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Association of *Aphis craccivora* Koch (Hemiptera: Aphididae) infesting *Phaseolus sinensis* and *Lablab purpureus* with its predator *Cheilomenes sexmaculata* (Fabricius) (Coleoptera: Coccinellidae) in different seasons

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Abstract
The present seasonal study of *Aphis craccivora* Koch and its predator *Cheilomenes sexmaculata* (Fabricius) was carried out in two years on two most common vegetables (*Phaseolus sinensis* and *Lablab purpureus*) under agroclimatic condition. The activity of aphids was recorded from August to January (5-6 months) and September to March (6-7 months) on *P. sinensis* and *L. purpureus* respectively. However, the activity of predators was observed from September to January (4 months) and October to March (5-6 months) on *P. sinensis* and *L. purpureus* respectively. Generally, the appearance of predator was observed on *A. craccivora* after 2-4 weeks (26-27 ºC; 56-57% RH) on *P. sinensis* and after 5-6 weeks (19-22 ºC; 50-60% RH) on *L. purpureus*. The early appearance of both aphids and its predators on *P. sinensis* was observed probably due to suitability of host plants. Thus, the appearance and population buildup of aphids and predator were observed host plants and temperature/humidity dependent. This study shows that host plants as well as whether parameter (temperature, relative humidity, rainfall, wind and sunshine hours) greatly influenced the aphid predator interaction. Thus, both the biotic and abiotic factors have equal role in regulating population of *A. craccivora* and *C. sexmaculata* in agro-ecosystem. Therefore, for effective management of pest and conservation of natural enemies requires a thorough understanding of their ecology.

Keywords: Seasonal study, *Aphis craccivora, Cheilomenes sexmaculata,* Temperature

1. Introduction
The seasonal associations in the community are essential to understand the nature of interaction among the food plants, herbivores insects, predators and parasitoids in varying ecological conditions in the field [1]. These complexes are useful sources of information for biological control programmes because it is well known that success or failure in any biological programmes depends primarily on accurate knowledge of natural enemies association with their pest and host plants [2]. Phenology and food quality of host significantly influence the population development of aphids and generally aphid population maintained by combine effect of abiotic and biotic factors [3].

Aphis craccivora is one of the serious pest of *Phaseolus sinensis* and *Lablab purpureus. A. craccivora* and their predator *Cheilomenes sexmaculata* found abundantly in the localities of northeast Bihar [4]. Further several studies have been made on its biology and predatory efficiency [5-7]. The emerging concept of pest population management embodies the ideas that knowledge of pest population ecology is essential to design of control strategies. Accordingly, the management programme must be concerned both with pest population and how to buildup in control environment within which the population exist. The seasonal study of aphids and their natural enemies studied by several workers [8-20]. A little work on population dynamic of *A. craccivora* with their predators in relation to their biotic factors has been done in India by few workers [21-28].

An information based on population buildup of predator would be useful to make sound eco-friendly by strategy for managing *A. craccivora* population on host plants *P. sinensis* and *L. purpureus.* Hence, due to importance of such works, the seasonal investigation of *A. craccivora* and *C. sexmaculata* was done different seasons on two different host plants in the research field which is considered as primary source of information in biological control programme.

2. Materials and Methods

Weekly investigation of *A. craccivora* and its predator, *C. sexmaculata* was done on two different host plants viz; *P. sinensis* and *L. purpureus* in the experimental field during two consecutive years (2012-2013 and 2013-2014). The experimental plots were kept free from insecticides and normal agrochemical practices were followed. Regular monitoring of aphids and their predators was done just after appearance. The temperature and humidity were also recorded every week during observation.

2.1 Assessment of incidence and infestation rate of aphids

[4, 29] also reported the intensity of infestation of aphids as low, moderate, high and very high on the basis of number of aphids appeared on the plants. In the present investigation, the intensity of infestation by aphids on various crops was done according to [30].

a Low infestation (+) = Scattered appearance of few aphids on the plant.
b Moderate infestation (++) =Severe infestation of aphids on any one branch of the plant.
c High infestation (+++) =Severe infestation of aphids on more than one branch or half portion of the plant.
d Very high infestation (++++) =Severe infestation of aphids on the whole plant.

2.2 Similarly, the incidence and population build up of predators are represented as follows:

a) Low population (+) =1 predator on one plant.
b) Moderate population (++) = 2-5 predators on one plant.
c) High population (+++) = 6-10 predators on one plant.
d) Very high population (++++) = More than 10 predators on one plant.

3. Results

During the study, the first appearance of *A. craccivora* was observed during the last week of August. The appearance and intensity of infestation was varied on the different host plants. The population started to build up in the month of September and reached its peak in the month of November to January. Its population started to decrease from March and completely disappeared in the month of April. However, the predator *C. sexmaculata* appeared in the first week of September but its population increased with the increase of aphid population. Its maximum population was observed during October to February.

3.1 Seasonal abundance of *A. craccivora* on different host plants

3.1.1 *Phaseolus sinensis*

The first appearance of aphid was observed in the field during 3rd week of September at 28.1 ºC, 90% RH during 2012-2013. The first standard peak with very high degree of association was observed at the end of October (22.4 ºC; 60% RH) to first week of November (22.2 ºC; 64% RH). After first week of November due to rain, the aphid population was suddenly decreased. The aphid population was observed low from 4th week of November to 3rd week of December. Again, its population increased rapidly and reached to 2nd standard peak level in the 4th week of December (10.5 ºC, 72% RH) with very high degree of infestation. Thereafter, its population was again decreased in the mid January with low to moderate degree of infestation (Table-01). Thus, only two peaks were observed.

However, in 2013-2014, it attained 3 standard peaks. Its first appearance was observed in the 4th week of August with low degree of infestation (28.7 ºC, 84% RH) and attained its first peak during 5th week of September (26.5 ºC, 61% RH). The 2nd peak was observed in the 1st week of November (22.8 ºC, 59% RH). Thereafter, it population completely decreased in the 3rd week of November. The population of aphid again increased and attained 3rd standard peak with very high degree of infestation during 2nd and 3rd week of December (Table-02).

3.1.2 *Lablab purpureus*

During 2012-2013, the appearance of *A. craccivora* was observed first time in the 2nd week of October with low degree of infestation (28.2 ºC; 56% RH). Its degree of infestation crossed the critical level attained a largest peak from last week of November (16.9 ºC, 51% RH) to the 3rd week of December (16.9 ºC; 61% RH) with high degree of infestation. The second standard peak was observed attained in the 4th standard week of February at 21.9 ºC; 56% RH (Table-01).

During 2013-2014, *A. craccivora* first time appeared in the 4th week of September (26.9 ºC; 68% RH) and its population attained 3 standard peaks till the end of season. The first standard peak was observed from 4th standard week of November to December (16.9 ºC; 80% RH) with high degree of infestation. After that, high to moderate infestation was observed from 1st week of January to 3rd week of January. Its degree of infestation suddenly increased and obtained 2nd standard peak during the end of January to the 2nd week of February. However, the 3rd peak was observed from 1st to 2nd week of March with high degree of infestation. Thereafter, its population started to decline (Table-02).

3.2 Seasonal abundance of *C. sexmaculata* on different host plants

3.2.1 *Phaseolus sinensis*

The population of aphidophagous coccinellids on *P. sinensis* was observed during September to January.

In 2012-2013 season, first appearance of predator was recorded in the field during 3rd week of October (26.6ºC; 58% RH) and reached to its peak level with very high degree of population in the 2nd week of November at 21.8 ºC; 63% RH. Thereafter, its population decreased and low degree of population was recorded from 1st to 3rd week of December. Again, its population build up from 4th week of December and 2nd highest peak was observed at the end of 4th standard week of December with very high degree of population at 6.2 ºC, 81% RH and its population decreased again with, high to moderate degree of population towards the end of season. Thus, it attained two standard peaks during this period (Table-01).

During 2013-2014, its first appearance was observed during 2nd week of September with moderate degree of population at 27.2 ºC, 75% RH and it population attained first peak during 1st week of October at 26.3 ºC , 56% RH. It population remains fluctuated with low/ moderate/ high degree of population from 2nd week of October to 1st week of January. The 2nd highest peak was observed in the 2nd standard week of December with very high degree of population at 17.5 ºC, 82% RH (Table-02).

3.2.2 *Lablab purpureus*

The *C. sexmaculata* on *L. purpureus* was observed from 3rd week of November to end of March.

In the year 2012-2013, it attained 2 standard peaks. The first

peak was observed during 1st to 2nd week of January with very high degree of population. Therefore, it population attained a single fluctuation from 4th week of January to the end of March. Between these periods, it again attained its 2nd peak in the second week of February at 16.2 ºC and 58% RH with very high degree of population (Table-01).

However, during 2013-2014 the activity of predator was observed first time in the 1st week of November at 22.8 ºC; 59% RH and their population increased gradually and reached at its peak during 5th week of December (9.6 ºC, 81% RH). Thereafter, it decreased gradually and low degree of predation was recorded in 2nd and 3rd week of January. The sudden increase of population of predator was observed in 4th standard week of January to the end of March. (Table-02).

3.3 Association of *C. sexmaculata* with *A. craccivora* on different host plants

3.3.1 *Phaseolus sinensis*

In year 2012-2013, population of *A. craccivora* and its predator *C. sexmaculata* both attained 2 standard peaks while, in the 2013-2014 they attained 2-3 standard peaks (Table-1 & 2). During 2012-2013, predator first time appeared in the field after 4th week of aphid infestation (26.2 ºC, 58% RH). The association of aphid and its predator was observed from 3rd week of October to the 2nd week of January. First time low association of predator was observed on high degree of infestation of aphid. Then, the population of predators gradually increased and high association was recorded on high infestation of aphids in the first week of November (22.2 ºC, 64% RH). Thereafter, the very high degree of association of predator was observed on moderate infestation of aphid. The aphid population was started to decline rapidly due to high predation rate. Therefore, from 1st week of December to 3rd week of December, the population of aphids completely decreased in the field. Again in the 3rdweek of December, aphid started to build-up their population due to absence of predators. Similar, observation was also observed in the next peak (Table-01).

During the 2013-2014, the first appearance of predator was observed in the field after 2 weeks of infestation of *A. craccivora*. The association of aphids and its predator was observed from 2nd week of September to 1st week of January. In this year, too much fluctuation in the population was observed for the association of aphids and its predator (Table-02).

3.3.2 *Lablab purpureus*

During 2012-2013, two standard peaks of *A. craccivora* and *C. sexmaculata* were observed on host plant *L. purpureus.* However 2-3 standard peaks were observed during 2013-2014. The appearance of predator was observed in the field at 19.1 ºC, 50% RH after 6 weeks of appearance of aphid during 2012-2013 (Table-01).

During 2013-2014, the predator appeared after 5 weeks from the appearance of aphids in the field (22.8 ºC, 59% RH). *C. sexmaculata* was appeared in the November on *L. purpureus* in both years of infestation (Table-01 & 02).

4. Discussion

The cluster of *A. craccivora* up to 10-20 does not cause serious damage in the present observation. Similarly, Dhiman and Agarwala [31] also reported, a cluster of aphids up to 10 do not cause much damage. But high to very high degree of infestation caused withering of inflorescence and nascent leaves, retard development of fruits and adversely affecting seed setting. *A. craccivora* first time appeared on *P. sinensis* plants in both the year. Early appearance of aphids was observed during 2012-2013, on both host plant, this is may be due to change of temperature and humidity etc. The temperature above 32 ºC has found to be detrimental for its multiplication. According to Khandwe et al. [32] reported that the maximum temperature (22 ºC to 24 ºC) minimum (8 ºC to 9.9 ºC) and 66% to 88% relative humidity favourable for *Myzus persicae*. Adverse effect was observed at 30 ºC [32].

The appearance of aphids and growth of population in the present investigation were observed host plant and temperature/humidity dependent. The early appearance of *A. craccivoora* was observed on *P. sinensis* during both years. Moderate to very high intensity of infestation was observed during September to January (5-6 months) on *P. sinensis* (Plate- A) and September to March (6-7 months) on *L. purpureus*. It revealed that aphids stay longer period on *L. purpureus* which caused severe damage to leaves, stem, inflorescence as well as fruits (Plate- B).

The data based on two years observation showed that none of the weather parameters alone was responsible for the aphid multiplication. In nature, one factor always acted in combination with others. The high aphid population in 2012-2013 and 2013-2014 might be due to low temperature, moderate relative humidity and slight rainfall that provided a very congenial condition for the rapid buildup of aphid population. Piyaratne et al. [28], also reported that the population of aphids greatly affected by weather parameters such as temperature, relative humidity, rainfall, wind and sunshine hours. Similar, observation of weather affects in relation to aphids or other insects was also reported by several workers [33-36].

C. sexmaculata found abundantly and more active from October to November and predator richness build up again during February to mid March. Similarly, Tank and Korat [37] found that good number of grubs and beetles of *C. sexmaculata* on cowpea crop from mid September to the end of October. The early appearance of *C. sexmaculata* was also observed on *P. sinensis* during both years, probably due to suitability of host plant. The population of *C. sexmaculata* was observed moderate to very high on *P. sinensis* from October to January (4-5 months). However on *L. purpureus*, its population was observed from November to March (5 months) (Plate-C & D). Thus, the appearance of predator *C. sexmaculata* and its population buildup also observed host plants and temperature dependent.

When the aphid populations build up, the population of predator increased continuously to maximum even after decline of aphid from field. Similarly, Atwal et al. [8] observed that the population of *C. sexmaculata* increased continuously to maximum after decline of aphid population. Though phenology and food quality of host significantly influence the population development of the aphid, the population of aphids are generally maintained, by a combine effect of biotic and abiotic factors [3]. Both the abiotic and biotic factors have equal role in regulating the population incidence of *A. craccivora* and *C. sexmaculata* in nature.

Table 1: Seasonal association of *A. craccivora* and their predator, *M. sexcmaculata* on two different host plants during 2012-2013

Date	Temp.	Humidity	*P. sinensis*		*L. purpureus*	
			Degree of infestation of *A. craccivora*	Degree of population of *C. sexmaculata*	Degree of infestation of *A. craccivora*	Degree of population of *C. sexmaculata*
13 Aug.	33.3 ºC	45%	-	-	-	-
20 Aug.	33.1 ºC	48%	-	-	-	-
27 Aug.	32.3 ºC	55%	-	-	-	-
3 Sep.	27.4 ºC	56%	-	-	-	-
10 Sep.	28.8 ºC	57%	-	-	-	-
17 Sep.	28.1 ºC	90%	+*	-	-	-
24 Sep.	31.1 ºC	83%	++	-	-	-
1 Oct.	33.1 ºC	69%	++	-	-	-
8 Oct.	28.2 ºC	56%	+++	-	+*	-
15 Oct.	26.6 ºC	58%	+++	+*	++	-
22 Oct.	24.9 ºC	50%	+++	+	++	-
29 Oct.	22.4 ºC	60%	++++	++	++	-
5 Nov.	22.2 ºC	64% rainfall	++++	+++	++	-
12 Nov.	21.8 ºC	63%	++	++++	+	-
19 Nov.	19.1 ºC	50%	++	+++	++	+*
26 Nov.	16.9 ºC	51%	+	++	++++	++
3 Dec.	15.8 ºC	55%	+	+	++++	++
10 Dec.	17.5 ºC	60%	+	+	++++	++
17 Dec.	16.9 ºC	61%	+	+	++++	++
24 Dec.	10.5 ºC	72%	++++	+++	++++	+++
31 Dec.	6.2 ºC	81%	+++	++++	+++	+++
7 Jan.	6.8 ºC	86%	++	+++	+++	++++
14 Jan.	12.3 ºC	78%	+	++	+++	++++
21 Jan.	11.6 ºC	69%	**	**	++	++
28 Jan.	10.8 ºC	64%	***	***	+	++
4 Feb.	16.9 ºC	61%	-	-	+	+++
11 Feb.	16.2ºC	58%	-	-	+	++++
18 Feb.	17.8 ºC	55%	-	-	+++	+++
25 Feb.	21.9 ºC	56%	-	-	++++	+++
4 Mar.	21.8 ºC	60%	-	-	+++	+++
11 Mar.	24.2 ºC	58%	-	-	+	++
18 Mar.	25 ºC	49%	-	-	**	**
25 Mar.	27.4 ºC	48%	-	-	***	***

*= Appearance of aphids and predators **= Disappearance of aphids and predators
***= Plant on brink of death
Degree of infestation/ population:
+ = Low, + + = Moderate, + + + = High, ++++ = Very high

Table 2: Seasonal association of *A. craccivora* and their predator, *M. sexcmaculata* on two different host plants during 2013 – 2014

Date	Temp.	Humidity	*P. sinensis*		*L. purpureus*	
			Degree of infestation of *A. craccivora*	Degree of population of *C. sexmaculata*	Degree of infestation of *A. craccivora*	Degree of population of *C. sexmaculata*
19 Aug.	29.9 ºC	85%	-	-	-	-
26 Aug.	28.7 ºC	84%	+*	-	-	-
2 Sep.	28.4 ºC	81%	++	-	-	-
9 Sep.	27.2 ºC	75%	+	++*	-	-
16 Sep.	27.1 ºC	70%	+	+++	-	-
23 Sep.	26.9 ºC	68%	+++	++	+*	-
30 Sep.	26.5 ºC	61%	++++	++	++	-
7 Oct.	26.3 ºC	56%	+++	++++	++	-
14 Oct.	25.1 ºC	58%	+	+++	++	-
21 Oct.	24.9 ºC	50%	+	+	+++	-
28 Oct.	22.5 ºC	60%	++	++	+++	-
4 Nov.	22.8 ºC	59%	++++	+++	+++	+*
11 Nov.	21.2 ºC	57%	++	+	+++	++
18 Nov.	19.9 ºC	51%	+	++	+++	++
25 Nov.	16.9 ºC	80%	++	++	+++	++
2 Dec.	15.8 ºC	81%	+++	+++	++++	++
9 Dec.	17.5 ºC	82%	++++	++++	++++	+++
16 Dec.	16.9 ºC	80%	++++	+	++++	+++
23 Dec.	10.5 ºC	80%	+++	+++	++++	+++
30 Dec.	9.6 ºC	81%	++	+++	+++	++++
6 Jan.	7.8 ºC	80%	+	++	+++	++
13 Jan.	10.8 ºC	80%	**	**	++	+

20 Jan.	13.4 ºC	70%	***	***	++	+
27 Jan.	14.4 ºC	65%	-	-	++++	+++
3 Feb.	17.8 ºC	62%	-	-	++++	++++
10 Feb.	17.9 ºC	57%	-	-	++++	++++
17Feb.	18.4 ºC	58%	-	-	++	++++
24 Feb.	19.8 ºC	57%	-	-	+++	++++
3 Mar.	21.8 ºC	60%	-	-	++++	++++
10 Mar.	23.9 ºC	60%	-	-	++++	++++
17 Mar.	24.5 ºC	61%	-	-	+++	++++
24 Mar.	24.8 ºC	65%	-	-	++	++++
31 Mar.	26.2 ºC	66%	-	-	**	**
7 Mar.	26.9 ºC	69%	-	-	***	***

*= Appearance of aphids and predators **= Disappearance of aphids and predators
***= Plant on brink of death
Degree of infestation/ population:
+ = Low, + + = Moderate, + + + = High, ++++ = Very high

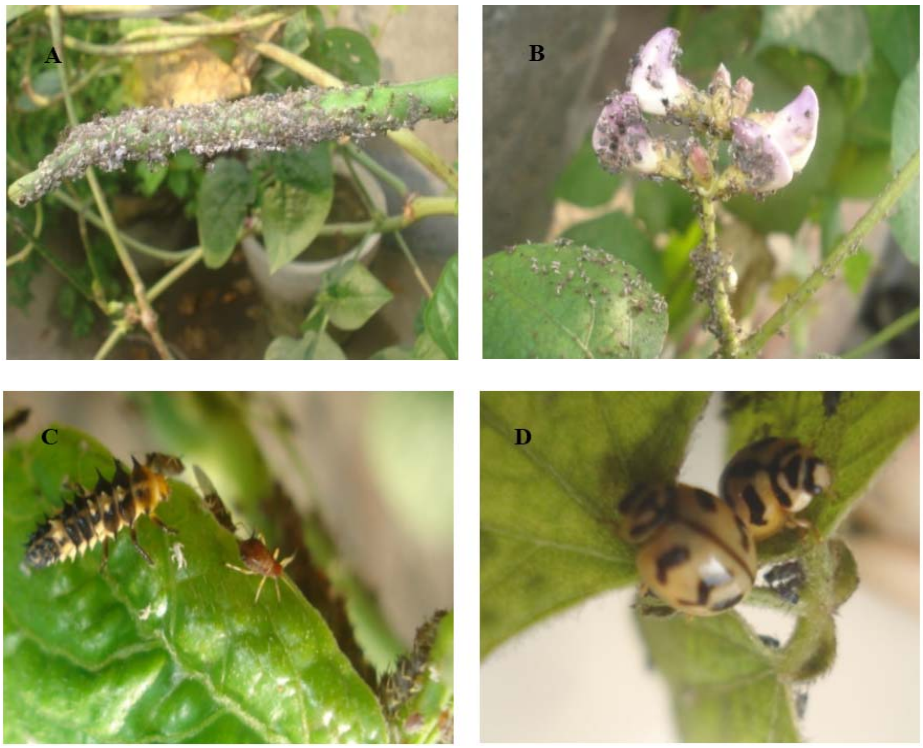

Fig 1: Plate A. Very high degree of infestation of *A. craccivora* on fruit of *P. sinensis.*
Plate B. Very high degree of infestation of *A. craccivora* on the inflorescence of *L. purpureus.*
Plate C. Association of grub of *C. sexmaculata* and *A. craccivora* on *P. sinensis.*
Plate D. Association of adults of *C. sexmaculata* and *A. craccivora* on *L. purpureus.*

5. Conclusion

The early appearance of both *A. craccivora* and its predator, *C. sexmaculata* was observed on *P. sinensis* in both years, probably due to suitability of host plant. The infestation of aphids was observed longer period on *L. purpureus* because of maximum survival of host plant. Thus, the present investigation reveals that both abiotic and biotic factors have equal role in regulation the population of aphids and their predator in agro-ecosystem. The analysis of coccinellid, prey in relations to host plants is important from theoretical point of view for predicting ladybird activity in the field and for improving their impact in the contexts of conservation and augmentative biological control. Therefore, for effective pest management needs ecology of predator prey system.

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7. References

1. Southwood TRE. Ecological Methods: with particular reference to the study of insect populations. John Wiley and Sons, New York, United States, 1978, 524.
2. Croft BA, Hoyt SC. Integrated management of insect pests of pome and stone fruits. New York: Wiley, 1983.
3. Dixon AFG. Aphid Ecology: Lifecycle, polymorphism and population regulation. Annual Review of Ecology and Systematics. 1977; 8:329-353.
4. Ahmad ME, Kumar S, Parween N, Rakhshan. Screening of Aphidophagous Coccinellids Coleoptera: Coccinellidae from Northeast Bihar. Journal of Advance Zoology. 2012; 33(2):103-112.
5. Rakhshan, Ahmad ME. Influence of host plants on the growth and development of *Cheilomenes sexmaculata*

Fabricius Coleoptera: coccinellidae prey on *Aphis craccivora* Koch. International Journal of Science and Research. 2015a; 4(5):250-254. http://www.ijsr.net/archive/v4i5/SUB154017.
6. Rakhshan, Ahmad ME. Predatory efficiency of *Cheilomenes sexmaculata* Fabricius Coleoptera: Coccinellidae against *Aphis craccivora* Koch on various host plants of family fabaceae. European Scientific Journal. 2015 b; 11(18):154-161. http://eujournal.org/index.php/esj/article/view/5829.
7. Kumar S, Ahmad ME, Rakhshan. Influence of prey species on feeding preference, postembryonic development and life span of *Cheilomenes sexmaculata* Fabricius. European Scientific Journal. 2016; 12(36):403-410. http://dx.doi.org/10.19044/esj.2016.v12n36p403
8. Atwal AS, Chaudhury JP, Ramzan M. Mortality factors in the natural population of *Lipaphis erysimi* (Kalt.) in relation to parasites, predators and weather condition. Indian Journal Agriculture. Science. 1971; 41:507-510.
9. Saha JL, Agarwala BK. Population trend of *Aphis gossipii* Glover Homoptera: Aphididae and its natural enemies on egg plant, *Solanum melongana.* Proc. Aphidology in India, Agartala ed. By B. K Agarwala. 1986, 13-18.
10. Bakhetia DRC, Brar KC, Sekhon BS. Seasonal incidence of *Lipaphis erysimi* (Kalt.) on the *Brassica* species in the Punjab. Journal of Aphidology. 1986, 29-36.
11. Verma KD, Parihar SBS. Development of *Myzus persicae* Sulzer Homoptera: Aphididae on some potato cultivar. Journal of Aphidology. 1996; 10:81-84.
12. Ramkishore, Malik K. Effect of abiotic factors on winged forms of *Myzus persicae* Sulzer on potato crop. Journal of Aphidology. 1997; 11(2):167-170.
13. Vijay KK, Raj D. Population dynamics of *Brevicoryne brassicae* L. infesting cauliflower, *Brassica oleracea* L. var. *botrytis* L. in mid hill sub humid zone of Himachal Pradesh. Journal of Aphidology. 1999; 13:67-74.
14. Bisht RS, Rana DS, Mishra PN. Bioecology of predators and parasitoids of aphids in Garhwal hills. Journal of Aphidology. 2001; 15:123-128.
15. Devi PB, Singh TK, Devi S. Natural enemies complex of *Myzus persicae* Sulzer Homoptera: aphididae on cabbage in Manipur. Journal of Aphidology. 2001; 15:181-183.
16. Biradar VK, Dhanokar BK. Seasonal dynamics of mustard aphid, *Lipaphis erysimi* Kalt. Homoptera: Aphididae and its parasitoid, *Diaeretiella rapae* Mcintosh Hymenoptera: Braconidae in Marathwada region of Maharastra. Journal of Aphidology. 2004; 18:1-4.
17. Debraj Y, Singh TK. Population dynamics of cabbage aphid *Brevicoryne brassicae* Linn. in relation to abiotic and biotic factors at different altitudes of Manipur. Indian Journal of Entomology. 2004; 66(2):172-175.
18. Bhatt NA, Borad PK, Darji VB, Jani JJ. Population fluctuation of *Uroleucon compositae* Theobald Homoptera: Aphididae on *Gaillardia Pilchella* Foug. In relation to biotic and abiotic factors. Journal of Aphidology. 2007; 21(1-2):55-58.
19. Santibala P, Bijaya RK, Lokeshewari, Singh TK. Impact of climatic changes on vulnerability of oak aphids and their natural enemies in Manipur, an indo-Burma biodiversity hotspot. Journal Experimental Zoology, India. 2009; 12(2):279-284.
20. Tomar SPS. Impact of weather parameters on aphid population in cotton. *Indian* Journal of Agriculture Research. 2010; 44(2);125-130. http://arccjournals.com/journal/indian-journal-of-agricultural-research/ARCC1059.
21. Talati GM, Butani PG. Reproduction and population dynamics of groundnut aphid *Aphis craccivora.* Gujarat Agricultural University Research Journal. 1980; 5:54-55.
22. Malik SP, Salik R, Panday ND, Singh SV. Effect of biotic and abiotic factors on the abundance of bean aphid, *Aphis craccivora* Koch. Bull. Ent., 1991; 32:25-31.
23. Sharma RP, Yadav. Population dynamics of bean aphid *Aphis craccivora* Koch. and its predatory complex in relation to crop type Lentil, *Lathyrus* and faba bean and weather conditions. Journal Entomological Research. 1994; 18(1):25-36.
24. Parsana GJ, Kapadia MN, Butani PG. Association of groundnut aphid, *Aphis craccivora* Koch with Coccinellid predators and their relation to abiotic factors. Journal of Aphidology. 1997; 11(2):199-200.
25. Hossain MA, Ferdou J, Salim MMR. Relative Abundance and yield loss Assessment of Lentil Aphid, *Aphis craccivora* Koch in Relation to Different Sowing Dates. Journal Agriculture & Rural Development. 2006; 4(172):101-106.
26. Thejaswi L, Mohan IN, Manjunatha M. Studies on population dynamics of pest complex of field bean *Lablab purpureus* L. and natural enemies of pod borers. Karnataka Journal of Agricultural Science. 2008; 21(3):399-402.
27. Yoldas Z, Guncan A, Koclu T. Seasonal Occurance of aphids and their natural enemies in Satsuma mandarian orchards in Izmir, Turkey. Turk. Entomol. Derg., 2011; 35(1):59-74.
28. Piyaratne MKDK, Huiyan Z, Zuqing H, Xiangshun H, Yu W, Bailing W. A model to analyze weather impact on aphid population dynamics: an application on swallow tail catastrophe model. European Scientific Journal. 2014; 10(18):300-311. https://scholar.google.ch/citations?view_op=view_citation&hl=de&user=s59mZZoAAAAJ&citation_for_view=s59mZZoAAAAJ:zYLM7Y9cAGgC.
29. Rakhshan, Ahmad ME. Study of mutualistic ants associated with *Aphis craccivora* Hemiptera: Aphididae on various host plants of family Fabaceae in Northeast Bihar (India). European Scientific Journal. 2015c; 11(18):317-327.
30. Kataria R, Kumar D. On the aphid-ant association and its relationship with various host plants in the Agroecosystems of Vadodara, Gujrat, India. Halteres. 2013; 4:25-32.
31. Dhiman DC, Agarwal BL. Damage caused by *Hysteroneura setariae* Thomas Homoptera: Aphididae to *Eulaliopsis binata* Retz. Journal of Aphidology. 1996; 10:49-52.
32. Khandwe N, Choudhary AK, Singh OP. Population dynamics of *Myzus persicae* Sulzer Homoptera: Aphididae on potato in Madhya Pradesh. Journal of Aphidology. 1999; 13:81-84.
33. Kidd NAC. The population dynamics of the large pine aphid, *Cinara pinea* mordy. Simulation of field populations. Population Ecology. 1990; 32:209-226.
34. Wool D. Herbivore abundance independent wheather. A 20-year study of a galling aphid *Baizongia pistaciae* Homoptera: Aphididae. Population ecology. 2002; 44:281-291.
35. Day KR, Ayres MP, Harrington R, Kidd NAC. Interannual dynamics of aerial and arboreal green spruce

aphid populations. Population Ecology. 2010; 52:317-327.
36. Finlay KJ, Luck JE. Response of the bird cherry oat aphid *Rhopalosiphum padi* climate change in relation to its pest status, vectoring potential and function in a crop-vector-virus pathosystem. Agriculture, Ecosystems and environment. 2011; 144:405-421.
37. Tank BD, Korat DM. Seasonal abundance of *Cheilomenes sexmaculata* Fab. in Middle Gujarat Conditions* Karnataka Journal of Agricultural Science. 2008; 21(3):453-455.