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Seasonal incidence of insect pests and natural enemies of mustard in relation to meteorological parameters

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Abstract
Field experiment was conducted to study the seasonal incidence of insect pests and natural enemies revealed that aphid (*L. erysimi*), flea beetle (*P. cruciferae*) and sawfly (*A. lugens proxima*) were appeared during 51st SMW i.e. 3rd week of December, 2018 while the natural enemies *viz.*, ladybird beetle (*C. transversalis*) and *D. rapae* appeared during 4th SMW i.e. (last week of January, 2019). The correlation studies between different weather parameters and population of major insect pests revealed that maximum temperature recorded positive correlation with aphid, flea beetle and sawfly with correlation coefficient, r= 0.502, r= 0.510 and r= 0.461, respectively. In case of natural enemies observed in mustard field, maximum temperature had a positive impact on *C. transversalis* (r= 0.195) and *D. rapae* population (r= 0.194). Minimum temperature had non-significant positive correlation with aphid (r= 0.456) and flea beetle (r= 0.120) population but had a significant negative correlation with sawfly population (r= -0.625) and significant positive correlation with ladybird beetle (r= 0.669) and *D. rapae* population (r= 0.682). Morning relative humidity had non-significant negative correlation with all the insect pests observed in mustard crop except aphid where it was found to be significant (r= -0.606). Evening relative humidity had non-significant negative correlation with aphid (r= -0.251), flea beetle (r= -0.484) and sawfly (r= -0.525) population and in case of natural enemies *viz.*, *C. transversalis* (r= -0.058) and *D. rapae* (r= -0.047) also it was found to be negatively correlated. Rainfall had positive and non-significant correlation with aphid (r= 0.038), *C. transversalis* (r= 0.066) and *D. rapae* (r= 0.080) population but it had negative and non-significant correlation with flea beetle (r= -0.206) and sawfly population (r= -0.552).

Keywords: Mustard, seasonal incidence, insect pests and natural enemies of mustard, meteorological parameters

Introduction
Mustard, *Brassica juncea* (Linnaeus) belongs to the family Brassicaceae and originated in China. It contributes about 28.6% in the total oilseeds production in India, whereas it is the second most important edible oilseed after groundnut sharing 27.8% in India's oilseed economy. Among the various factors responsible for the low yield of mustard, damage inflicted by various insect pests is an important factor, more than 43 species of insect pests had been reported to infest rapeseed-mustard crop in India, out of which about a dozen of species are considered as major pest. Amongst all, the mustard aphid, *Lipaphis erysimi* (Kalt), the mustard saw fly, *Athalia lugens proxima* (Klug), the painted bug, *Bagrada hilaris* (Burmeister) and the leaf miner, *Phytomyza horticola* (Goureau) are considered as major pests of mustard. Among these, the mustard aphid, *L. erysimi* (Kalt) has been mentioned as the most important insect pest infesting the crop right from seedling stage to maturity causing up to 96% yield losses [1, 2]. Mustard aphid may cause 66% to 99% loss in *B. campestris* L. and 27-28% in *B. juncea* L [3] with an 15% reduction in oil content [4]. Pradhan *et al.* [5] estimated 87.9% yield loss in various parts of the country. Mustard sawfly, *A. lugens proxima* Klug (Hymenoptera: Tenthredinidae) has become a serious pest of mustard and radish in several regions of India, including the north-east India [6, 7]. It is a pest of cold weather and is generally active during October to March. Mustard sawfly attacks the crop at early growth period when the seedlings are 3-4 weeks old [8-10]. In some situations, complete reduction in yield may be observed due to attack of *A. proxima* but on an average, reduction is about 25% [11]. The Painted bug, *B. hilaris* Burmeister (Hemiptera: Pentatomidae) is one of the most notorious pests of cruciferous crops in almost all parts of the country.

The damage caused by the pest adversely affects both the quality and quantity of mustard seeds. Bugs also attack the harvested mustard crop and due to infestation on an average 30.09% reduction in seed weight, 2.75% in oil, 3.56% in protein and 1.11% in sugar contents has been reported [12].

Hence, in the present investigation, seasonal incidence of major insect pests and their natural enemies and the effect of different meteorological parameters like maximum and minimum temperature, morning and evening relative humidity, rainfall on development and survival of the insect pests and natural enemies was studied.

Materials and Methods

The field experiment was conducted in the Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat (26°45′ latitude and 94°12′ E longitude), Assam, India during *rabi* season of 2018-19. Climate of this region is characterized by subtropical humid having hot and humid summers and cold and dry winters. Monthly morning relative humidity of the station always remains above 85%, whereas monthly evening relative humidity varies from 61-76% throughout the year and the monthly average maximum and minimum temperature of Jorhat varies from 22.6-32.7 °C and 9.7-25.2 °C, respectively. The soil of Jorhat is mostly alluvial and sandy loam with pH ranging from 4.8 to 5.5. The seeds of mustard were sown on 15th November, 2018 @ 10 kg/ha, in lines spaced 30 cm apart and plant to plant distance was maintained at 10 cm by thinning. Application of manure and fertilizer at recommended dose as per package of practices and intercultural operations such as thinning, weeding etc. were done at proper time.

Method of observations

Observations on incidence of mustard aphid and its natural enemies were recorded on 10 cm apical twig at weekly interval by selecting 10 plants randomly. To assess the population of mustard sawfly and flea beetle 10 plants were selected at random and from each plot the population of the insects counted visually *in situ* at weekly interval.

Meteorological factors and their association

Meteorological factors such as maximum and minimum temperature, morning and evening relative humidity and rainfall that prevailed during the field experiment were collected from Department of Agrometeorology, Assam Agricultural University, Jorhat.

To study the influence of meteorological factors on the population build up, correlation studies were carried out with major insect pests and natural enemies of rapeseed.

Results and Discussion

During the period of investigation, the population of insect pests was fluctuating and present throughout the crop season. Population buildup of insect pests and the influence of several weather parameters on their population were presented in the Table 1.

Simple correlation and regression equation of major insect pests and their natural enemies with maximum and minimum temperature, morning and evening relative humidity and rainfall are presented in the Table 2.

Mustard aphid, *Lipaphis erysimi* (Kalt.) (Hemiptera: Aphididae)

Mustard aphid was observed during 51st SMW i.e. 3rd week of December 2018 and active until 9th SMW i.e. 1st week of March 2019. Population peaked (50.33/10 cm twig) was observed during the 6th SMW i.e. 2nd week of February 2019 when the maximum and minimum temperature were 25.8 °C and 12.1 °C with 95% and 60% morning and evening relative humidity, respectively and 9.2 mm rainfall. Sinha *et al.* [13] also observed that the *L. erysimi* appeared and established on the mustard crop in 3rd week of December. This finding was in confirmation with Malik and Sachan [14] and according to them the incidence of mustard aphid started during 51st standard week and reached its peak level in 5th SMW and 8th SMW. These results were also at par with the results of Singh and Lal [15] who reported that appearance of mustard aphid population started from 2nd week of January and reached its peak in 8th standard week. The data represented in the Table 2 revealed that among the different weather parameters affecting the population of insect, the morning relative humidity (r = -0.606) was the most dominant factors which showed negative and significant correlation with the insect population. A negative but non-significant correlation was also observed with evening relative humidity (r = -0.251). However, a positive correlation of aphid was registered with maximum temperature (r = 0.502), minimum temperature (r = 0.456) and rainfall (r = 0.038) which was found to be non-significant. Kashyap *et al*. [16] from Chhattisgarh revealed that the aphid population exhibited positive but non-significant interaction with maximum temperature (r = 0.146), minimum temperature (r = 0.279) and rainfall (r = 0.500). However, Patel *et al.* [17] from Gujarat reported morning and evening relative humidity exhibited negative influence (r= -0.022, -0.327) on activity of aphid population. In addition to this, Ishwarbhai [18] from Gujarat also found positive correlation in between aphid population and maximum and minimum temperature while a negative correlation with morning and evening relative humidity was recorded with aphid population. However, the present findings were in accordance with the results of Kumar *et al.* [19], Hasan *et al.* [20], Singh and Lal [15] and Abbas *et al.* [21] also reported that the aphid population was found to be positively governed by temperature whereas, relative humidity had shown negative effect. Buragohain *et al.*, 2017, reported that the correlation studies indicated that *A.gossypii*, S. *dorsalis*, *B. tabaci*, *A. biguttula biguttula* had a negative correlation with maximum and minimum temperature, wind speed and rainfall. However, morning and evening relative humidity showed a positive correlation for all the sucking pests during both the years of study.

Mustard sawfly, *Athalia lugens proxima* (Klug) (Hymenoptera: Tenthredinidae)

Mustard sawfly was observed during 51st SMW i.e. 3rd week of December, 2018 and active until 9th SMW i.e. 1st week of March 2019. Highest population (1.01/plant) was observed during the 4th SMW i.e. last week of January 2019 when the maximum temperature and minimum temperature were 25.9 °C and 10.3 °C with 93% and 61% morning and evening relative humidity, respectively and zero rainfall. However, Bhatt and Bhapodra [23] from Gujarat also observed that the infestation of mustard sawfly commenced in December and kept fluctuating throughout the crop season.

The minimum temperature (r = -0.625) was the most dominant factor which showed negative but significant correlation with the insect population. A negative and non-significant correlation observed with morning relative

humidity (r = -0.328), evening relative humidity (r = -0.525) and rainfall (r = -0.552). However, a positive correlation of sawfly was registered with maximum temperature (r = 0.461) which was found to be non-significant. Patel *et al.* [17] from Gujarat also revealed that morning relative humidity and evening relative humidity had negative and non-significant correlation (r= -0.354, -0.327) with sawfly population. However, the temperature had a negative correlation with *A. lugens proxima* as reported by Manzar *et al.* [24]. Similarly, Bhatt and Bapodra [23] also reported that mustard sawfly population had negative correlation with minimum temperature.

Flea beetle, *Phyllotreta cruciferae* (Goeze) (Coleoptera: Chrysomelidae)

Flea beetle was observed during 51st SMW i.e. 3rd week of December 2018 and active till 9th SMW i.e. 1st week of March 2019 and maximum population (1.60/plant) was observed during the 6th SMW i.e. 2nd week of February 2019 when the maximum temperature and minimum temperature were 25.8 °C and 12.1 °C with 95% and 60% morning and evening relative humidity, respectively and 9.2 mm rainfall. Similarly, Gogoi [25] also observed from Assam that mustard flea beetle started an increasing trend from last fortnight of December and reached its peak during February.

The morning relative humidity (r = -0.523), evening relative humidity (r = -0.484) and rainfall (r = -0.206) showed non-significant negative correlation with the insect population. A positive and non-significant correlation was also observed with maximum temperature (r = 0.510) and minimum temperature (r = 0.120). In the present findings, maximum temperature and minimum temperature exhibited positive correlation with flea beetle population which was in agreement with the results of Kashyap *et al.* [16] who reported a non-significant positive correlation with maximum temperature (r= 0.128) and minimum temperature (r= 0.106) whereas, morning relative humidity (r= -0.319), evening relative humidity (r= -0.499) showed a non-significant negative correlation. However, Nayak [26] also supported with the present findings that the flea beetle population was negatively correlated with relative humidity and positively correlated with maximum and minimum temperatures, respectively. Similar kind of results was also observed in the findings of Lal *et al.* [27] where they revealed that relative humidity was negatively correlated with flea beetle population.

Ladybird beetle, *Coccinella transversalis* (Coleoptera: Coccinellidae)

Ladybird beetle, *C. transversalis* was observed during 4th SMW i.e. last week of January 2019 and was found to be active till 9th SMW i.e. 1st week of March 2019 and maximum population of 1.80/plant was observed during the 9th SMW i.e. 1st week of March 2019 when the maximum temperature and minimum temperature were 24.5 °C and 12.2 °C with 95% and 61% morning and evening relative humidity, respectively and 5.3 mm rainfall. The findings were in confirmation of earlier reports as reported by Lal *et al.* [27] (2018) where they observed the ladybird beetle during 4th SMW (0.4 beetles/10 cm apical twig) and which reached at its peak (3.2 beetles/10 cm apical twig) during 9th SMW. The minimum temperature (r = 0.669) was the most dominant one which showed positive and significant correlation with the insect population.

A negative and non-significant correlation was also observed with morning relative humidity (r = -0.453) and evening relative humidity (r = -0.058). However, a positive correlation with *C. transversalis* was registered with maximum temperature (r = 0.195) and rainfall (r = 0.066) which were found to be non-significant. According to Kashyap *et al.* [16] (2018) maximum temperature (r =0.334), minimum temperature (r = 0.476) and rainfall (r = 0.479) exhibited a positive and non-significant correlation with ladybird beetle population whereas, morning RH (r = -0.480) and evening RH were found to be negatively correlated (r = -0.480, -0.321 respectively). However, Lal *et al.* [27] also observed that maximum and minimum temperature and rainfall showed positive correlation (r= 0.76, 0.03, 0.02) where both morning and evening relative humidity had negative correlation (r= -0.92, -0.90) with insect population. similarly, Khedkar [28], Achintya [29] and Kewad [30] were also reported the natural enemies showed positive correlation with maximum and minimum temperature and negative correlation with morning and evening relative humidity. However, Begam *et al.*, [31] observed that *Coccinella transversalis* and *Micraspis discolor* were the most dominant predator species observed throughout the cropping season of Bhut Jalakia and there was a positive correlation of the predators with pests. On the other hand, Borkakati *et al.* [32], reported that the highest numbers of predator Coccinellid beetles were proportional to highest yield of cabbage, which is also an important cruciferous vegetable. Moreover, the result of the field experiments conducted by Borkakati *et al.* [33] revealed that the highest numbers of Coccinellid predator with highest yield of and highest cost benefit ratio also recorded from the module comprise of cabbage intercropped with cowpea and mustard as border crop.

Aphid parasitoid, *Diaeretiella rapae* (M'lntosh) (Hymenoptera: Braconidae)

A parasitoid, *D. rapae* associated with aphid population was observed during 4th SMW i.e. last week of January 2019 and active till 9th SMW i.e. 1st week of March 2019 and the highest population (1.73/plant) was observed during the 9th SMW i.e. 1st week of March 2019 where the maximum temperature and minimum temperature were 24.5 °C and 12.2 °C with morning and evening relative humidity of 95% and 61%, respectively and 5.3 mm rainfall. However, Lal *et al.* [27] also reported that the first appearance of *D. rapae* was recorded during 5th SMW (28 January to 03 February) which reached its peak during 8th SMW (18 February to 24 February). Moreover, Kulkarni and Patel [34] also reported that *D. rapae* was found during the 1st week of February and then gradually increased until the 4th week of February. Similar result was also found by Singh and Rawat [35] who reported that *D. rapae* began its activity in mid-January which raised in the second week of February and reached its peak in March.

The data indicated in the Table 2 revealed that among the different weather parameters affecting the population of aphid parasitoid, the minimum temperature (r = 0.682) was the most dominant factor which showed positive and significant correlation with the insect population. A negative and non-significant correlation observed with morning relative humidity (r = -0.447) and with evening relative humidity (r = -0.047). However, a positive correlation of *D. rapae* was registered with maximum temperature (r = 0.194) and rainfall (r = 0.080) which was found to be non-significant. However,

Lal *et al.* [27] revealed that the *D. rapae* population showed significant positive correlation with maximum, minimum temperature and rainfall, while morning and evening relative humidity were found to be negatively correlated. Moreover, Patel *et al.*, [17] also reported that morning and evening relative humidity were found to be negatively correlated. These results were also at par with the results of Kashyap *et al.* (2018) and they reported that maximum temperature (r= 0.232), minimum temperature (r= 0.388) and rainfall (r= 0.488) were found to be positively correlated with *D. rapae* population whereas, morning RH (r=-0.293) and evening RH (r= -0.218) were negatively correlated.

Table 1: Population buildup of major insect pests and their natural enemies on *Brassica campestris* var. *toria* in relation to weather parameters during December, 2018 to March, 2019

Date of observation	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Aphid/10 cm twig	Sawfly/ plant	Flea beetle/ plant	Ladybird beetle/plant	*Diaeretiella rapae*/ plant
	Max.	Min.	RH (M)	RH (E)						
17 December - 23 December	22.7	12.9	99	77	29.6	4.12	0.27	0.04	0	0
24 December – 31 December	24.2	9.7	98	65	0.0	6.17	0.42	0.08	0	0
1 January – 7 January	23.3	8.2	95	61	0.6	7.50	0.48	0.35	0	0
8 January – 14 January	24.1	9.1	96	62	6.6	8.50	0.61	0.40	0	0
15 January – 21 January	25.4	8.1	96	57	0.0	9.33	0.79	0.58	0	0
22 January – 28 January	25.9	10.3	93	61	0.0	20.50	1.01	0.86	0.97	1.01
29 January – 4 February	25.0	10.2	94	58	3.5	30.05	0.72	1.39	1.06	1.10
5 February – 11 February	25.8	12.1	95	60	9.2	50.33	0.49	1.60	1.11	1.26
12 February – 18 February	27.2	12.2	90	59	8.2	48.12	0.38	0.80	1.40	1.43
19 February – 25 February	21.3	14.2	98	76	17.9	28.12	0.24	0.60	1.52	1.62
26 February – 4 March	24.5	12.2	95	61	5.3	12.71	0.12	0.45	1.80	1.73

Table 2: Correlation coefficient (r) and regression equation of major insect pests and their natural enemies of *Brassica campestris* var. *toria* with meteorological parameters during December, 2018 to March, 2019

Insect pests	Correlation coefficient (r)				
	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
	Max.	Min.	RH (M)	RH (E)	
Aphid *L. erysimi*	0.502	0.456	-0.606* Y= 399.39-3.9732x	-0.251	0.038
Sawfly *A. lugens proxima*	0.461	-0.625* Y= 1.389-0.0818x	-0.328	-0.525	-0.552
Flea beetle *P. cruciferae*	0.510	0.120	-0.523	-0.484	-0.206
Ladybird beetle *C. transversalis*	0.195	0.669* Y= -1.8878+0.2402x	-0.453	-0.058	0.066
D. rapae	0.194	0.682* Y= -1.9755+0.2507x	-0.447	-0.047	0.080

*: Significant at 5% level of probability

Conclusion

Seasonal incidence of insect pests and natural enemies revealed that aphid (*L. erysimi*), flea beetle (*P. cruciferae*) and sawfly (*A. lugens proxima*) were appeared during 3rd week of December followed by the appearance of natural enemies *viz.*, ladybird beetle (*C. transversalis*) and *D. rapae* appeared during last week of January. Therefore, application of broad spectrum chemical pesticides should be restricted after arrival of the insect pests.

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References

1. Pradhan PP, Borkakati RN, Saikia DK. Bio efficacy of certain entomopathogenic fungus against major insect pests of *Brassica campestris* var. Toria. Journal of Entomology and Zoology Studies. 2020; 8(1):840-843
2. Singh YP, Sharma KC. Integrated approach to manage the mustard aphid *Lipaphis erysimi* (Kaltenbach) (Homoptera: Aphididae) in oilseed Brassica crops- a review. Journal of Amphibiology. 2002; 16:77-78.
3. Bakhetia DRC. Insect pest problems and their management in rape and mustard crops. XV Annual Workshop Cum-Seminar on rapeseed and mustard, held at CSAU Agric. Techno. Kanpur. 1979, 12-13.
4. Verma SN, Singh OP. Estimation of avoidable losses to mustard by the aphid, *Lipaphis erysimi* in Madhya Pradesh. Indian Journal of Plant Protection. 1987; 15(1):87-89.
5. Pradhan S, Jotwani MO, Swarup P. Control schedule for mustard crop particularly against mustard aphid. Indian Oilseeds Journal. 1960; 4:125-141.
6. Narayanan K, Gopalakrishnan C. Evaluation of entomopathogenic nematode, *Steinernema feltiae* against field population of mustard sawfly, *Athalia lugens proxima* (Klug) on radish. Indian Journal of Experimental Biology. 2003; 41:376-378.
7. Chowdhury M. Incidence of saw fly, *Athalia lugens proxima* Klug as influenced by level of irrigation and fertilizers on mustard. Journal of Plant Protection Science. 2009; 1:80-82.
8. Bogawat JK. Biology of mustard sawfly on different host plants. Indian Journal of Entomology. 1967; 29:270-274.
9. Sehgal VK, Bhattacharya AK, Singh KN. Food preference of mustard sawfly grubs, *Athalia proxima* Klug. (Hymenoptera: Tenthredinidae). Scientific Culture. 1975; 41(9):430-433.
10. Verma RK, Sachan GC. Impact of sowing time on the occurance of *Athalia proxima* Klug on three Brassica cultivars. Annals of Plant Protection Sciences. 1997; 5(1):44-47.
11. Sachan GC. Insect pest problem in *Brassica* and research work at Pantnagar, Paper presented at second *Brassica*

subnet work meeting sponsored by DRC Canada held on January 4-6, 1986 at G.B.P.U.A.T., Pantnagar, India, 1990
12. Singh HV, Gupta DS, Yadav TP, Dhawan K. Post-harvest losses caused by painted bug (*Bagrada cruciferarum* Kirk) to mustard. Haryana Agriculture University Journal of Research. 1980; 10(3):407-409.
13. Sinha RP, Yazdani SS, Verma GD. Population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt) in relation to ecological parameters. Indian Journal of Entomology. 1990; 52(3):387-392.
14. Malik R, Sachan SK. Population buildup of mustard, *Lipaphis erysimi* (Kalt.), on Indian mustard in relation to some abiotic factors. Progressive Agriculture. 2013; 13(1):153-157.
15. Singh AK, Lal MN. Population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt,) on mustard in relation to weather parameters. Asian Journal of Bio Science. 2012; 7:216-218.
16. Kashyap N, Painkra GP, Painkra KL, Bhagat PK. Insect-pests succession, natural enemies and their correlation with weather parameters in mustard crop. Journal of Plant Development Sciences. 2018; 10(10):563-568.
17. Patel MR, Patel HN, Khanpara AV, Dabhi MV. Population dynamics of major insect pests and predator-parasite of aphid on mustard. Indian Journal of Plant Protection. 2014; 42:297-299.
18. Ishwarbhai CR. Insect pest succession and management of aphid, *L. erysimi* (kalt.) infesting mustard, *Brassica juncea* 9L.) Czerm and Coss. M.Sc. (Agri.) thesis submitted to Anand Agricultural University, Anand, Gujarat, 2015.
19. Kumar J, Singh SV, Malik YP. Population dynamics and economic status of *Lipaphis erysimi* on mustard, *Brassica juncea*. Indian Journal of Entomology. 2000; 62:253-259.
20. Hasan MR, Ahmad M, Rahman MH, Haque MA. Aphid incidence and its correlation with different environmental factors. Journal of the Bangladesh Agricultural University. 2009; 7:15-18.
21. Abbas Q, Ahmad I, Shahid MA, Akhtar MF, Hussain M, Akram M and Raza A. Role of Climatic Factors on Population Fluctuation of Aphids (*Brevicoryne brassicae*, *Myzus persicae* and *Lipaphis erysimi*) on Canola (*Brassica napus*) in Punjab, Pakistan. Pakistan Journal of Nutrition. 2014; 13:705.
22. Buragohain P, Saikia DK, Borkakati RN, Dutta BC, Thangjam R. Pest Complex and the Population Dynamics of Major Pests of Bhoot Jolokia. Ecology, Environment and Conservation. 2017; 23(3):265-272
23. Bhatt PD, Bhapodra JG. Population dynamics of mustard sawfly, *Athalia lugens proxima* (Klug) on mustard in relation to weather parameters. Indian Journal of Entomology. 2004; 66:284-285.
24. Manzar A, Lal MN, Singh SS. Correlation between incidence of insect pests on *Brassicae* species and ecological parameters. Shashpa. 1998; 5:171-174.
25. Gogoi LP. Biology and management of mustard flea beetle, *Phyllotreta cruciferae* on mustard. M.Sc. Thesis submitted to Assam Agricultural University, Jorhat, 1998.
26. Nayak MK. Population dynamics of major insect species of mustard (*Brassica compestris* Sariah) towards weather parameters. Journal of Rural and Agricultural Research. 2010; 10(1):19-21.
27. Lal B, Nayak MK, Srivastava AK, Tomar DS. Seasonal incidence of major insect pests of mustard and their natural enemies. International Journal of Chemical Studies. 2018; 6(3):3658-3661.
28. Khedkar AA. Population dynamics and impact of nitrogenous fertilizer on major insect pests and management of aphid *L. erysimi* (Kalt.) in mustard. M.Sc. thesis, Anand Agricultural University, Anand, Gujrat, 2011.
29. Achintya PA, Debjani D, Kumar AD. Redescription of *Diaeretiella rapae* (MacIntosh) with emphasis on morphometrics. Journal of Entomological Research. 2012; 36(1):77-82.
30. Kewad NK. Biology and activity of *Diaeretiella rapae* an endo parasitoid of aphids infesting crucifereous crops. M.Sc. (Agri.) thesis, Anand Agricultural University, Anand, Gujrat, 2013
31. Begam N, Saikia DK, Borkakati RN. Seasonal incidence of major insect-pests and their natural enemies of Bhut Jolokia. Annals of Plant Protection Science. 2016; 24(2):259-264
32. Borkakati RN, Saikia DK, Buragohain P. Natural enemy fauna of agri-horti ecosystem of Assam. Indian Journal of Entomology. 2018; 80(3):658-661
33. Borkakati RN, Saikia DK, Sarma D. Manipulation of crop habitat to encourage natural enemies against key pests of cabbage ecosystem. Journal of entomology and zoology studies. 2019; 7(3):151-54
34. Kulkarni AI, Patel IS. Seasonal abundance of mustard aphid (*Lipaphis erysimi*) and associated bio-agent in Indian mustard crop. Indian Journal of Agricultural Sciences. 2001; 7(10):681-682.
35. Singh OP, Rawat RR. Note on safety of some insecticides for *Dairetiella rapae* - M' Intosh, a parasite of the mustard aphid. Indian Journal of Agricultural Sciences. 1981; 51(3):204-205