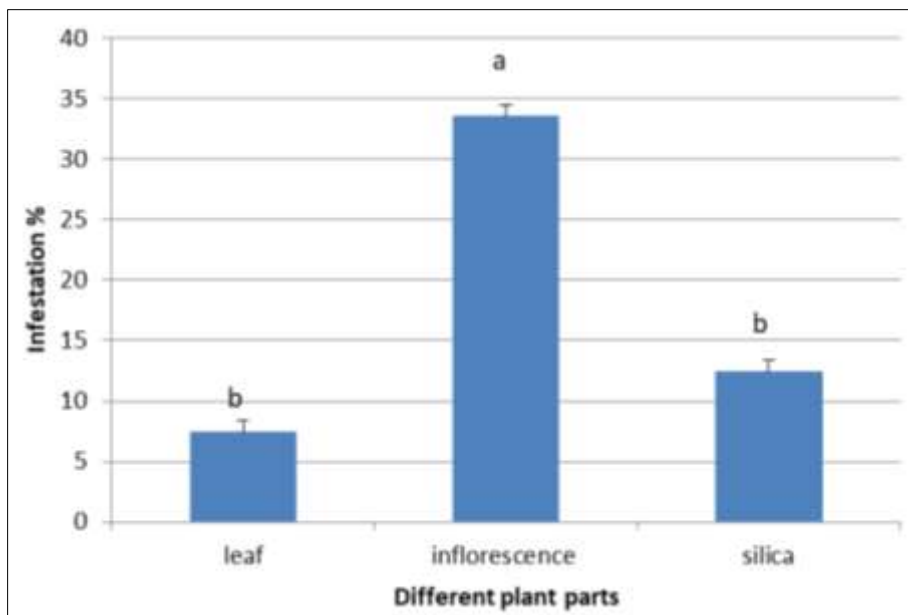


Fig 3: Mean infestation level (% mean ± SE) on different plant parts of B9 in overall crop growing period. Bars with same alphabets do not differed significantly ( $p \leq 0.05$ ) by Tukey HSD posthoc test.

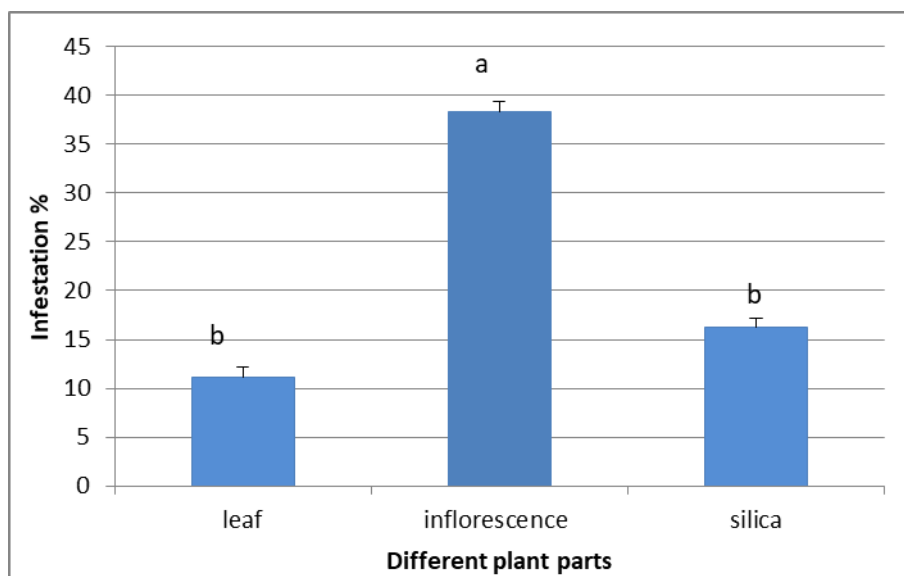


Fig 4: Mean infestation level (% mean ± SE) on different plant parts of B54 in overall crop growing period. Bars with same alphabets do not differed significantly ( $p \leq 0.05$ ) by Tukey HSD posthoc test.

## Conclusion

It can be concluded from this study that plant microclimatic parameters play a key role in build-up of aphid population. Seasonal incidence of aphids on mustard seems to be largely depended upon the temperature and humidity variation of that particular location. The dynamicity of the regression models attributed to 86-94% variation in aphid population and makes it more adjustable to the changing climate scenario. The study would be helpful to challenge the pest by manipulating the cultural practices of cultivation like planting or harvesting time adjustment, varieties selection, timely application of insecticides etc.

## Acknowledgements

The authors would like to thank all of the teaching and non-teaching staffs of the Agricultural Entomology department of BCKV for their co-operation and assistance during the period of investigation.

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