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Population density of *Aphis fabae* Scopoli (Hemiptera, Aphididae) and its natural enemies in intercropping of faba bean (*Vicia faba* L.) and dragonhead (*Dracocephalum moldavica* L.)

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Abstract

Increasing crop diversity via intercropping is a simple and effective strategy for reducing pest density. A field experiment was conducted at Research Farm of Tabriz University, Tabriz, Iran during 2014. The experiment was arranged as factorial, based on randomized complete block design with three replications. The first factor was four cropping systems including monocropping of faba bean and three row intercropping of faba bean with dragonhead and the second factor was three levels of fertilizers as 100% chemical fertilizer, 50% chemical fertilizer + biofertilizer and biofertilizer. The results indicated that the population density of black bean aphid (*Aphis fabae*) was affected by cropping pattern and fertilizer. Also at flowering stage the interaction effect of cropping pattern × fertilizer on population density of *Aphis fabae* was significant. The faba bean monocropping had the greatest mean number of *Aphis fabae* for all fertilizer treatments. Also the lowest density of *Aphis fabae* was observed at 1 faba bean - 1 dragonhead cropping patterns with application of biofertilizer. The population densities of *Hippodamia variegata* Goeze *and Coccinella septempunctata* L. were the lowest and greatest in faba bean monocropping and 1 faba bean - 1 dragonhead intercropping, respectively. Generally by application of biofertilizer, the effect of cropping pattern on reduction of *Aphis fabae* density increased.

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Introduction

Exploration of agricultural biodiversity that improve pest management is necessary in sustainable agricultural system to avoid environmental pollution caused by the over resilience on synthetic insecticides (Gurr *et al.,* 2003). The modern growing systems imply the simplification of the structure of the environment over large areas of land, replacing natural plant diversity with only a limited number of cultivated plants in monocultures (Vandermeer *et al.*, 1998; Sachs, 2009; Amini *et al.*, 2009; Amini *et al.*, 2013). Increasing crop species diversity via intercropping is a simple and effective measure that offers advantages at reducing pest densities (Smith and McSorley, 2000).

Aphis fabae Scopoli (black bean aphid) is one of the major aphid pests in Iran. The *Aphis fabae* dominant coccenellid predators are *Hippodamia variegata* Goeze (lady beetle) and *Coccinella septempunctata* L. (seven-spot ladybird). *C. septempunctata* originated in Europe and Asia, but is now found throughout the Middle East, India and North America (Franzmann, 2002). *H. variegate* is one of the best known and most common American lady beetles and is found from southern Canada to South America. Adults and larvae prey mainly on aphids. Reported preys include cotton, pea, melon, cabbage, potato, green peach, and corn leaf aphids. If aphids are scarce, beetles and larvae may feed on small insect larvae, insect eggs, mites and, occasionally, nectar, and honeydew secreted by aphids and other sucking insects (Hodek and Honek, 1996; Obrycki and Orr, 1990; Azimi and Amini, 2014).

Intercropping or planting different crops as a traditional agricultural technique is used for reducing pest infestation in different geographical areas (Ma *et al.*, 2006). The plant components of intercropping system do not necessarily have to be sown at the same time, but they should be grown simultaneously for a substantial part of their growth periods (Altieri and Letourneau, 1999). Components of intercropping system suffer significantly less damage from insects compared to their cultivation as a sole crops (Altieri and Letourneau, 1999) which has positive impact on yield (Sarker *et al.,* 2007). Significantly lower population of insects was observed on the cowpea (*Vigna unguiculata* (L.) Walp intercropped with maize then on cowpea as a sole crop (Olufemi, and Odebiyi, 2001). Maize cultivated with cassava (*Manihot esculenta* Crantz) had significantly lower infestations by insects (*Sesamia calamistis* Hampson, *Eldana saccharina* Walker, and *Mussidia nigrivenella* Ragonot) up to 80% (Schulthess *et al.*, 2004). Rice (*Oryza sativa* L.) intercropped with peanut (*Arachis hypogaea* L.) had lower infestations by green stink bug (*Nezara viridula* L.) and stem borer (*Chilo zacconius* Blez) in comparison with rice monoculture (Epidi *et al.*, 2008). The oviposition of turnip root fly (*Delia floralis* Fall.) was lower in cabbage-clover intercrop than that on cabbage monoculture. Disruption in the oviposition behavior of *D. floralis* by presence of clover caused reduction in the number of their pupae (Bjorkman *et al.,* 2010). Strip intercropping of wheat and alfalfa significantly increased the egg and larval densities of the mite *(Allothrombium ovatum)* as well the percentage of wheat aphid *(Macrosiphum avenae)* which was parasitized by larval mites compared with the monoculture of wheat (Ke-Zheng *et al.*, 2007).

Plant growth-promoting rhizobacteria have been successful in promoting the growth of crops such as canola, soybean, lentil, pea, wheat and radish have been isolated (Timmusk *et al.,* 1999). Khattak *et al.* (1996) observed that application of nitrogen alone increased the aphid infestation, whereas nitrogen and phosphorous in combination suppressed the aphid attack. Increases in the production cost, and the hazardous nature of chemical fertilizers for the environment has led to a resurgence of interest in the use of biofertilizers for enhanced environmental sustainability, lower cost production and good crop yields. Therefore, the objectives of this study were to evaluate the effects of faba bean-dragonhead intercropping patterns and fertilizer levels on population density of *Aphis fabae* and its natural enemies *Hippodamia variegata* Goeze and *Coccinella septempunctata* L.

Materials and methods

Site description and experimental design

A field experiment was conducted during 2014 at Research Farm of Tabriz University, Tabriz, Iran (Latitude, 46° 17´ E; 38° 05´ N, Altitude 1360m a.s.l.). The experiment was arranged as factorial, based on randomized complete block design with three replications. The first factor was four cropping systems including monocropping of faba bean; row intercropping of faba bean with dragonhead at three patterns (1 row faba bean-1 row dragonhead; 2 rows faba bean-1 row dragonhead; 3 rows faba bean-1 row dragonhead and the second factor was three levels of fertilizers as 100% chemical fertilizer, 50% chemical fertilizer + biofertilizer Azotobarvar and biofertilizer Azotobarvar. Chemical fertilizer included triple superphosphate and urea and biofertilizers were Azotobarvar (include free living nitrogen fixing bacteria). For 100% chemical fertilizer treatment, 100kg/ha of triple superphosphate (46% P) and 200 kg/ha urea (46% N) and for 50% chemical fertilizer + biofertilizer, the 50% of these quantities + Azotobarvar were used. Chemical fertilizers were applied at sowing time and biofertilizers applied through seed inoculation. The seeds of faba bean and dragonhead were sown by hand on 02 May 2014. Plot size in each cropping system was different and consisted of different number of rows of 4 m length, and the row distance for faba bean and dragonhead was 25 cm. The planting density for faba bean and dragonhead were 40 and 30 plants/m^2, respectively.

Sampling and data collection

The sampling for *Aphis fabae* Scopoli (Hemiptera, Aphididae) and *Hippodamia variegata* Goeze and *Coccinella septempunctata* L. were done weekly from faba bean vegetative growth stage (30 days after planting) until flowering stage (65 days after planting) as described by Wang *et al.* (2009). The abundance of *Aphis fabae* and its natural enemies were recorded for each plot. At both stages, *Aphis fabae* Scopoli (black bean aphid), *Hippodamia variegata* Goeze (lady beetle) and *Coccinella septempunctata* L. (seven-spot ladybird) on all faba bean plants within a one square meter covering four rows of the plots were identified and recorded. Four sampling sites were chosen from each plot and ten randomly selected faba bean plants were used as a sampling unit (Alhmedi *et al.,* 2007).

Statistical analysis

The experiment was conducted as factorial, based on randomized complete block design with three replications. The data of the experiments were subjected to analysis of variance (ANOVA). The obtained data for abundance of studied insects were transformed by log (n + 1) and were analyzed using ANOVA with SAS 9.1. The Duncan multiple range test was used to compare the means at $p \leq 0.05$.

Results and discussion

Aphis fabae Scopoli

The results of analysis of variance indicated that the population density of black bean aphid (*Aphis fabae*) at vegetative stage was affected by cropping pattern ($p \leq 0.01$) and fertilizer ($p \leq 0.05$) (Table 1). The interaction effect of cropping pattern × fertilizer on population density of *Aphis fabae* was not significant (Table 1).

The mean comparison showed that highest number of *Aphis fabae* (366) was obtained in faba bean monocropping that was not significantly different with 3-1 faba bean-dragonhead cropping pattern (Fig. 1). The 1 faba bean-1dragonhead cropping pattern had the lowest mean number of *Aphis fabae* that was not significantly different with 2 faba bean-1dragonhead cropping pattern. These results revealed that by increasing the proportion of dragonhead in intercropping the *Aphis fabae* density decreased in comparison with faba bean monocropping. The 100% chemical fertilizer treatment had the highest mean number of *Aphis fabae* and also was not significantly different with 50% chemical fertilizer + biofertilizer treatment (Fig. 2). The biofertilizer treatment had the lowest mean number of *Aphis fabae* and also was significantly different with other fertilizer treatments.

Table 1. The results of analysis of variance for population densities of *Aphis fabae*, *Hippodamia variegata* and *Coccinella septempunctata* at vegetative and flowering stages of faba bean, affected by cropping patterns and fertilizers.

S.O.V	df	MS					
		Aphis fabae		*Hippodamia variegata*		*Coccinella septempunctata*	
		Vegetative	Flowering	Vegetative	Flowering	Vegetative	Flowering
Block	2	0.83	2.39	0.011	0.25	0.03	0.21
Cropping Pattern (CP)	3	17.4**	23.1**	0.61*	2.311*	0.315*	0.641*
Fertilizer (F)	2	12.18*	12.4*	0.234	0.783	0.025	0.127
CP × F	6	2.9	10.8*	0.131	0.153	0.035	0.456
Error	22	4.7	4.3	0.091	0.216	0.035	0.153
Total	35	---	---	---	---	---	---
CV (%)	---	16.5	21.7	14.01	13.54	17.61	19.61

*Statistically significant at $p<0.05$. ** significant at $p< 0.01$.

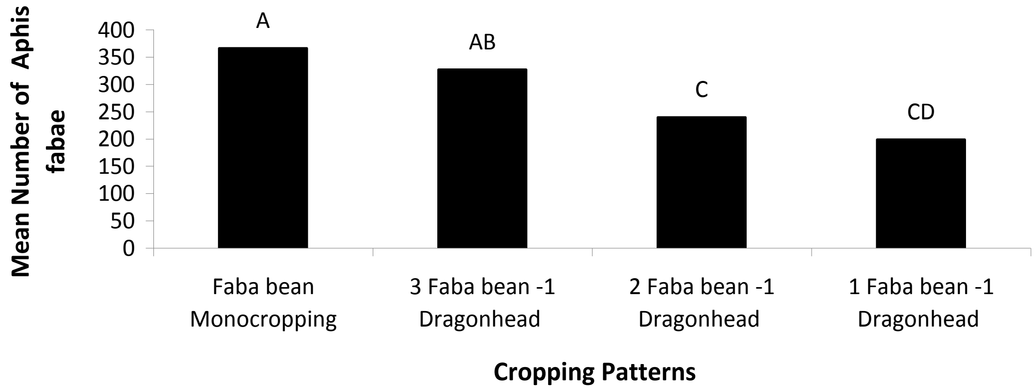

Fig. 1. Effect of different faba bean - dragonhead cropping patterns on mean number of *Aphis fabae*. Different letters indicate significant difference at $p \leq 0.05$.

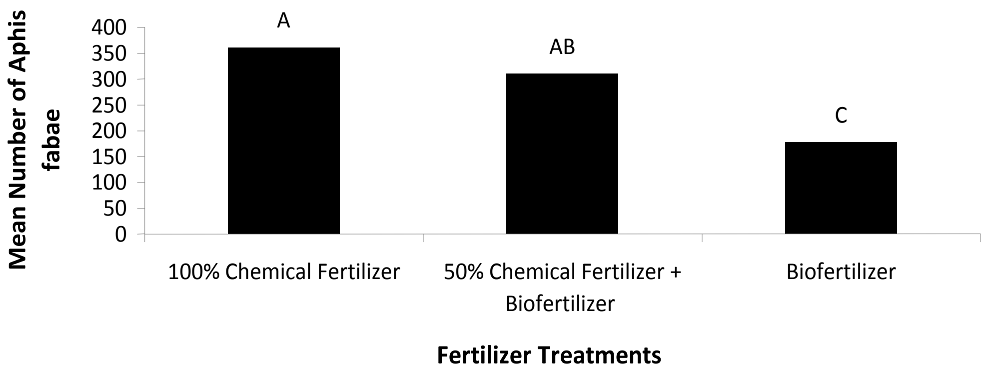

Fig. 2. Effect of different fertilizer treatments on mean number of *Aphis fabae*. Different letters indicate significant difference at $p \leq 0.05$.

Analysis of variance indicated that at flowering stage, the effect of cropping pattern ($p \leq 0.01$) and fertilizer ($p \leq 0.05$) was significant on population density of black bean aphid (*Aphis fabae*). Also the interaction effect of cropping pattern × fertilizer was significant ($p \leq 0.05$) on population density of *Aphis fabae* (Table 1). The faba bean monocropping had the highest mean number of *Aphis fabae* for all fertilizer treatments. In this cropping pattern the mean number of *Aphis fabae* for 50% chemical fertilizer + biofertilizer and biofertilizer treatments were not significantly different (Fig. 3). In 3 faba bean - 1 dragonhead cropping pattern, the population densities of *Aphis fabae* for 100% chemical fertilizer and 50% chemical fertilizer + biofertilizer treatments were not significantly different and the biofertilizer treatment had the lowest density of *Aphis fabae.* In 2 faba bean - 1 dragonhead and 1 faba bean - 1 dragonhead cropping patterns, the mean number of *Aphis fabae* was significantly lower than that of 100% chemical fertilizer and 50% chemical fertilizer + biofertilizer levels. These results indicate that by application of biofertilizer, the effect of cropping pattern on reduction of *Aphis fabae* density increased.

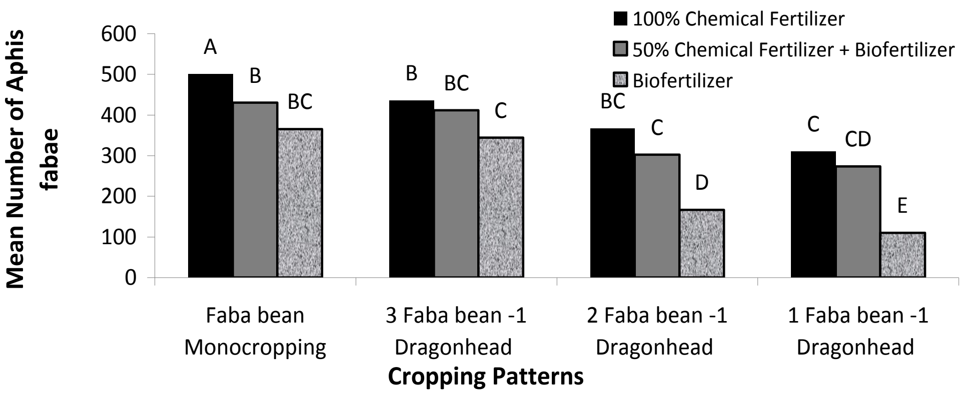

Fig. 3. The interaction effect of faba bean - dragonhead cropping pattern × fertilizer treatment on mean number of *Aphis fabae*. Different letters indicate significant difference at $p \leq 0.05$.

Hippodamia variegata Goeze and Coccinella septempunctata L.

The results of analysis of variance indicated that the mean number of *Hippodamia variegata* at flowering and flowering stages, were affected significantly ($p \leq 0.05$) by cropping pattern (Table 1). The mean comparison for vegetative growth stage showed that the mean number of *Hippodamia variegata* at all cropping patterns with dragonhead were significantly greater than that of faba bean monocropping (Fig. 4). The 1 faba bean – 1 dragonhead cropping pattern had the greatest mean number of *Hippodamia variegate* that was not significantly different with 2 faba bean - 1 dragonhead cropping pattern. The 3 faba bean - 1 dragonhead cropping pattern had greater mean number of *Hippodamia variegata* than faba bean monocropping but lower than other cropping patterns.

The results for mean number of *Hippodamia variegate* at faba bean flowering stage showed that all faba bean - dragonhead intercropping patterns had significantly greater mean number of *Hippodamia* than faba bean monocropping (Fig. 4). Generally the results indicate that by increasing the proportion of dragonhead at intercropping patterns, the mean number of *Hippodamia variegata* increased. The 1faba bean - 1 dragonhead intercropping pattern had the greatest mean number of *Hippodamia variegate* and was significantly greater than that of 2 faba bean - 1 dragonhead intercropping pattern.

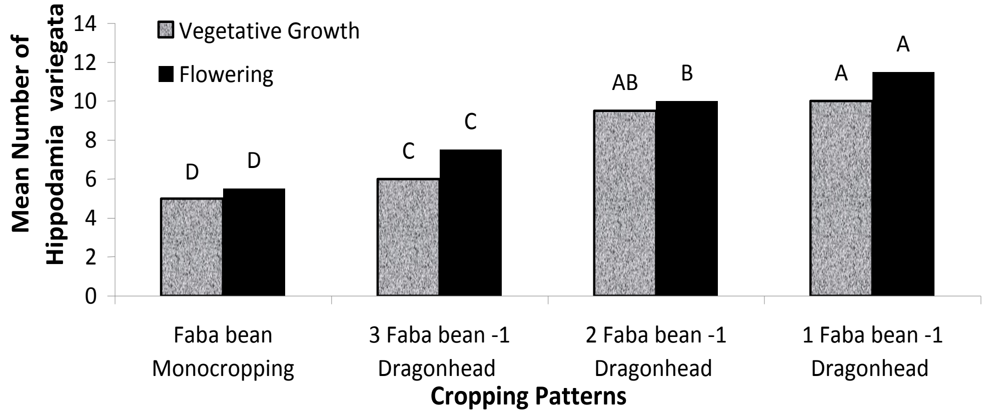

Fig. 4. The effect of different faba bean - dragonhead cropping patterns on mean number of *Hippodamia variegata* in vegetative growth and flowering stages. Different letters indicate significant difference at $p \leq 0.05$.

The results of analysis of variance indicated that the mean number of *Coccinella septempunctata* at flowering and flowering stages, were affected significantly ($p \leq 0.05$) by cropping pattern (Table 1). The mean comparison for vegetative growth stage showed that the mean number of *Coccinella septempunctata* at all cropping patterns with dragonhead were significantly greater than that of faba bean monocropping (Fig. 5). The 1 faba bean – 1 dragonhead cropping pattern had the greatest mean number of *Coccinella septempunctata* that was significantly different with 2 faba bean - 1 dragonhead cropping pattern. The 3 faba bean - 1 dragonhead cropping pattern had greater mean number of *Coccinella septempunctata* than faba bean monocropping but was not significantly different with 2 faba bean - 1 dragonhead cropping pattern.

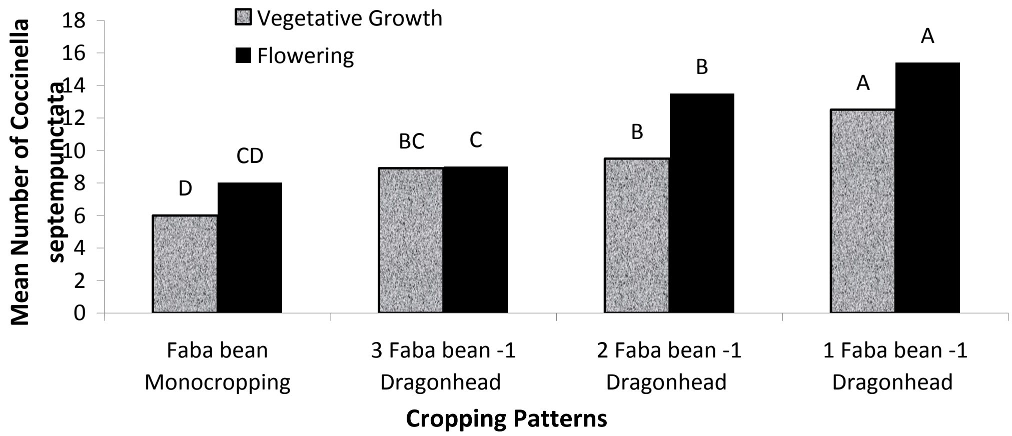

Fig. 5. The effect of different faba bean - dragonhead cropping patterns on mean number of *Coccinella septempunctata* L. in vegetative growth and flowering stages. Different letters indicate significant difference at $p \leq 0.05$.

The results for mean number of *Coccinella septempunctata* at faba bean flowering stage showed that 1 faba bean - 1 dragonhead and 2 faba bean - 1 dragonhead intercropping patterns had significantly greater mean number of *Coccinella septempunctata* than faba bean monocropping (Fig. 5). The mean number of *Coccinella septempunctata* in 3 faba bean - 1 dragonhead intercropping pattern was not significantly different with faba bean monocropping. Generally the results indicate that the mean number of *Coccinella septempunctata* increased as the proportion of dragonhead at intercropping patterns increased.

The experiments demonstrated that row and strip intercropping of faba bean - dragonhead was benefit to reduce *Aphis fabae* population density. It suggests that the increasing biodiversity make suitable niche for natural enemies which induce biocontrol of pests (Stiling *et al.*, 2003). The addition of second crop could be useful for natural enemies by providing them with favorable microclimate (Hossain *et al.*, 2002) or a supply of plant-based foods (pollen and nectar) (Wackers *et al.*, 2007). Zhang and Li (1996) found that the strip intercropping resulted in a moister, shadier soil surface microclimate which caused adult female mites to lay more egg pods.

Our results showed that different row ratio of intercropping had different results. The mean number of *Aphis fabae* in faba bean monocropping and 1 faba bean - 1 dragonhead were the lowest and greatest, respectively. When the faba bean row number increased we observed that the mean number of *Aphis fabae* increased and the density of *Hippodamia variegata* and *Coccinella septempunctata* L. decreased in comparison with cropping patterns with lower ratio of faba bean. Lavandero *et al.* (2006) also observed that the number of parasitoids decreased significantly with the distance from the flowers. Our results revealed that intercropping gave a control advantage for faba bean aphid by reduction of its population and increasing the population densities of its natural enemies *Hippodamia variegata* and *Coccinella septempunctata* L.. Wang *et al.,* (2009) found that the densities of *S. avenae* were significantly higher on the monoculture pattern than on either the 8-2 intercropping pattern or the 8-4 intercropping pattern. Also we found that the mean number of *Aphis fabae* and its natural enemies; *Hippodamia variegata* and *Coccinella septempunctata* L. in faba bean flowering were greater than them in vegetative growth stage.

The results showed that application of 100% chemical fertilizers increased the *Aphis fabae* density but had no significant effect on population density of *Aphis fabae* natural enemies that it is in agreement with Ge *et al.*, (2003). Singh *et al.*, (1995) found that an increase in the level of nitrogen application resulted in an increase of Indian mustard density by *Lipaphis erysimi*, while significant reductions in infestation were observed due to addition of phosphorus and potassium. We also found that application of biofertilizer reduced mean number of *Aphis fabae*, especially in 1faba bean-1 dragonhead cropping pattern.

It could be concluded that intercropping patterns cause increased crop diversity in the agro-ecosystems which significantly affected the abundances of insects and also their natural enemies. The population densities of *Aphis fabae* in the intercropping patterns such as 1 faba bean-1 dragonhead and 2 faba bean-1 dragonhead were significantly lower than those in the faba bean monoculture. Also the population densities of natural enemies *Hippodamia variegata* and *Coccinella septempunctata* L. were the greatest in 1 faba bean-1 dragonhead. Therefore using intercropping systems and also biofertilizers could help growers to management pest population and also reduce chemical insecticide and fertilizers application that is consistent with sustainable and organic agriculture.

References

Alhmedi A, Haubruge E, Bodson B, Francis F. 2007. Aphidophagous guilds on nettle (*Urtica dioica*) strips close to fields of green pea, rape and wheat. Insect Science **14**, 419-424.

Altieri MA, Letourneau DL. 1999. Environmental management to enhance biological control in agroecosystems. In Bellows, T.S. & Fisher, T.W. (Eds), Handbook of biological control (pp. 319–354). San Diego, CA: Academic Press.

Amini R, An M, Pratley J, Azimi S. 2009. Allelopathic assessment of annual ryegrass (*Lolium rigidum*): Bioassays. Allelopathy Journal **24 (1),** 67-76.

Amini R, Shamayeli M, Dabbagh Mohammadi Nasab A. 2013. Assessment of yield and yield components of corn (*Zea mays* L.) under two and three strip intercropping systems. International Journal of Biosciences **3 (3),** 65-69. http://dx.doi.org/10.12692/ijb/3.3.65-69

Azimi S, Amini R. 2014. Effect of proteinaceous extract of redroot pigweed (*Amaranthus retroflexus* L.) seeds on α-amylase activity of Indian flour moth (*Ephestia kuehniella* Zeller, Lepidoptera: Pyralidae). International Journal of Biosciences **5 (4),** 170-176. http://dx.doi.org/10.12692/ijb/5.4.170-176

Björkman M, Hamback PA, Hopkins RJ, Ramert B. 2010. Evaluating the enemies hypothesis in a clover-cabbage intercrop: effects of generalist and specialist natural enemies on the turnip root fly (*Delia floralis*). Agricultural and Forest Entomology **12(2),** 123–132.

Epidi TT, Bassey AE, Zuofa K. 2008. Influence of intercrops on pests' populations in upland rice (*Oryza sativa* L.). African Journal of Environmental Science and Technology **2(12),** 438–441.

Franzmann BA. 2002. *Hippodamia variegata* (Goeze) (Coleoptera: Coccinellidae), a predacious ladybird new in Australia. Australian Journal of Entomology **41**, 375–377.

Ge F, Liu X, Li H, Men X, Su J. 2003. Effect of nitrogen fertilizer on pest population and cotton production. The Journal of Applied Ecology **14 (10),** 1735- 1738.

Gurr GM, Wratten SD, Luna JM. 2003. Multifunction agricultural biodiversity: Pest management and other benefits. Basic and Applied Ecology **4**, 107–116.

Hodek I, Honek A. 1996. Ecology of Coccinellidae. Kluwer Academic Publishers, Dordrecht.

Hossain Z, Gurr GM, Wratten SD, Raman A. 2002. Habitat manipulation in Lucerne (*Medicago sativa* L.): arthropod population dynamics in harvested and 'refuge' crop strips. Journal of Applied Ecology **39**, 445–54.

Ke-Zheng M, Shu-Guang H, Hui-Yan Z, Le K. 2007. Strip cropping wheat and alfalfa to improve the biological control of the wheat aphid *Macrosiphum avenae* by the mite *Allothrombium ovatum*. Agriculture Ecosystem and Environment **119**, 49–52.

Khattak SU, Khan A, Shah SM, Alam Z, Iqbal M. 1996. Effect of nitrogen and phosphorus fertilization on aphid infestation and crop yield of three rapeseed cultivars. Pakistan Journal of Zoology **28 (4),** 335-338.

Lavandero BI, Wratten SD, Didham RK. 2006. Increasing floral diversity for selective enhancement of biological control agents: a double-edged sward? Basic and Applied Ecology **7**, 236–243.

Ma XM, Liu XX, Zhang QW, Zhao JZ, Cai QN, Ma YA, Chen DM. 2006. Assessment of cotton aphids, *Aphis gossypii*, and their natural enemies on aphid-resistant and aphid-susceptible wheat varieties in a wheat–cotton relay intercropping system. Entomologia Experimentalis et Applicata **121(3),** 235–241.

Obrycki JJ, Orr CJ. 1990. Suitability of 3 prey species for Nearctic populations of *Coccinella septempunctata*, *Hippodamia variegata*, and *Propylea quatuordecimpunctata* (Coleoptera, Coccinellidae). Journal of Economic Entomology **83**, 1292–1297.

Olufemi ORP, Odebiyi JA. 2001. The effect of intercropping with maize on the level of infestation and damage by pod-sucking bugs in cowpea. Crop Protection **20**, 367-372.

Sachs JD, Baillie JEM, Sutherland WJ, Armsworth PR, Ash N, Beddington J, Blackburn TM, Collen B, Gardiner B, Gaston KJ. 2009. Biodiversity conservation and the millennium development goals. Science **325(5947),** 1502-1503.

Sarker PK, Rahman MM, Das BC. 2007. Effect of intercropping with mustard with onion and garlic on aphid population and yield. Journal of BioScience **15**, 35–40.

Schulthess F, Chabi-Olaye A, Gounou S. 2004. Multi-trophic level interactions in a cassava-maize mixed cropping system in the humid tropics of West Africa. Bulletin of Entomological Research **94(3),** 261–272.

Singh RP, Yazdani SS, Verma GD, Singh VN. 1995. Effect of different levels of Nitrogen, phosphorus and potash on aphid infestation and yield of mustard. Indian Journal of Entomology, **57(1),** 18-21.

Smith HA, McSorley R. 2000. Intercropping and pest management: A review of major concepts. American Entomologist **46(3),** 154–161.

Stiling P, Rossi AM, Cattell MV. 2003. Associational resistance mediated by natural enemies. Ecological Entomology **28**, 587–592.

Timmusk S, Nicander B, Granhall U, Tillberg E. 1999. Cytokinin production by *Paenibacillus polymyxa*. Soil Biology and Biochemistry **31**, 1847-1852.

Vandermeer J, van Noordwijk M, Anderson J, Ong C, Perfecto I. 1998. Global change and multi-species agroecosystems: Concepts and issues. Agriculture, Ecosystems & Environment **67(1),** 1–22.

Wackers FL, Romeis dan van J, Rijn P. 2007. Nectar and pollen-feeding by insect herbivores and implications for tri-trophic interactions. Annual Review of Entomology **52**, 301–23

Wang W, Liu Y, Chen J, Ji XL, Zhuo H, Wang G. 2009. Impact of intercropping aphid-resistant wheat cultivars with oilseed rape on wheat aphid (*Sitobion avenae*) and its natural enemies. Acta Ecologica Sinica **29**, 186–191.