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Seasonal incidence of major insect pests and predators of mustard in lower gangetic plains of West Bengal

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Abstract
The present investigation was carried out during *rabi*, 2019-20 at Jaguli instructional farm of Bidhan Chandra Krishi Viswavidyalaya by using four varieties (ADV414, Bulet, TBM 204 and ADV 406) of rapeseed-mustard. Altogether two insects viz., mustard aphid (*Lipaphis erysimi*) and sawfly (*Athalia lugens proxima*) cause most of the damages at different crop growth stages. In the middle of January maximum intensity of sawfly was observed when the crop was flower bud formation stage. Maximum aphid population was noticed during 2nd week of February at silica formation stage of the crop irrespective of the varieties. The aphid population was very strongly correlated with the incidence of coccinellid population. The correlation study between sawfly population and weather parameters revealed that maximum and minimum temperature had significant negative correlation with the pest population. Among the weather parameters minimum relative humidity showed significant negative correlation with the aphid and coccinellid population. Regression studies indicated that temperature and relative humidity were the most influencing factors over the incidence of sawfly and aphid population respectively.

Keywords: Mustard aphid, coccinellid, population dynamics, abiotic factors, seasonal incidence

Introduction

The rape seed, *Brassica napus* L. and mustard, *Brassica juncea* (L.) Czern. belong to the family Brassicaceae, are the major oil seed crops of different agro-climatic zones in India mainly cultivated during *rabi* seasons. The oil content in mustard ranged from 36 to 42 percentage [1]. It also contains two essential fatty acid viz. linoleic and linolenic acid and lowest amount of saturated fatty acid which is harmful for us. India produces 7.67 million tons of rapeseed and mustard from an acreage of 6.51 million hectare and with a productivity of 1179 kg/ha [2]. The vegetable oil consumption in India is rising continuously due to improvement in living standards and increased purchasing power. Therefore, every effort is being made to raise yield of this crop by adopting modern crop production and protection practices. Insect pest infestation is one of the major causes of lower productivity of mustard. About 38 species of insect pests are reported from the Brassica oilseed crops [3]. Out of which mustard aphid, *Lipaphis erysimi* and sawfly, *Athalia lugens proxima* are considered as the most damaging pests in West Bengal condition. Mustard aphid is one of the major limiting factors for successful cultivation of mustard causing 35 to 73 per cent reduction in yield [4]. Both nymph and adult stages of this pest cause quantitative and qualitative losses in the mustard crop by sucking the cell sap from leaves, petioles, tender stems, inflorescence and the pest also secretes the honeydew which provides suitable medium for the development of sooty mould [3]. Due to fast multiplication within few days aphid covers the entire crop particularly in cloudy weather. On the other hand, the non-agile nature and colonial feeding behavior of aphid species makes them vulnerable to a number of predators like coccinellid, syrphid etc. In case of Sawfly, Larvae alone are destructive which generally prefer to feed the young leaves stared from margin of leaves and slowly skeletonizing them [5]. Numbers of chemical insecticides were used to control the pest population but these are found to be more or less toxic to various predators, parasitoids and pollinators [6]. Therefore, it is necessary to use the ecological approach of pest management which suggests using different cultural and biological practices. It is well known that attack of insect pests depends upon climatic conditions, crop growth stage and presence of natural enemies at a particular time. Under suitable climatic conditions, mustard aphids spread very rapidly and cross ETL boundary.

Hence, keeping in mind the above facts the current experiment was conducted to study the population dynamics of major pest and predators associated with mustard.

Materials and methods

The field experiment was carried out at the Jaguli instructional farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia during *rabi* seasons of 2019-20. The four different cultivars of rapeseed-mustard (ADV414, Bulet, TBM 204 and ADV 406) were sown on 25th November in 3×3 m^2 plots at a spacing of 30 ×10 cm in Randomized Block Design (RBD) with five replications. Manures and fertilizers were applied as per recommended doses and intercultural operations like thinning and weeding were done at proper time. No plant protection measure was taken throughout the crop period. Weekly visual observations were taken from three weeks after sowing (WAS) and continued up to harvesting of the crop to study the population dynamics of pest and predator. To find out the incidence of pest population ten plants were randomly selected from each plot and tagged them. Larval population of sawfly present on tagged plant was counted. In case of aphid the nymph and adult occurred on 10 cm shoot tip of the sampled plants were separated with the help of a fine brush and kept on a white paper and then counted manually. The number of adult and grubs of coccinellid beetles present on the tagged plants was also counted and consolidated population of four different coccinellid species was recorded. Finally, average population of pest and predator per plant was worked out. Meteorological parameters such as maximum and minimum temperature, relative humidity, wind speed and sunshine hour that prevailed during the field experiment were collected from Department of Agro-meteorology, Directorate of Research, BCKV. The data recorded on the intensity of pest and predators in mustard ecosystem were statistically analyzed and then correlation and multiple step wise linear regression were worked out between the mean pest and predator population with weekly mean of above-mentioned meteorological parameters. All the data were analyzed by using the software IBM SPSS20.0.

Results and Discussions

Population dynamics of mustard aphid *L. erysimi* (Kalt.) (Hemiptera-Aphididae): Seasonal incidence of mustard aphid in four different varieties of rapeseed-mustard during *rabi* seasons of 2019-2020 was presented in Table 1 and Figure1. The data indicates that the pest population commenced its activity from 2nd standard meteorological week (SMW) in varieties ADV414, TBM 204, ADV 406 at flower bud initiation stage of the crop. However, in Bulet variety it was observed on 3rd SMW. In initial level the number the number of aphid population varies from 0.85-3.26 aphids/ top 10 cm twig/plant in different germplasms. The population increased gradually with the increase of temperature and reached to its peak on 7th SMW i.e., second week of February at silica formation stage of the crop when maximum temperature was 26.56^{0}C, minimum temperature 11.96^{0}C, maximum RH 89.14%, minimum RH 47.14%, wind speed 0.17 km/hour and sunshine hour 6.16 hours. Maximum infestation was observed in variety ADV 406 (73.38 aphids/ top 10 cm twig/plant) and it was followed by ADV 414 (65.27 aphids/ top 10 cm twig/plant) TBM 204 (58.21 aphids/ top 10 cm twig/plant) and Bulet (43.49 aphids/ top 10 cm twig/plant). Infestation in Bulet variety was comparatively lower may be due to late flowering. Thereafter, the pest population showed declining trend as crop progressed to maturity and temperature became increased day by day. The results of the present study are at par with the results of Singh and Lal (2012) [7] who reported that appearance of mustard aphid population started from 2nd week of January and reached its peak during 8th SMW. Similarly, Ansari *et al*. (2007) [8] observed that the appearance of aphid on brassica germplasms occurred on 11th January at flowering stage of the crop and disappeared after 2nd March. Antithetical to present study, Pradhan *et al.* (2020) [9] reported that incidence of mustard aphid started during 51 SMW and reached its peak level in 5th SMW and 8th SMW. While Lal *et al*. (2018) [10] reported that aphid population was most abundant during 4th week of January when the maximum and minimum temperature were 31.1^{0}C and 10.3^{0}C respectively. The present study supports the findings of Kundu and Pant (1968) [11] who reported that aphid damage at pre flowering stage was significantly lower than that of flowering and pod formation stages. The observations on seasonal incidence of mustard aphid are to some extent in conformity with the findings of Choudhury and Pal (2009) [12] and Bhati *et al*. (2015) [13] who reported that aphid population multiplied during January-February and reached at the peak around mid-February. The present findings are in partially agreement with Thakur (1976) [14] who observed that the temperature above 28.8^{0}C and average relative humidity below 62.2 percent adversely affect on aphid multiplication.

Population dynamics of mustard sawfly *A. lugens proxima* (klug) (Hymenoptera-Tenthridinidae): The data presented in Table1 and Figure2 indicated that the sawfly population was fluctuating throughout the season. First appearance of sawfly was recorded in 52nd standard week i.e. on 24th December with its initial intensity of 0.16, 0.06, 0.07 and 0.10 larvae /plant on mustard varieties of ADV414, Bulet, TBM 204, ADV 406 respectively. The intensity of sawfly population increased in ensuring weeks and continued up to 3rd SMW, thereafter, it started to decline and became zero after 8th SMW. In the middle of January maximum intensity of sawfly was observed with 3.26, 1.48, 2.54 and 1.75 larvae/plant on varieties ADV414, Bulet, TBM 204, ADV 406 respectively when maximum temperature was 22.57^{0}C, minimum temperature 10.51^{0}C, maximum RH 93.71%, minimum RH 59.86%, wind speed 0.20 km/hour and sunshine hour 6.14 hours. At that time the crop was in flower bud formation stage. The incidence of mustard sawfly on Bulet variety was recorded in very low number throughout the crop growing period. The present findings are in accordance with Pal *et al*. (2018) [15] who recorded mustard sawfly population at early stage of the crop and the peak population at flower initiation stage. The results in relation to seasonal incidence of sawfly population are more or less falling in the line of Srivastava and Srivastava (1972) [16] who observed that maximum incidence of mustard sawfly in cold wave weather conditions during 50th to 52nd standard week with 22 to 26^{o}C temperature and 62 to 82 percent relative humidity. However, Manzar *et al*. (1999) [17] observed that the peak population of *Athalia lugens proxima* during the 49th standard week.

Population dynamics of Coccinellids: During investigation, four different species of coccinellid beetles viz. *Coccinella septempunctata, C. transversalis*, *Micraspis discolor* and *Menochilus sexmaculatus* were noticed in the field. The

Coccinella beetle was first recorded in the 3rd SMW (15th January) in variety ADV 414, TBM 204 and ADV4061 with the population of 0.23 beetles/plant, 0.03 beetles/plant and 1.17 beetles/plant respectively. However, in variety Bulet the predator was first observed on 29th January (0.41 beetles/plant) may be due to late appearance of its prey. Coccinellid population reached at its peak during 7th SMW (12th February) and thereafter, declined suddenly with decreasing of aphid population. Highest predator population was observed in variety ADV406 followed by ADV 414, TBM 204 and Bulet. The present findings support the findings of Sinha *et al.* (1982) [18] who reported that Coccinellid predators have proven their worth during the peak aphid incidence period i.e., mid-February. According to Singh *et al.* (2018) [19] *C. septempunctata* a potential predator of *L. erysimi*, that was first observed during 1st week of December and increased gradually with the increasing aphid population which is similar with our finding. The results are in accordance with Rahman *et al.* (1991) [20] who reported that maximum population of the coccinellid beetles attained at flowering stage. While, Hossain *et al.* (2001) [21] reported the population abundance of different coccinellids in the aphid infested crop fields during November to March.

Impact of abiotic factors on the intensity various pest and predators

Influence of weather parameters on mustard aphid: Simple correlation was worked out (Table 2) between the weather parameters and aphid population in order to study the impact of different abiotic factors on aphid population. The pest population exhibited significant negative correlation with minimum relative humidity in all varieties but for maximum relative humidity it shows non-significant negative correlation in varieties ADV 414 (r = - 0.426) and Bulet (r = -0.480) whereas, significant negative correlation in varieties TBM 204 (r = - 0.525) and ADV406 (r = -0.626). Maximum temperature showed positive non-significant correlation with the pest population however, minimum temperature showed negative non-significant correlation though it was very weak (r = -0.162, r = -0.199, r = -0.222, r = -0.067 for varieties ADV414, Bulet, TBM 204 and ADV 406 respectively). Bright sun shine hour also showed positive correlation with the intensity of aphid population but it was significant on varieties TBM 204 (r = 0.565) and ADV406 (r = 0.531) but non-significant on ADV414 (r = 0.416) and Bulet (r = 0.481). The impact of wind speed on intensity of aphid was not very much prominent, as the correlation coefficient values ranged from 0.137 to 0.188 in different varieties. Thus, it can be stated that increasing temperature and decreasing humidity are responsible for escalation of aphid population. These results are in accordance with the findings of Kumar *et al.* (2000) [22] and Varmora *et al.* (2009) [23] who reported that the aphid population was positively governed by temperature whereas, relative humidity had shown negative effect. Similarly, Singh and Malik (1988) [24] found that increase in temperature was significantly conducive for aphid multiplication but RH has shown negative response. The result partially supports the findings of Lakhanpal and Desh (2002) [25] who observed that aphid population showed significant positive correlation with maximum temperature and significant negative correlation with minimum temperature. However, Kulat *et al.* (1996) [26] and Chandre and Kushwaha (1986) [27] reported a significant negative correlation between temperature and aphid population but positive correlation with relative humidity.

Weather based forecasting models were developed (Table 3) by taking aphid population (y) as a dependent variable and weather parameters (x) as independent variables to predict the incidence aphid population in mustard crop well in advance. From the multiple stepwise regression models, it was observed that minimum relative humidity was the most influencing factor for aphid multiplication and it could explain 37.9 to 62.5 percent variation in aphid population in different cultivars. Our results are in conformity with Jaglan *et al.* (1988) [28] who found that relative humidity was the most influencing factor for increasing the aphid population.

Influence of weather parameters on mustard sawfly: The data presented in Table 2 indicated that among the various meteorological variables, sawfly had non-significant positive correlation with maximum relative humidity (except in ADV 414 where it was significant with r = 0.563) and minimum relative humidity whereas, negative and significant correlation existed with maximum temperature (except in Bulet where it was non-significant with r = - 0.461) and minimum temperature and negative non-significant correlations with wind velocity. The sawfly population showed non-significant positive correlation with bright sunshine hour for varieties Bulet (r = 0.110), TB 204 (r = 0.020), ADV 406 (r = 0.125) but negative correlation in case of ADV 414 (r = - 0.170). The result of the present study can be compared with the findings of Kashyap *et al.* (2018) [29] who found that saw fly population showed negative correlation with maximum and minimum Temperature and positive correlation with morning and evening relative humidity. Similarly, Bhatt and Bapodra (2004) [30] reported that mustard sawfly population had negative correlation with maximum and minimum temperature.

The regression equation (Table 3) was fitted to study the effectiveness of weather parameters on sawfly population. The multiple stepwise regression equations revealed that among the various abiotic factors maximum and minimum temperature were found to be most influencing factor, which contributed 28-39 percent variation in saw fly in different varieties of mustard. The present findings are more or less in agreement with the findings of Pradhan *et al*. (2020) [9] who reported that minimum temperature was the most dominant factor for population fluctuation of sawfly.

Influence of weather parameters on Coccinellid: The Correlation studies revealed that except for a few instances the weather parameters show a low order of association with Coccinellid population. Maximum temperature, bright sunshine hour and wind speed exhibited non-significant and positive correlation with the predator population. On the other hand, minimum temperature showed a negative but very weak correlation with Coccinellid population. The negative correlation between Coccinellid population and maximum relative humidity was found to be significant only in the variety Bulet (r = - 0.513) and ADV 406 (r = - 0.622). The correlation between predators and minimum relative humidity was negative and significant for ADV 414 (r = - 0.582), Bulet (r = - 0.611) and TBM 204 (r = - 0.602) however, it was non-significant and positive in case of variety ADV406 (r = 0.093). Thus, it is evident from the correlation coefficient between predators and abiotic factors that population of predators decreasing with rising relative humidity. The present results are in partially accordance with Kashyap *et al.*

(2018) [29] who found that maximum temperature and minimum temperature exhibited a positive non-significant correlation with ladybird beetle population whereas, morning RH and evening RH were found to be negatively correlated. Similarly, Kewad (2013) [31] also reported the natural enemy population showed positive correlation with maximum and minimum temperature and negative correlation with morning and evening relative humidity. However, according to Mishra and Kanwat (2018) [32] there was a significant negative correlation between maximum and minimum temperature and *C. septempunctata* and significant positive correlation with morning and evening relative humidity.

Correlation between aphid population and coccinellid predators: Perusal of the data presented in Table 4 indicated that coccinellid population was highly correlated with the aphid population. Correlation coefficients (r = 0.92, r = 0.95, r = 0.89, r = 0.85) between aphid population and their predators revealed that mustard aphid population showed significant positive correlation with its predators and it was showed that population of predator increased with increasing aphid population. Coefficient of determination (R) values of the regression models between the pest and predator population could explain 79-92 percent variability in Coccinellid population was accounted by incidence of aphid population on different varieties of rapeseed-mustard. Our findings are also close to that of Singh *et al*. (2018) [19] and Dwivedi *et al*. (2018) [33] who indicated that the rising population of predators was due to increase in aphid population. The present result confirms the findings of Kalra (1988) [34], Mishra and Kanwat, (2018) [32] who observed a strong positive correlation between coccinellid and *L. erysimi* population.

Table 1: Population dynamics of major pest and predators in different varieties of mustard

date	SMW	No. of Mustard Aphid*/ top 10 cm twig/plant				No. of sawfly Larvae*/plant				Adults and grubs of Cocccinellid* /plant			
		ADV 414	Bulet	TBM 204	ADV 406	ADV 414	Bulet	TBM 204	ADV 406	ADV 414	Bulet	TBM 204	ADV 406
17.12.19	51	0.00 (0.10)**	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)**	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)
24.12.19	52	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.16 (0.41)	0.06 (0.26)	0.07 (0.28)	0.10 (0.33)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)
01.01.20	1	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	1.21 (1.10)	0.12 (0.36)	0.54 (0.74)	0.41 (0.65)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)
08.01.20	2	3.26 (1.81)	0.00 (0.10)	1.25 (1.12)	0.85 (0.93)	2.03 (1.43)	0.59 (0.77)	1.32 (1.15)	0.54 (0.74)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)
15.01.20	3	6.54 (2.56)	2.31 (1.52)	4.58 (2.14)	7.27 (2.70)	3.26 (1.81)	1.48 (1.22)	2.54 (1.60)	1.75 (1.33)	0.23 (0.49)	0.00 (0.10)	0.03 (0.20)	1.17 (1.09)
22.01.20	4	10.36 (3.22)	4.64 (2.16)	16.35 (4.04)	26.58 (5.16)	1.02 (1.01)	0.92 (0.96)	1.65 (1.29)	1.26 (1.13)	1.45 (1.21)	0.00 (0.10)	0.94 (0.97)	2.15 (1.47)
29.01.20	5	35.73 (5.98)	13.62 (3.69)	27.37 (5.23)	43.31 (6.58)	1.40 (1.19)	1.42 (1.20)	1.03 (1.02)	1.14 (1.07)	1.83 (1.36)	0.41 (0.65)	2.01 (1.42)	3.04 (1.75)
05.02.20	6	48.68 (6.98)	25.46 (5.05)	38.21 (6.18)	52.75 (7.26)	0.29 (0.55)	0.16 (0.41)	0.54 (0.74)	0.42 (0.66)	2.15 (1.47)	1.23 (1.11)	1.76 (1.33)	5.02 (2.24)
12.02.20	7	65.27 (8.08)	43.49 (6.60)	58.21 (7.63)	73.38 (8.57)	0.03 (0.20)	0.00 (0.10)	0.31 (0.57)	0.06 (0.26)	5.31 (2.31)	2.54 (1.60)	4.20 (2.05)	6.42 (2.54)
19.02.20	8	32.41 (5.69)	28.37 (5.33)	42.61 (6.53)	62.03 (7.88)	0.00 (0.10)	0.00 (0.10)	0.10 (0.33)	0.00 (0.10)	1.95 (1.40)	2.01 (1.42)	1.62 (1.28)	3.00 (1.73)
26.02.20	9	24.43 (4.94)	5.87 (2.42)	10.34 (3.22)	32.94 (5.74)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	1.04 (1.02)	0.13 (0.37)	0.35 (0.60)	1.87 (1.37)
05.03.20	10	13.72 (3.71)	1.63 (1.28)	6.68 (2.59)	24.31 (4.93)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.05 (0.24)	0.00 (0.10)	0.10 (0.33)	0.75 (0.87)
12.03.20	11	1.63 (1.28)	0.45 (0.68)	2.31 (1.52)	12.04 (3.47)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.00 (0.10)	0.10 (0.33)

* Mean values of five replication; ** Figures in parenthesis are square root transformed values.

Table 2: Correlation between insect pest population of mustard and different abiotic factors

Abiotic factors	Aphid population				Saw fly population				Coccinellid population			
	ADV 414	Bulet	TBM 204	ADV 406	ADV 414	Bulet	TBM 204	ADV 406	ADV 414	Bulet	TBM 204	ADV 406
Tmax (°C)	0.254	0.230	0.236	0.401	-0.629*	-0.461	-0.564*	-0.533*	0.168	0.255	0.143	0.173
Tmin (°C)	-0.162	-0.199	-0.222	-0.067	-0.564*	-0.565*	-0.561*	-0.601*	-0.219	-0.154	-0.277	-0.421
RHmax (%)	-0.426	-0.480	-0.525*	-0.626*	0.563*	0.304	0.405	0.313	-0.457	-0.513*	-0.441	-0.622*
RHmin (%)	-0.615*	-0.635*	-0.699**	-0.784**	0.422	0.061	0.225	0.094	-0.582*	-0.611*	-0.602*	0.093
WS (km/ h)	0.137	0.188	0.167	0.182	-0.220	-0.186	-0.268	-0.207	0.147	0.233	0.046	0.462
BSH (h)	0.416	0.481	0.565*	0.631*	-0.170	0.110	0.020	0.125	0.390	0.479	0.417	0.275

* Significant at 5% level (two tail); ** Significant at 1% level (two tail)

Table 3: Multiple step-wise linear regression between insect pest population and meteorological parameters

Pest population	Cultivars	model	R^2 value	Remarks
Aphid population	ADV 414	$Y_1 = 92.3 - 1.29 X_4$*	0.379	Minimum Relative humidity becomes the prime influencing factor over population dynamics of aphid for all varieties.
	Bulet	$Y_1 = 60.1 - 0.88 X_4$*	0.403	
	TBM 204	$Y_1 = 90.8 - 1.34 X_4$**	0.586	
	ADV 406	$Y_1 = 132.4 - 1.98 X_4$**	0.625	

Sawfly population	ADV 414	$Y_2 = 5.49 – 0.19 X_1$*	0.39	Minimum temperature becomes the sole influencing factor over aphid population for varieties Bulet and AVD406 but in case of variety ADV414 minimum temperature plays major role. While in TBM204 both maximum and minimum temperature play significant role over population fluctuation of aphid.
	Bulet	$Y_2 = 1.95 – 0.12 X_2$*	0.32	
	TBM 204	$Y_2 = 2.87 – 1.75 X_1$*– 0.18 X_2*	0.28	
	ADV 406	$Y_2 = 2.21 – 0.14 X_2$*	0.36	

* Significant at 5% level (two tail); ** Significant at 1% level (two tail)

NB: X_1=Tmax (°C), X_2 = Tmin (°C), X_3 = RHmax (%), X_4 = RHmin (%), X_5 = WS (km/ h), X_6 = BSH (h), Y_1 = Aphid population and Y_2 = Sawfly population.

Table 4: Correlation and Regression between Aphid Population and its Natural Enemies

Cultivars	Model	Correlation coefficient (r)	Coefficient of determination (R^2)	Coefficient of Variation (%)
ADV 414	Y = -0.16 + 0.02 X	0.92**	0.86	86
Bulet	Y = -0.10 + 0.06 X	0.95**	0.92	92
TBM 204	Y = -0.25 + 0.12 X	0.89**	0.81	81
ADV 406	Y = -0.32 + 0.18 X	0.85**	0.79	79

** Significant at 1% level (two tail) Where, Y= Coccinellid population and X = Aphid population

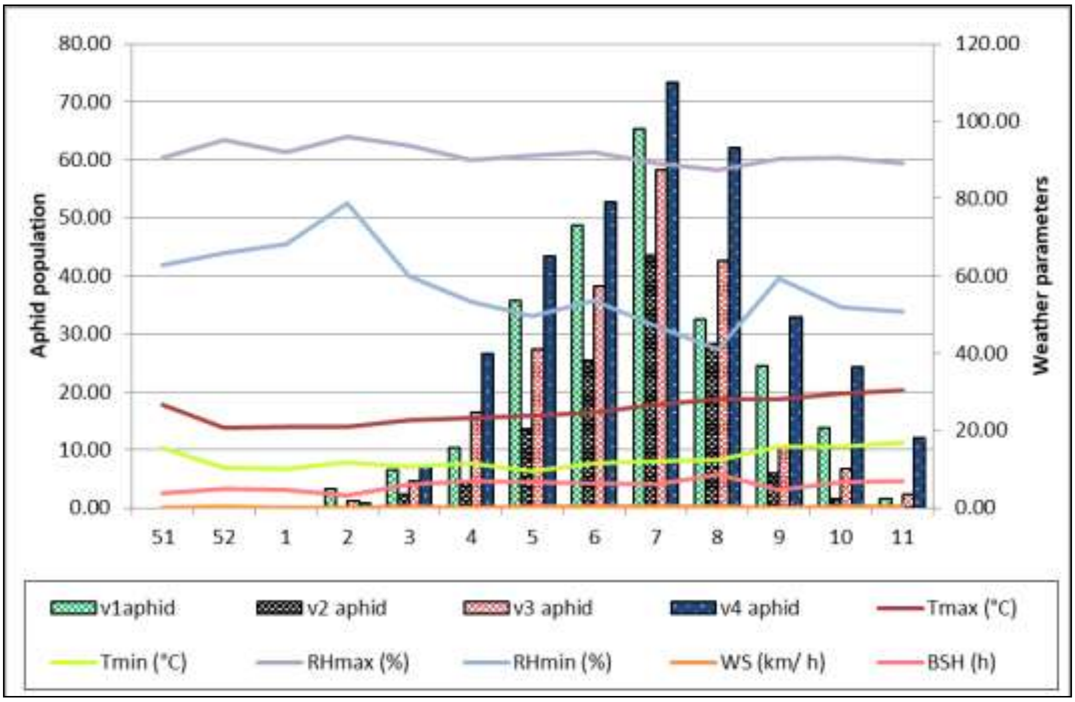

Fig 1: Seasonal incidence of mustard aphid in four different varieties of mustard

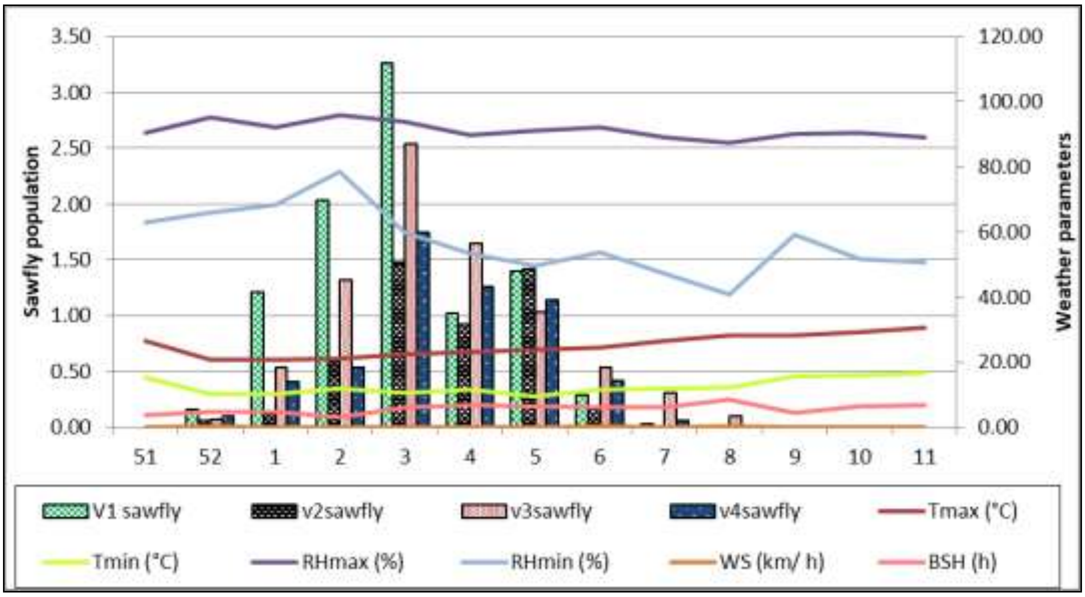

Fig 2: Seasonal incidence of mustard sawfly in four different varieties of mustard

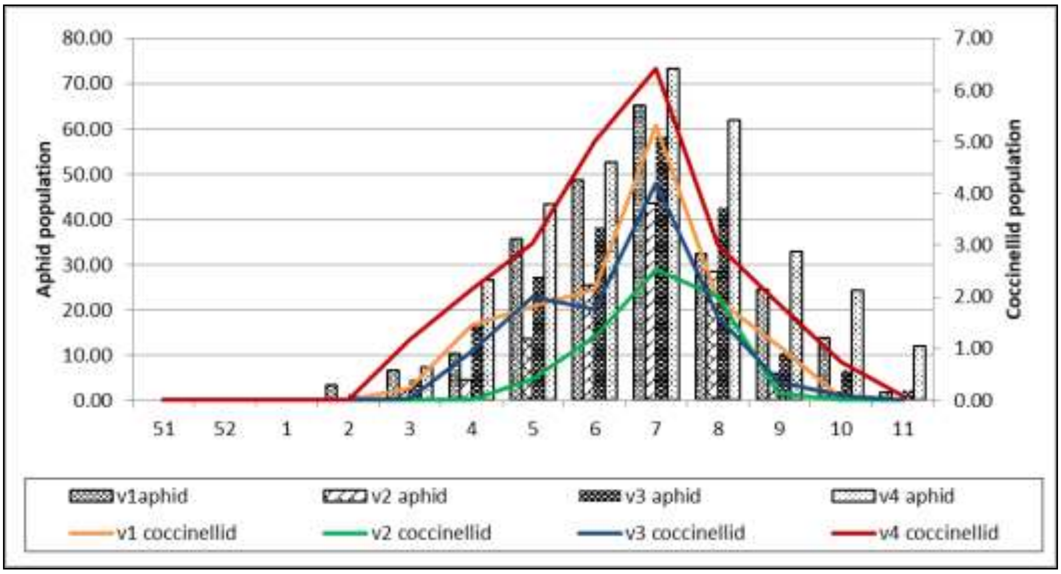

Fig 3: population dynamics of Coccinellid predators associated with mustard aphid [NB: Where, V_1= ADV 414, V_2 = Bulet, V_3 =TBM 204, V_4 =ADV 406]

Conclusion

Seasonal incidence of insect pests revealed that maximum sawfly and aphid were appeared during mid of January and February respectively. The natural enemy population was also appeared during second week of January which are closely associated with aphid population. The results of present investigation concluded that weather parameters like temperature and relative humidity were found to be most influencing factors over the incidence of pest and predators' population in mustard. Predictions from the forewarning models under changing scenarios of climate help to decide the sowing time, selection of varieties and time of application of insecticides etc.

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