Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

J E Z S Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2016; 4(5): 326-331

Received: 19-07-2016
Accepted: 20-08-2016

Hakim Ali Sahito
Department of Zoology, Faculty of Natural Sciences, Shah Abdul Latif University, Khairpur Mir's, Sindh, Pakistan

Rukhsana Solangi
Department of Zoology, Faculty of Natural Sciences, Shah Abdul Latif University, Khairpur Mir's, Sindh, Pakistan

Tasneem Kousar
Department of Zoology, Faculty of Natural Sciences, Shah Abdul Latif University, Khairpur Mir's, Sindh, Pakistan

Zafar Hussain Shah
Department of Zoology, Faculty of Natural Sciences, Shah Abdul Latif University, Khairpur Mir's, Sindh, Pakistan

Wali Muhammad Mangrio
Department of Zoology, Faculty of Natural Sciences, Shah Abdul Latif University, Khairpur Mir's, Sindh, Pakistan

Correspondence
Hakim Ali Sahito
Department of Zoology, Faculty of Natural Sciences, Shah Abdul Latif University, Khairpur Mir's, Sindh, Pakistan
Email: hakim.sahito@salu.edu.pk

Population fluctuation of aphids, *Lipaphis erysimi* (Kalt) with response of biological control under mustard field conditions

Hakim Ali Sahito, Rukhsana Solangi, Tasneem Kousar, Zafar Hussain Shah and Wali Muhammad Mangrio

Abstract
The field experiment was carried out in the experimental area of Shah Abdul Latif University, Khairpur during Rabi season, 2014-15 on six cultivated mustard varieties viz., S-9, Toria selection, Aghati sarhein, J.S -13, Janbho selection and Sindh raya. The results indicated that sucking insect pest; *Lipaphis erysimi* (Kalt) appeared from seedling till harvest of the crop. The overall means showed that the maximum population was recorded on T. selection, 28.92 per leaf followed by A. sarhein, 22.45; J.S-13, 13.71; S.9, 13.31; S. raya, 11.55 and J. selection, 10.52. The analysis of variance showed significant differences in the population of pest in all varieties. The predators' activities were recorded on the varieties having maximum pest activities. Overall data suggested that the population of insect pest and predators remained constant on all varieties. Finally, the less population of the predators was due to less population of aphids. Similarly the predator population was also observed on same 6 varieties of mustard crop namely; S-9, T. selection, A. sarhein, J.S-13, J. selection and S. raya. The overall means showed that the maximum population of *C. septempunctata* recorded on A. sarhein, 1.36 per plant followed by T. selection, 1.14; S-9, 0.69; J.S- 13, 0.65; S. raya, 0.63, and J. selection, 0.38, respectively. It was concluded that in starting the predator population was found lesser but when it went in to peak levels the pest aphid population reduced which found to be positive correlation with pest population.

Keywords: *L. erysimi*, varieties, predators, correlation and mustard

1. Introduction
The oil seed crops play a significant role in the economy of the country because of their value in import exchange [1]. Mustard, *Brassica campestris* is cultivated throughout the world, the most commonly grown brassica oil seed crops occupy significant place regarding the edible oil production because the seeds of brassica contain about 42% oil. According to [2] this crop is originated in China and from there it was introduced to India. In Pakistan oil seeds crops are mostly grown in Rabi season [3]. The mustard oil is an edible used in cooking and preparing ointments, soap whereas; crop is used for green manure and fodder grown on 81% of the total area [4]. The area and production level of rape and mustard grown in winter season in Pakistan about 649x103 acres, 217x103 tons seeds and 69x103 tons oil [5]. Edible oil is one of the nutritionally essential diets and its consumption is increasing in our country from 0.3 million tones to1.95 million tones. The per capita consumption of edible oil is around 14-15 kg against an average of 8-9 kg for developing countries [6]. Pakistan is constantly scarce in production of edible oil and meets its requirements through import from other countries which cost an enormous amount of foreign exchange. Its import bill is continuously the second largest after petroleum and constitutes the single largest expenditure on any of the imported food items. During 2009-2010, due to scarcity, Pakistan imported 1.246 million tons of edible oil that cost 77.78 billion rupees [7].

The mustard crop is more vulnerable to a wide variety of insect pests from sowing till harvest than other oil seed crops. The invasion by insect pests are one of the important factors responsible for low yield such as; mustard aphid, *L. erysimi* (Kalt), cabbage aphid, *B. brassica* (L), mustard sawfly, *A. proxima* (Klug), cabbage butterfly, *P. brassicae* (Linn), painted bug, *B. picta* (K), mustard leaf eater, *S. litura* (F), leaf miner, *Ch. horticola* (Goureau) thrips, *T. tabaci* and whitefly, *B. tabaci* (Gennedius) [8]. Among them, *L. erysimi* Kaltenbach, (Aphididae: Homoptera) is the most devastating pest [8] in Bangladesh and is distributed in many other countries [9, 10] also found most preferred crop to sucking complex and six varieties of mustard

mostly attacked in Sindh who evaluated the pest population was also reduced through natural enemies [11]. Reported that the whiteflies are limiting factor in the production of mustard and rape seed. Three species of aphids i.e., *B. brassicae, L. erysimi* and *M. persicae* are more abundant and widely distributed [12]. Among all, aphids found very serious insect pest throughout the world [13, 14] reported that the *L. erysimi* (K) is a worldwide pest on brassica crops. Another species of mustard aphid, *L. erysimi* (Kaltenbach) was known as a major pest of *Brassica campestris* and *Brassica juncea* reported by [15]. The mustard aphid, *L. erysimi* (Kalt) ravaged the crop during the reproductive phase and acts as a limiting of aphid, *L. erysimi* (Kalt) may become so plentiful during winter [16]. Mustard aphid, *L. erysimi* both the adults and nymphs are pale greenish in color and look like louse and feed in large numbers on leaves, flower buds, pods and shoots of cruciferous oilseeds. Both nymphs and adults suck the cell sap from leaves, stem, inflorescence or the developing pods of the host plants that results in curly appearance, the flowers fail to form pods and the developing pods do not produce healthy seeds. Due to sap sucking of *L. erysimi*, leaves become curled and discolored, spots appear on the foliage, and plants may gradually wilt, turn yellowish or brownish and finally die. *L. erysimi* causes 35-73% reduction in yield and 5-6% in oil content, about 30 to 90% yield of mustard without any control measure [17].

It is necessary to find new control measures for the aphid management programme therefore, the studied relative abundance of the effective natural enemies of mustard aphid, *L. erysimi* in farmers' fields with highest (41.97%) consuming species, due to self-powered self-sufficient and self-regulating, requiring no further investments in control till harvest [18]. Reported the availability of alternative prey considered to be an important factor for the conservation of predators in agro-ecosystems. However, scarcity of prey may prevent *C. septempunctata* from reproducing or initiate long distance migration. Time of sowing has a significant effect on the infestation of mustard crop by aphids. Sowing the crop early in the season is reported to be less affected by aphid attack [19]. The present study was conducted at farmer's unsprayed field to check the population fluctuating of pest and predators, finally the better results were shared among researchers mustard growing farmers of the region at district Khairpur - Sindh.

2. Material and Methods

The six mustard seed varieties namely; S-9, T. selection, A. sarhein, J. selection, J.S-13 and S. raya were taken from oil seed section, Agriculture Research Institute (ARI) Tandojam and cultivated on 10.11.2014, under farmer's field conditions, located near at city UC, Gadeji Ranipur during Rabi season, 2014-15 on Randomized Complete Block Design (RCBD). The seed was cultivated through broad casting method on six different same plot sizes in a one acre which left to be pesticides free. All agronomical practices were applied such as; weeding, thinning, fertilizers, watering as per need basis etc. The data were started when plant bearded 5-7 leaves after cultivation till the harvesting to check the population fluctuation of pest and predators, further methods applied in the study are given as below.

2.1. Sampling methods of pest, *Lipaphus erysimi* (Kalt) and predator, *Coccinella septempunctata* (Linnaeus) under field conditions

Aphid, *L. erysimi* appeared from 2nd week of January till harvest of the crop thereafter, it increased slowly and gradually and reached its peak in last week of March. The aphids damage the leaves and shoots of the crop habitually therefore population of aphids at initial stage mostly remains low in population and thus count was made on leaves and shoots as well. On shoots, the population was counted on 10 cm, whereas population on the leaves was counted throughout the leaf similarly as in all six cultivated mustard varieties. Therefore, 30 plants of each variety were selected at random and data was taken from top, middle and bottom sides for pest, *L. erysimi* whereas, the population of predators (grub and adult) was taken throughout the plant from top to bottom.

2.2. Statistical analysis

The statistical analysis of variance (ANOVA) of pest population on different varieties were done and least significant differences (LSD) were compared among mustard varieties and the mean values were compared at ($P \leq 0.05$) through computer software Statistics-(8.1) student package, USA. Finally, the correlation of predators with pest on different mustard varieties was also carried out.

3. Results

3.1. Aphids, *L. erysimi* on different mustard oil seed varieties

During the research period the aphid population was observed on six varieties of mustard crop viz., S-9, T. selection, A. Sarhein, J.S-13, J. selection and S. Raya. The crop kept unsprayed to check the aphid population on different varieties with the response of natural enemy. Initially, the pest appeared on 2nd week of January, 2015. The lower aphids population on the variety S-9 was observed (1.87/ twig) 10 cm whereas; the peak population was observed (28.70) on dated 19.3.2015 with the overall mean population (13.31), respectively (Fig. 1). On variety T. selection, the lower aphids population was observed (2.70/ twig) 10 cm whereas; the peak population was observed (55.97) on dated 19.3.2015 with the overall mean population (13.31/twig) 10 cm / plant (Fig. 2). On variety A. Sarhein, in starting it was found to be most affected variety with aphid population was observed (4.03/ twig) on 10 cm. After that, it was observed bit reduced on third week of the data collection thus; the peak population was observed (42.47) on dated 2.4.2015 with the overall mean population (22.45) (Fig. 3).

On variety A. Sarhein mostly in starting conditions it was found to be most affected variety on which the aphid population was observed (4.03/ twig) 10 cm / plant. Letter on, it reduced on 3rd week of the data collection. The peak population was observed (42.47) on dated 2.4.2015 with the overall mean population (22.45) on 26.2.2015, (Fig. 3). In variety J.S-13, the lower aphids population was observed (2.63/ twig) in starting dates whereas; the peak population was observed (28.30) with the overall mean population (13.71/twig) 10 cm / plant (Fig. 4). Only the variety J. selection was observed resistance against this vigorous pest because in starting there was no any damage was observed but the pest population appeared when other varieties were found most affected. Therefore, the aphids' population was observed in the peak population (21.93) on dated 26.3.2015 with the overall mean population (10.52), respectively (Fig. 5). On variety S. Raya, the lower aphids population was observed (2.13/ twig) in starting dates whereas; the peak population was observed (24.97) on dated 19.3.2015 with the overall mean population (11.55/twig) 10 cm / plant (Fig. 6).

The analysis of variance showed the significant differences (DF= 13, 2; F= 366; P= 0.001) among all varieties (P<0.005).

3.2. Predator 7 spotted beetle, *C. septempunctata* on different mustard oil seed varieties

Similarly, the predator population was also observed on same six cultivated varieties, the voracious predator was first time found in the 1st week of February, 2015 on variety S-9 with the initial appearance which was observed (0.03) / plant on dated 8.1.2015. The peak population was observed (2.23) on dated 5.2.2015 with the overall mean population (0.69), respectively (Fig. 1). On variety T. selection, the lower predator population was observed (0.03) in starting dates of data collection. The peak population was observed (3.93) on dated 2.4.2015 with the overall mean population (1.14) / plant (Fig. 2). On variety, A. Sarhein, in starting it was found to be most favorable variety that predator population was observed (0.07) whereas; the peak population was observed (4.13) on dated: 14.4.2015 with the overall mean population (1.30) / plant (Fig. 3).

On variety J.S- 13, the lower predator population was observed (0.03) whereas; the peak population was observed (2.17) on dated 2.4.2015 with the overall mean population (22.45) on dated 26.2.2015, (Fig. 3) on the variety J. selection, the lower predator population was observed (0.03) in starting dates when data was taken to check the population fluctuation with the response of pest and natural enemy. The peak population was observed (1.50) on dated 14.4.2015 with the overall mean population (0.38), respectively (Fig. 5). On variety S. Raya, the lower predator population was observed (0.03) in starting dates whereas; the peak population was observed (2.30) on dated 9.4.2015 with the overall mean population (0.63) / plant, respectively (Fig. 6).

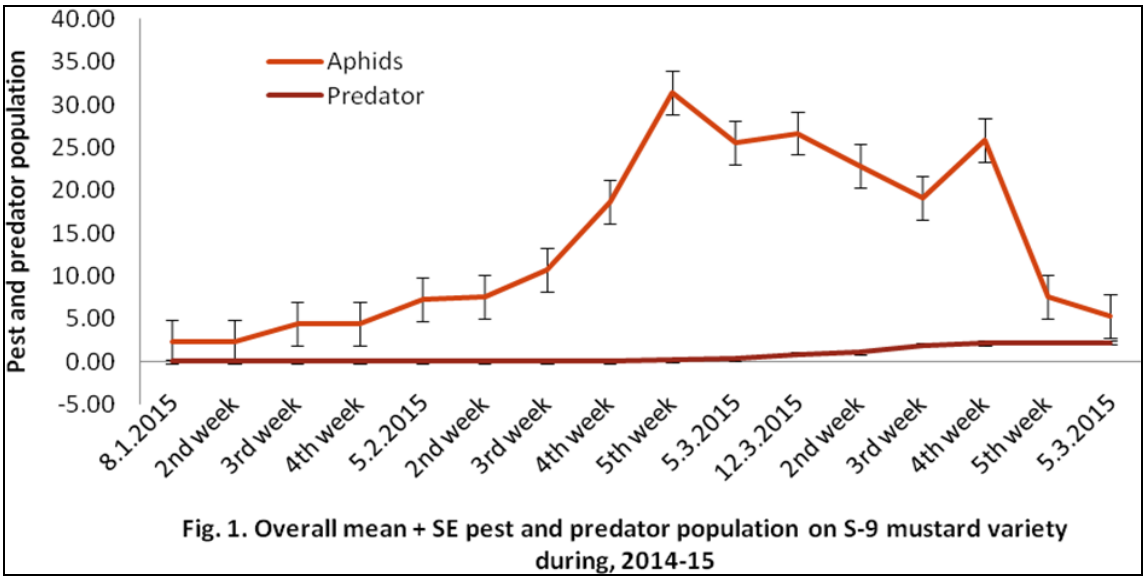

Fig. 1. Overall mean + SE pest and predator population on S-9 mustard variety during, 2014-15

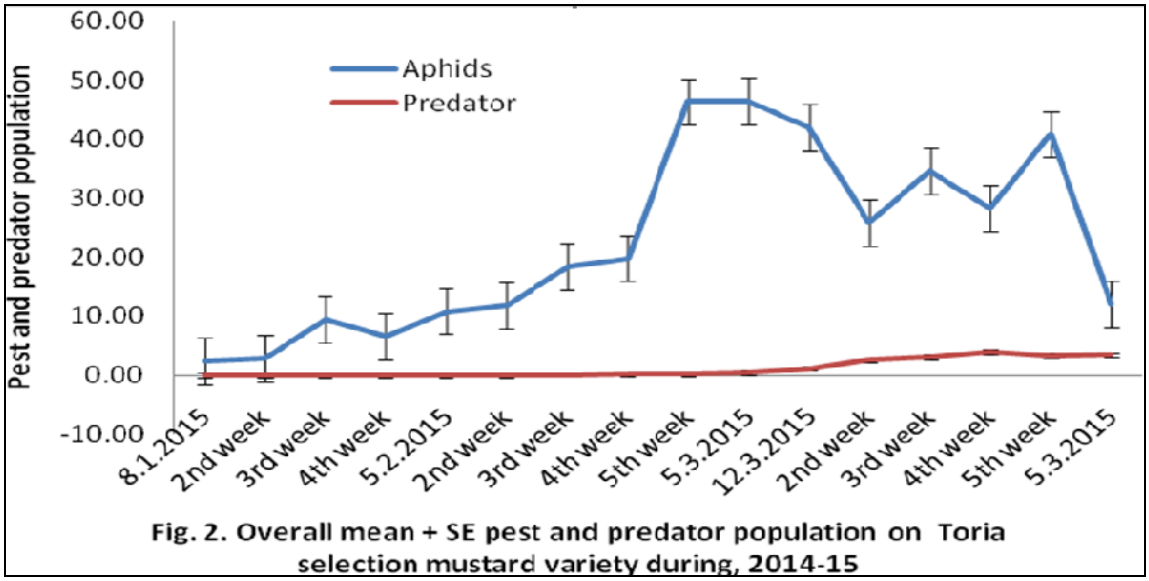

Fig. 2. Overall mean + SE pest and predator population on Toria selection mustard variety during, 2014-15

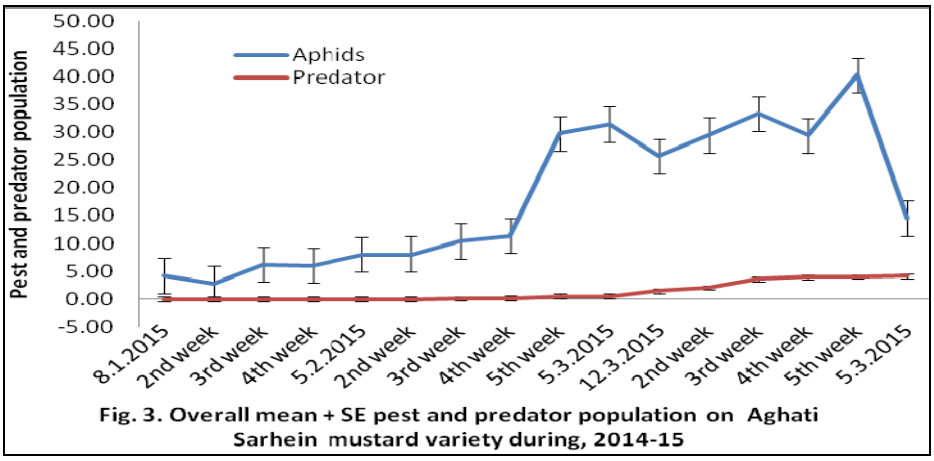

Fig. 3. Overall mean + SE pest and predator population on Aghati Sarhein mustard variety during, 2014-15

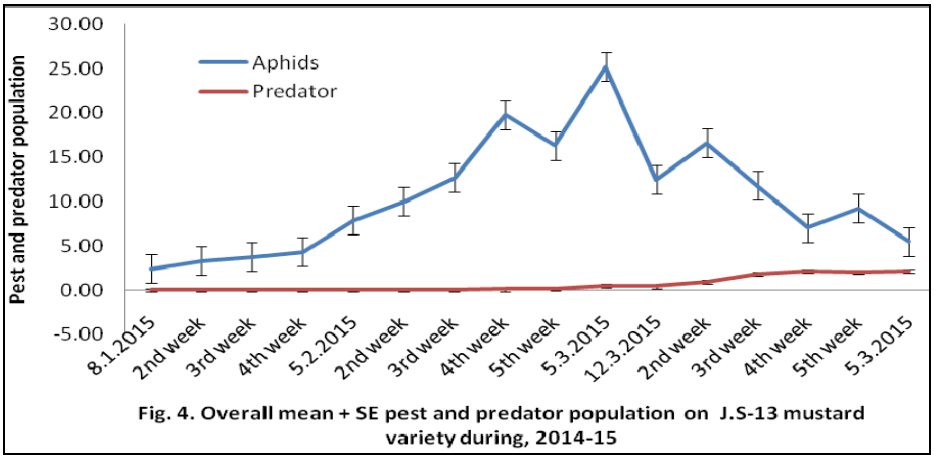

Fig. 4. Overall mean + SE pest and predator population on J.S-13 mustard variety during, 2014-15

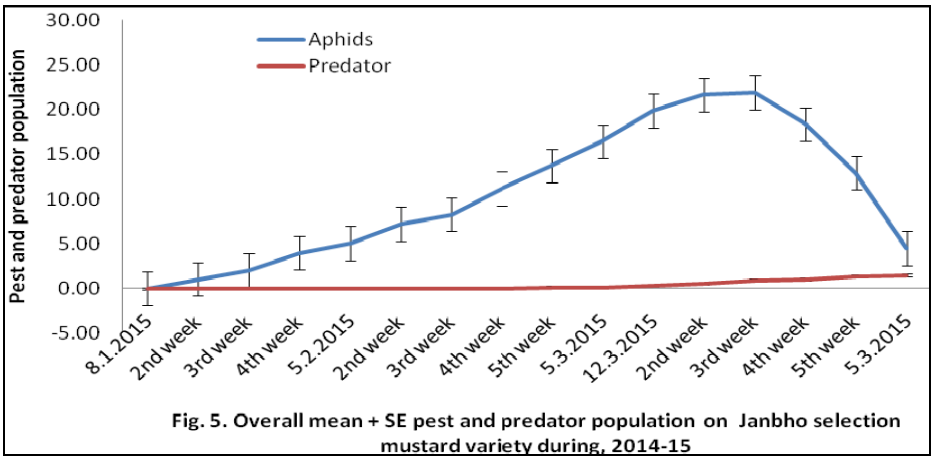

Fig. 5. Overall mean + SE pest and predator population on Janbho selection mustard variety during, 2014-15

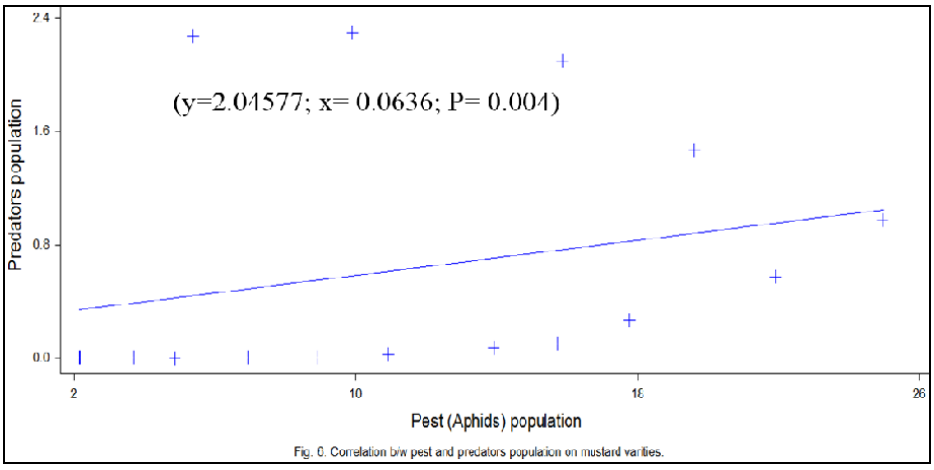

Fig. 6. Correlation b/w pest and predators population on mustard varities.

4. Discussion

The research was carried out at district Khairpur during, 2014-15 to investigate the aphid population dynamics on six different varieties of mustard crop namely; S-9, T. selection, A. Sarhein, J.S-13, J. selection and S. Raya. Occurrence of *L. erysimi* was recorded just after one week of germination of mustard crop. After that, the population increased in the 1st week of April. The results are well supported by [20] who reported that *L. erysimi* known as the most important destructive pest of oil seed / mustard crop among different varieties. *L. erysimi* was recorded from seedling up to harvest of the crop. Initially, it appeared on the unsprayed plots of mustard crop in the 2nd week of January, 2015 [21] reported that the major activity period of the aphid population was started from the middle of December to the end of February. But according to our observation the major activity period of aphid population was started from February to April [22]. Reported that the maximum aphid population was recorded on T. selection variety whereas [23], reported the maximum aphid population per plant was recorded from Yellow Sarsoon. On the variety S-9, the lower aphids population was observed in starting of the dates of data collection whereas; the peak population found in the month of March with the overall mean population remained up to (13.31/twig) 10 cm / plant, respectively. The analysis of variance showed the significant difference in the population of this sucking insect pest [24] eported that the peak activity period of the aphid remained confined to January and first fortnight of February. But according to our observation the major period of activity was observed from the end of February to the mid of April during, 2015. *L. erysimi* is the most dreaded insect caused loss in yield ranged from 9 to 95% at different places of India [25, 26]. During present study, the results demonstrate that aphid attacked all varieties of Brassica. *L. erysimi* is the main insect pest of *Brassica campestris*.

The pest aphid population appeared at starting on the variety, T. selection in the 3rd week of January with the minimum population whereas; the peak population was observed in the 3rd week on March with the overall mean population (13.31/twig) 10 cm / plant. On variety A. Sarhein, the aphid population bit reduced on 3rd week of the data collection thus, the peak population was observed on 2nd week of April with the overall mean population (22.45), respectively. After that the population started declining towards the maturity of the crop. The peaks in *L. erysimi* population were recorded in last week of March and 3rd week of April. On every variety aphid population reached peak level coinciding with its flowering stage. The predator population started increasing with the increase in the aphid population. The highest predator population was observed in variety S-9 and A. Sarhein and in starting the lowest population was observed in variety T. selection, than consequently step forwarded slowly and gradually. On variety J. selection and S. Raya the minimum population was observed with predator population in starting of the dates which fluctuated and reached at maximum population. The bio-control agent like coccinellid has been reported to be effective for controlling the aphids, *L. erysimi* [27, 28] under laboratory and field conditions. Besides, the aphids are controlled most effectively through insecticides but they caused serious health problems and environmental hazards and their overuse quickly produces resistant to aphid populations [29]. Therefore, [30] reported that, *C. septempunctata* was more abundant in the Brassica crops. However, maximum activities were recorded on the varieties having maximum insect pest activities. Predators such as; Coccinellids, *Chrysoperla* sp., Orius sp., and spiders were found active as population of sucking pest complex appeared on mustard crop; feeding on aphid and others. Among different predators, lady bird beetle, *C. septempunctata* (Linn.) is the most important groups of entomophagous predator preying upon wide variety of aphids and managed the pest population in the field [31, 32, 33].

During the research study the coccinellids beetles were found ravenous feeding on aphids with its monomorphic with black spots on a bright red background. The research proved that the adults as well as immature stages were feeding on all stages of aphids. The population of predators on different varieties indicated that, the varieties having maximum activities of sucking insect pests harbored the maximum predator populations from the beginning till the maturity of mustard crop during the month of November to February. The results are in agreement with those of [25, 26] who also reported the co-existence of predators and pests in various agro- ecosystems [30]. Reported that *C. septempunctata* was more abundant than others in the mustard crops due to having maximum insect pest activities during the research activity and major biological control agents of Hemiptera, Thysanoptera and Acarina pests in all parts of the world. It was also observed among the various natural enemies of mustard aphid, the aphidophagous ladybird beetle, *C. septempunctata* Linnaeus, 1758 (Coleoptera: Coccinellidae) is the most efficient predator and occupies a remarkable place among the different bio-control agents of aphids. The family coccinellidae comprises 5,200 described species worldwide [34]. The majority of beetles are useful because of their predaceous nature; but some are harmful, being polyphagous [35]. Many appeared to be distasteful to birds, and their conspicuous appearance is an example of aposematic warning coloration. It is often assumed that aphidophagous lady beetles, consuming most aphid species that they encounter. *C. septempunctata* is one of the potential predators of the *L. erysimi* (Kalt.) that is a key pest of the rapeseed and mustard. For most, the augmentative releases and conservation techniques for ladybird beetle are significantly emphasized to exploit their uses in biological control [23]. It is an important predator of many species of aphids; eggs and small nymphs of mealybugs, jassids, eggs, and larvae of cotton leafworm [36] in Egypt and often plays a certain role in bringing them under control on aphids.

5. Conclusion

Keeping in the view, the significance results taken from this natural enemy 7- spotted ladybird beetle concluded and suggested for a safest control of aphid in different mustard crop varieties.

On the basis of the present result, it is further concluded that the sucking insect pest namely; *L. erysimi* attacked all varieties of mustard crop from germination till its maturity and caused considerable damage of all varieties. Indirect relation was seen in pest and predator population that means initially pest population increased due to low population of predator and lastly pest population was decreased due to increase in predator population. Therefore, it is suggested to enhance the predator activity is fruitful to decrease the pest population and eco-friendly safest to nature.

6. References

1. Jessop JP Toelkon HR. Flora of Australia. Part-1. Lycopodiaceae: Rosaceae South Australia Govt. Printing Division, Adelaide. 1996, 24-30.

2. Prain GK. Modern technique of raising field crops. Oxford and IBH Publication Company New Delhi. 1978, 302-313.
3. Khoso AW. Oil seed crops. Crops of Sindh. 5th revised edition. 1998, 225.
4. Nazir S. Oil seed crops. Crop Production, National Book Foundation, Islamabad. 1994, 374-380.
5. Anonymous. Economic survey, Government of Pakistan, Finance Division, Islamabad. 2002-2003, 19.
6. Agricultural Statistics of Pakistan. Ministry of Food Agriculture and Live stock (Economic Wing), Islamabad. 2005, 211.
7. MINFAL. Pakistan Economic Survey (2009-10). Govt. of Pakistan, Finance Div. (Econ. Advisor's Wing) Islamabad, Pakistan. 2010.
8. Verma AK, Patyal SK, Bhalla OP, Sharma KC. Bioecology of painted bug (*Bagrada cruciferarum*) (Hemiptera: Pentatomidae) on seed crop of cauliflower (*Brassica oleracea*) var. (botrytis) Subvar. (Cauliflora). Indian J. Agri. Sci. 1993; 63(10):676-678.
9. Setokuchi O. Seasonal prevalence of *Myzus persicae* Sulzer. and *L. erysimi* Kalt. (Homoptera: Aphididae) Kagoshima prefecture. Japanase J. Appil. Entomol. Zool. 1983; 21:219-233.
10. Sahito HA, Lanjar AG, Mal B. Studies on population dynamics of sucking insect pests of mustard crop (*Brassica campestris*). Pak. J. Agri., Agri. Engg., Vet. Sci., 2010; 26(1):66-74.
11. Pardhan TS. Status of insect pests of cruciferous in U.P. India. Indian J. Agri. Res. 1990; 12:45-50.
12. Rehman KA, Munir M, Yousaf A. Rape and Mustard in Pakistan, Park Islamabad. 1987, 101.
13. Minks AK, Harrewijn P. Aphids, their control: biology, natural enemies and control. Elsevier, Amsterdam, Oxford, New York, Tokyo. 1987; B:171-310.
14. Saljoqi AUR, Sadur-Rehman, Hussainand N, Shah AK. Insect pests of canola crop (other than aphid). Agri. and Biolog. Sci. 2006; 1(4):19-21.
15. Ghosh AK. Aphids (Homoptera: Insecta) of economic importance in India, Calcutta. The agriculture society of India. 1975, 134.
16. Bakhetia DRC. Insect pest problems and their management in rape and mustard crops. XV Anal. Workshop Cum-Seminar on rapeseed and mustard, held at CSAU Agric. Techno. Kanpur, September. 1979, 12-13.
17. Rouf FMA, Kabir H. Economic efficacy of some insecticides for the control of mustard aphid, *Lipaphis erysimi* Kalt. Bangladesh J. Entomol. 1997; 7:1-5.
18. Bianchi FJJA, Werf WVD, Der WWV, Van DW. Model evaluation of the function of prey in non-crop habitats for biological control by ladybeetles in agricultural landscapes. Ecol. Model. 2004; 38:177-193.
19. Patel SR, Awasthi AK, Tomar RKS. Assessment of yield losses in mustard (*Brassica juncea* L.) due to mustard aphid (*L. erysimi* Kalt.) under different thermal environments in Eastern Central India. Appl. Eco. and Envir. Res. 2004; 2(1):1-15.
20. Dutta SK, Dutta BC. A preliminary survey of insect pests of rapeseed-mustard in Central Brahmaputra valley zone of Assam. Plant Health. 1995; 1(15):20.
21. Prasad SK, Chakravarty. A model to predict the aphid population on rapeseed crop. In. Proceeding of National Workshop on Dynamic Crop Simulation Modeling for Agro Meteorological advisory Services. 315-320.
22. Desh R. Impact of weather factors on population build up of aphids infesting rape and mustard *(Brassica campestris* L.) at Palampur, Himachal Pradesh. Pest Management and Eco. Zool. 2002; 10(1):11-16.
23. Rizvi NH, Hussain T, Ali SS, Rajput MR, Ahmed, Shakoori AR. Comparative predatory behavior of larvae and adults of *Coccinella septempunctata* L. Proc. Pakistan Congr. Zool. 1994; 12:285-289.
24. Prasad SK, Pradhan S. Distribution and sampling of mustard aphid, *Lipaphis pseudobrassicae* (Davis). Indian J. Ento. 33, 260-71.
25. Singh NN, Pandey R, Rai S. Relative abundance of effective natural enemies of mustard aphid, *Lipaphis erysimi* (Kalt.). J. Appl. Zool. Res. 2003; 10:209-211.
26. Singh K, Singh NN, Raju SVS. Studies on preying potential of lady bird beetle (*Coccinella septempunctata* Linn.) in relation to mustard aphid (*Lipaphis erysimi* Kaltenbach). Indian J. Entomol. 2012; 74(1):93-94.
27. Singh K, Singh NN. Preying capacity of different Established predators of the Aphid, *Lipaphis erysimi* (Kaltenbach) infesting rapeseed - mustard Crop in Laboratory conditions. Plant Prot. Sci. 2013; 49(2):84-88.
28. Shukla AN, Singh R, Tripathi CPM. Effect of predation period on the functional response of *C. septempunctata* Linn. (Coleoptera: Coccinellidae) a predator of (*Lipaphis erysimi* (Kalt.) (Hemiptera: Aphididae). J. Adv. Zool. 1990; 11(1):27-32.
29. Ives AR, Karei VP, Perry. Response of a predator to variation in prey density at three hierarchical scales: lady beetles feeding on aphids. Ecology; 1995; 74:1929-1938.
30. Jogender S, Rana. Response of *Coccinella septempunctata* and *Menochilus sexmaculatus* (Coleoptera: Coccinellidae) to their aphid prey, *Lipaphis erysimi* (Hemiptera: Aphididae) in rapeseed-mustard. Eur. J. Entomol. 2006; 103:81-84.
31. Agarwala BK, Das S, Bhaumik AK. Natural food range and food habits of aphidophagous insects in north-east India. J. Aphidol. 1987; 1:18-22.
32. Ahmad MM, Ahmad SB. Comparative toxicity of two pesticides to adults of *Coccinella septempunctata* Linn. (Coleoptera: Coccinellidae). Insect Environment, 2009; 14(4):187-189.
33. Afroz S. Relative abundance of aphids and their coccinellid predators. J. Aphidol. 2001; 15:113-118.
34. Hawkeswood T. Beetles of Australia. Augus and Robertson, Sydney, Australia. Huffaker CB. (1958). Experimental studies on predation: dispersion factors and predator-prey oscillations. Hilgardia. 1987; 27:343-383.
35. Omkar, Bind RB. Record of aphids- natural enemies' complex of Uttar Pradesh. V. The Coccinellids. J. Adv. Zool. 1996, 44-48.
36. Ibrahim MM. Studies on *Coccinella undecimpunctata aegyptiaca* Reiche. II. Biology and life-history. Bull. Soc. Entom., Egypt, 1955b; 39:395-423.