www.biodicon.com Biological Diversity and Conservation

ISSN 1308-5301 Print; ISSN 1308-8084 Online BioDiCon 2/2 (2009) 85-89

Populations' synchronization of aphids (Homoptera: Aphididae) and ladybird beetles (Coleoptera: Coccinellidae) and exploitation of food attractants for predator

Muhammad SARWAR *

[1] Nuclear Institute of Agriculture, Tando Jam- 70060, Sindh, Pakistan

Abstract

Field Surveillance was conducted on synchronization in populations build up of aphids and its predator ladybird beetles (Coccinellidae) in canola [rape] (*Brassica napus* L.) field. Studies reflected that there was no appropriate synchronization between populations of the prey and its predator that appeared later. The nominal population of the predator was recorded when the population of the aphid was at its peak and the pest started to migrate from the canola fields. This gap may only be filled up by the use of environmentally non-toxic chemicals to attract predator for acceptable and eco-friendly suppressive measures of insect pest. Since behavioral approaches are key elements in integrated pest management, insect's food attractants technique to attract aphid predator coccinellids ladybird beetles was tested using the foliar application of protein hydrolysate, casein, sugar and torula yeast. Results demonstrated that increased population of lady beetle and reduced aphid damage occurred in treated plants in comparison with those in control. Treatments consisting of protein hydrolysate and sugar were more efficacious where the uppermost predator numbers were observed than in casein-applied treatment where the slight population was detected. Studies further revealed that the predator observed in torula yeast treated crop were moderate in numbers but significantly higher than in non-treated. The aphids' infestation was significantly low in protein hydrolysate bait spray treatment followed by sugar and torula yeast treatments. An identical trend of grain yield was recorded in the chemically treated crop in comparison with control where dropped yield was recorded. These results suggest that predator-attracting strategy may be used for aphid management.

Key words: *Synchronization, Ladybird beetle, Coccinellid, Aphid, Food attractants*

1. Introduction

Aphids constitute one of the key pests and main phyto-sanitary problems in rapeseed and mustard crops. An experiment conducted to determine the spatial distribution of *Lipaphis erysimi* (Kaltenbach) infesting Cruciferae under field conditions analyzed that its population followed an aggregated distribution pattern throughout the crop growth period (Rao and Lal, 2004). The typical life cycle of aphids includes several generations, and aphid *Myzus persicae* (Sulzer), collected from oilseed rape has developed several insecticide resistance mechanisms as a consequence of intense insecticide uses (Zamoum *et al*., 2005). Ideally, integrated pest management of aphids should rely on an array of tactics. In reality, the main technologies in use are synthetic pesticides. Because of well-documented problems with reliance on synthetic pesticides, viable alternatives are sorely needed, so, biological control must be improved and further studies should be done. The aphidophagous ladybird beetle, *Coccinella septempunctata* L. is one of the important potential predators of the mustard aphid *L. erysimi*. The beetle occupies quite a remarkable place among the naturally occurring biological control agents of aphids (Mathur, 1983). The researchers have studied the behavior and efficiency of its predation, and abiotic factors influencing its population in field as well as laboratory conditions (Singh and Singh, 1986). This predator has high potential of predation both in the immature as well as adult stages. Adults as well as larvae fed variously on aphids and consumed on an average 1203.55 aphids in the entire life, which is completed in 17.91 days (Akram *et al*., 1996).

Biological control constitutes the attempts to use natural enemies against pests either by introducing new species into the environment or by increasing the effectiveness of those already present. Monitoring for the presence and relative

* *Corresponding author* / Haberleşmeden sorumlu yazar: drmsarwar64@yahoo.com

abundance of natural insects enemies is an important component of an area-wide pest control. Food attractants can be used to attract predator's populations as direct control efforts of pest control, and to measure the effectiveness and influence of natural enemies whether or not valuable for crop protection. Earlier researchers like Sivinski and Calkins (1986) reported various pest fruit flies attracted to pheromones, pheromone precursors and Para pheromones. Food bait attractants are generally considered to be relatively efficient as compared to other forms of attractants available. So, food bait attractants are generally considered to be relatively efficient as compared to other forms of attractants available. However, the standard technique for the attraction of ladybird beetles species in particular is lacking. But the other factors affecting the hatching of ladybirds, such as climatic conditions might also be important. Arshad and Rizvi (2007) investigated an overall development and predatory performance of *C. septempunctata* on different aphid species to be significant under the conditions of 25±1°C, 70±5% RH and 12 h L: 12 h D. A linear correlation curve showed the dependency of predation on the developmental period of *C. septempunctata*. Ansari *et al*., (2007) observed the peak aphid population at a maximum, minimum and average temperature of 23.3 °C, 6.8 °C and 15.7 °C, respectively and mean relative humidity of 54.7% on *Brassica* germplasm at 90 days after sowing. Then, decline in aphid population and simultaneously increase of *Coccinella* was at 100 and 110 days after sowing, respectively. Maximum and average temperature showed a positively non-significant effect, while minimum temperature caused negatively non-significant effect on the population of aphid. However, relative humidity had a negative effect. Late appearance of *Coccinella* too could not have any regulatory effect on the incidence of this pest.

Our previous year preliminary study revealed that there was no appropriate harmonization between populations of the aphid prey and its coccinellids predator in canola field. Therefore, the present investigation was undertaken to find out lag time between populations of the aphid and its coccinellids predator. Park and Obrycki (2004) observed the temporal changes in aphid abundance posing a considerable challenge to ovipositing aphidophagous ladybirds, and in order to maximize their fitness they need to synchronize their reproduction with the early development of aphid population. The behavioral approaches are key elements in integrated pest management (Foster and Harris, 1997), and researchers like Cook *et al*., (2007) proposed the push-pull strategy as a behavioral manipulation method that uses repellent/deterrent (push) and attractive/stimulant (pull) stimuli to direct the movement of pest or beneficial insects for pest management. As a result, development of improved food-based strategy consisting of different food components was designed and investigated to attract the beetles. Then the aim of this work was to study the role of coccinellids in reducing the populations of aphids on canola crop. The dynamics numbers of aphids, coccinellids and degree of grain output were examined. Moreover, the species composition of the studied group of insects was also determined. Therefore, we evaluated the attractiveness of some selected food attractants for coccinellids, this strategy if integrated with other population-reducing methods would be environmentally nontoxic and the use of insecticides can be reduced.

2. Materials and methods

To assess the field efficacy of different food attractants, an experiment was conducted at the experimental farm of Nuclear Institute of Agriculture, Tando Jam-70060, Sindh, Pakistan during winter season between last week of November 2004 and first week of April 2005. This constituency is characterized by moderately cold winter where the average maximum temperature raised upto 30.82°C, while, it fall to minimum 13.75°C with 60.33% R.H. during study period. The experimentations were embarked on the canal and tube-well irrigated clay loam type soil. The test canola (*Brassica napus* L.) variety "Hyola-42" was moderately aphid and lodging tolerant showing normal volume of expansion. It was particularly selected for its better grain yield and yield stability in that location. The experiment was laid out in a randomized complete block design and replicated 3 times. The experimental plots were 2.5 m^2 sizes in which seeds were sown at 9 cm and 30 cm plant and rows spacing, respectively. A uniform dose of fertilizers were applied in all treatments at the time of sowing. Manual weeds removal method was advocated in controlling the commonly occurring wild plants in crop. All the agronomic packages of practices were followed to raise the crop except no application of pesticides.

Field Surveillance on synchronization in populations build up of aphids and its predator ladybird beetles (Coccinellidae) in canola field was carried out from crop sowing to maturity at 10 days intervals in field. The experimental treatments involved were Protein Hydrolysate, Sugar, Torula Yeast, Casein and untreated Control. These attractants were selected after a preliminary round of their evaluation as spots treatments. The attractant admixtures were applied in each plot arranged with spots treatment below plant canopy above the ground level and the attracted coccinellids were counted. Palm oil was added to the baits to prevent them from rapid drying because of the atmospheric temperature. After 10 days interval, the formulations were sprayed on the host plants using an atomizer @ 5% concentrated solution used twice during crop growing season. Control host plants were also maintained for spraying with simple water. The effectiveness of the treatments was compared on the basis of aphid severity; predator population and crop yield after application of chemical sprays. At the time aphid started its appearance in the second week of February, the observations were taken on aphid as well as predator population counts from 5 randomly selected plants in each replicate, at 10 days interval, till the last week of March when data recording were came to an end. After the crop reaped, seed yield per plot was recorded. The statistical interpretation were undertaken to correlate the aphid, its predator populations and seed yield observations. The statistical design used in these experiments was calculation of analysis of variance and treatment means were compared using the LSD test at the 0.05% level of significance.

3. Results

The results of studies reflected that there was no proper synchronization between populations of the prey and its predator that appeared late. Our studies further revealed that food attractants used for biological control were effective for ladybird beetles and did not create any problems or harmful effects for canola plant. The study observed (Table 1) that aphid started its appearance in 2nd weeks of February (26.6 per plant), its population went on increasing steadily (157.0 and 332.7) during the 3rd and 4th weeks of the same month till March initiation, then started declining (206.3-34.6) from 2nd to last weeks of March, and upto the beginning of April it disappeared during the year of investigation. Ladybird beetles come into sight late in 3rd week of February (1.3/ plant) during the respective study year. The influx of predator 3.0 per plant was recorded in 1st week of March, attaining its fall (2.6-1.3) till March ending. The nominal population of the predator was recorded when the winged population of the aphid was at its peak and these started to drift from the canola fields to other crops during the year of investigations. The beetles were unable to reproduce due to low population of the aphid on canola during March ending and onward. Surveillance conducted on harmonization in populations build-up of aphid and ladybird beetles, concluded that there was no suitable synchronization between populations of the prey and its predator. The predator population appeared 2 weeks later than aphid; so, there is a lag time between the pest population and that of its natural enemy. This gap was managed by the use of eco-environmentally nontoxic substances like food attractants to attract predators. The most prevailing species with respect to their densities were the 11-spotted lady beetle *Coccinella undecimpunctata* L. (50%), zigzag beetle *Cheilomenes sexmaculate* Fabr. (30%) and 7-spotted lady beetle *Coccinella septempunctata* L. (20%). So, the populations' dynamics of the individual species were different, the first two being the most numerous.

Table 1. Synchronization in populations' build-up of aphid and ladybird beetles.

S. No.	Date of observation	Predator (Ladybeetle) population/ plant	Aphids population/ plant	Predator's species composition
1.	1st observation (10. 2. 05)	0.00 c	26.67 c	*Coccinella undecimpunctata* (50%)
2.	2nd observation (21. 2. 05)	1.33 b	157.0 b	
3.	3rd observation (3. 3. 05)	3.00 a	332.7 a	*Cheilomenes sexmaculate* (30%)
4.	4th observation (14. 3. 05)	2.66 a	206.3 b	
5.	5th observation (25. 3. 05)	1.33 b	34.67 c	*Coccinella septempunctata* (20%)
LSD value		1.16	118.2	

Different capital letters denote statistical significance in column and row values at alpha 0.05.

Current comparisons of food-based attractants employed had different array of chemicals/baits when exposed to predatory species. There was significantly more difference between the numbers of aphids organized due to varying populations of lady beetles recorded in the 5 component treatments. However, yeast hydrolysate and sugar baited plants had an average 100.8 and 102.6 aphids population per plant, respectively, than any of the other 3 treatments, such as torula yeast (114.9), casein (141.0) and in untreated control component (178.0). Hence, the aphid was observed in all treatments at varying severity levels and all formulations were more effective in reducing its severity through its predator than the control. In studies conducted, it has been found that plots induced with protein hydrolysate and sugar treatments took into custody the most predators' species of economic importance as 4.8 and 4.4 lady beetles/ plant, respectively. Conversely, torula yeast, casein and untreated control baited plots attracted marginal predators populations (3.4, 2.5 and 1.2/ plant, respectively) (Table 2).

Data in Table 2 also showed the variations in yield characteristics of the canola hybrid in different treatments found during cropping season. A grain yield as high as 270.0 and 250.0 gm/ 2.5 m^2 plot (1080.0 and 1000.0 kg/he) was obtained in protein hydrolysate and sugar treatments, respectively. For grain yield potential and quality, torula yeast, casein and untreated control treatments gave 230.0, 200.0 and 180.0 gm/ 2.5 m^2 plot (920.0, 800.0 and 720.0 kg/he), accordingly. Hence, for grain superiority parameter, protein hydrolysate and sugar treatments met the higher standard seeds production, and as a result achieved the best seed yield. This is attributed due to positive attraction by food attractants to ladybird beetles, their predation upon aphids and ultimately canola yield increased because of low pest's intensity in treated plots.

Table 2. Efficacy of different Food Attractants to exert a pull on ladybird beetles.

S. No.	Treatments	Predator (Lady beetle) population/ plant	Aphids population/ plant	Yield/plot (2.5 m$^{2)}$ (gm)	Yield Kg/ Hec
1.	Protein Hydrolysate	4.8 a	100.8 b	270.0 a	1080.0
2.	Casein	2.5 bc	141.0 ab	200.0 bc	800.0
3.	Sugar	4.4 a	102.6 b	250.0 ab	1000.0
4.	Torula Yeast	3.4 ab	114.9 b	230.0 abc	920.0
5.	Untreated Control	1.2 c	178.0 a	180.0 c	720.0
LSD value		1.724	42.50	57.48	

Different capital letters denote statistical significance in column and row values at alpha 0.05.

4. Conclusions

Current studies reflected that there was no appropriate synchronization between populations of the prey and its predator that appeared later. Parallel to our results, Yadava and Singh (1994) reported the population of the predator composed of 4-5 different species, which were affected by environmental factors. It was observed that the predator population could not synchronized with the economic threshold level and peak of the population of aphid, and hence were found unable to control the pest. However, the lag time may be bridged up by the application of environmentally chemicals, once or twice sprays. Analogous to current result, Pankanin and Ceryngier (1995) revealed considerable differences in the abundance of the species of aphids and also synchronization between the development of aphids and their Coccinellidae natural enemies. Park and Obrycki (2004) showed that the distribution of lady beetles did not always coincide with that of aphids. Converse to these findings, Woin *et al*., (2006) confirmed synchronization between the development of aphids and coccinellids.

Insect's food attractants technique tested to attract aphid predator ladybird beetle using the foliar application of protein hydrolysate, casein, sugar and torula yeast, demonstrated that increased population of lady beetle and reduced aphid damage occurred in treated plots in comparison with those in control. Treatments consisting of protein hydrolysate and sugar were more efficacious where the uppermost predator numbers were observed than in casein-applied treatment where the slight population was observed. These results suggest that predator-attracting strategy may be used for aphid management. Brewer and Elliott (2004) concluded the mediating effects of host plant and habitat manipulations on aphid biological control, which provided significant and under explored avenue to optimize aphid management. Wackers (2003) accepted that most parasitoids and many predators require sugar sources to cover their energetic needs. It was argued that the field of food ecology could help in selecting food supplements for use in their rearing as well as application in biological control. Though, the literature focusing on standard approaches for the attraction of ladybird beetle species in particular is lacking elsewhere, current studies could be compared with other related work. Holler *et al*., (2006) demonstrated that a synthetic lure consisting of putrescine and ammonium acetate was more efficacious in the capture of fruit flies than hydrolyzed yeast. The effects of food attractants were used to attract *Agrotis segetum* (Ilichev, 1992), mites (Sato *et al*., 1993), beetles (Arredondo-Bernal *et al*., 1995) and Hymenoptera (honey bee) (Chaudhary, 2006), these species gave positive responses in field tests, as the present study investigated. Food attractants technique for predators can play an important role for acceptable and eco-friendly suppressive measures against insect pests. Some recent field studies conducted by Hasyim *et al*., (2007) and Shivayya *et al*., (2008) using different food attractants in reducing the incidence of Tephritidae were found to be very promising.

Due to variance in results, it is suggested that further comparisons of attractants be performed under different food attractants and environmental conditions in hopes of revealing patterns that will further trap development and deployment tactics. Inferences from the empirical data are made and new avenues for future research are suggested. This finding presented is an example of habitat manipulations within fields that would positively affect predators of aphids. These studies led to conclude that coccinellid beetles are competent predator but these could not control the aphid population as expected due to their lower population and a delay time of arrival between the pest population peak and that of natural enemy, and the lag time gap may be minimize by orchestrating the application of food attractants. Such behavioral manipulations of natural enemies through the integration of stimuli that act to lure them toward an attractive source, could remove the pests subsequently. Therefore, such strategies should be usually integrated with other methods for pest's population reduction, preferably in biological control. This strategy is generally non-toxic and useful tool for integrated pest management programs for reducing pesticide uses in order to establish a method of biological control suited to sufficiently protecting the canola plantations.

References

Akram, W., Akbar, S., Mehmood, A. 1996. Studies on the biology and predatory efficacy of *Coccinella septempunctata* with special reference to cabbage. Pakistan Entomol. 18 (1/2): 104-106.

Ansari, M.S., Barkat, H., Qazi, N.A. 2007. Influence of abiotic environment on the population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.) on *Brassica* germplasm. Journal of Biological Sciences. 7 (6): 993-996.

Arredondo-Bernal, H.C., Cibrian-Tovar, J., Williams, R.N. 1995. Responses of *Macrodactylus* spp. (Coleoptera: Scarabaeidae) and other insects to food attractant in Tlaxcala and Jalisco, Mexico. Florida Entomol. 78 (1): 56-61.

Arshad, A., Rizvi, P.Q. 2007. Development and predatory performance of *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) on different aphid species. Journal of Biological Sciences. 7 (8): 1478-1483.

Brewer, M.J., Elliott, N.C. 2004. Biological control of cereal aphids in North America and mediating effects of host plant and habitat manipulations. Ann. Rev. Entomol. 49: 219-242.

Chaudhary, O.P. 2006. Diversity, foraging behaviour of floral visitors and pollination ecology of fennel (*Foeniculum vulgare* Mill.). J. Spices and Aromatic Crops. 15 (1): 34-41.

Cook, S.M., Khan, Z.R., Pickett, J.A. 2007. The use of Push-Pull Strategies in Integrated Pest Management. Ann. Rev. Entomol. 52 (52): 375-400.

Foster, S.P., Harris, M.O. 1997. Behavioural manipulation methods for insect pest management. Ann. Rev. Entomol. 42: 123-146.

Hasyim, A., Muryati, I.M., Kogel, W.J. 2007. Male fruit fly, *Bactrocera tau* (Diptera; Tephritidae) attractants from *Elsholtzia pubescens* Bth. Asian Journal of Plant Sciences. 6 (1): 181-183.

Holler, T., Sivinski, J., Jenkins, C., Fraser, S. 2006. A comparison of yeast hydrolysate and synthetic food attractants for capture of *Anastrepha suspensa* (Diptera: Tephritidae). Florida Entomol. 89 (3): 419-420.

Ilichev, A.L. 1992. Segeton - the food attractant of *Agrotis segetum*. Z. Rastenii (Moskva). 7: 41 pp.

Mathur, K.C. 1983. Aphids of agricultural importance and their natural enemies of Jullunder Punjab. In: The Aphids. Ed. by Behura BK. The Zool. Soc. Orissa, Utkal University, Bhubneshwar, India. pp 229-233.

Pankanin, F.M., Ceryngier, P. 1995. Cereal aphids, their parasitoids and coccinellids on oats in central Poland. J. Appl. Entomol. 119 (2): 107-111.

Park, Y.L., Obrycki, J.J. 2004. Spatio-temporal distribution of corn leaf Aphids (Homoptera: Aphididae) and lady beetles (Coleoptera: Coccinellidae) in Iowa cornfields. Biological Control. Elsevier Science Publishers, Amsterdam, Netherlands. 31 (2): 210-217.

Rao, S.R.K., Lal, O.P. 2004. Distribution pattern of the mustard aphid, *Lipaphis erysimi* (Kaltenbach), on cabbage. Pest Management and Economic Zoology. 12 (2): 173-177.

Sato, M., Kuwahara, Y., Matsuyama, S., Suzuki, T. 1993. Chemical ecology of astigmatid mites XXXVII. Fatty acid as food attractant of astigmatid mites, its scope and limitation. App. Entomol. and Zool. 28 (4): 565-569.

Shivayya, V., Kumar, C.T.A., Jayappa, A.H. 2008. Management of melon fly, *Bactrocera cucurbitae* Coq. (Diptera: Tephritidae) using food attractants. Environment and Ecology. 26 (2): 602-605.

Singh, H., Singh, B. 1986. Population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.) on various Brassica genotypes. Proc. Nat. Conf. on Key Pests of Agric. Crops. CSAUAT, Kanpur. 2: 117-123.

Sivinski, J.M., Calkins, C.O. 1986. Pheromones and parapheromones in the control of Tephritids. Florida Entomol. 69: 157-168.

Wackers, F.L. 2003. The parasitoids need for sweets: sugars in mass rearing and biological control. Pp 59- 72. In: Quality Control and Production of Biological Control Agents: Theory and Testing Procedures. Ed. by Van Lenteren JC, CABI Publishing, pp 327.

Woin, N., Volkmar, C., Ghogomu, T. 2006. Numerical response of predatory ladybirds (Coccinellidae) to aphid outbreaks and their diversity in major rice ecosystems of Cameroon. Arch. of Phytopatho. and Plant Protec. 39 (3): 189-196.

Yadava, R.P., Singh, V.S. 1994. Species complexity, population density and dominance structure of predatory coccinellids associated with mustard aphid, *Lipaphis erysimi* (Kalt.) in rapeseed mustard ecosystem. J. Insect. Sci. 7 (1): 18-20.

Zamoum, T., Simon, J.C., Crochard, D., Ballanger, Y., Lapchin, L., Masutti, F.V., Guillemaud, T. 2005. Does insecticide resistance alone account for the low genetic variability of asexually reproducing populations of the peach-potato aphid *Myzus persicae*? Heredity. 94: 630–639.

(Received for publication 24 January 2009; The date of publication 01 August 2009)