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Population Dynamics of Aphids and their Natural Enemies Associated with Strip-Intercropping in Wheat Crop

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SA performed the experiments and data observation. MA, MS and ZA conceived the idea, designed the experiments, analyzed the data and wrote the paper.

Key words
Aphid, Biological control, Biodiversity, Strip-cropping, Wheat.

ABSTRACT

Aphids are considered serious pests of many agricultural crops worldwide. The present study was conducted to assess the wheat aphids' diversity and their predators association with strip intercropping (brassica, alfalfa, berseem and garlic) and wheat monoculture. Results showed that the first aphid was seen in the last week of January while the predator population was first recorded during the first week of March. Aphid population was maximum on wheat monoculture when 130 specimens were recorded per tiller. Among strip cropping garlic showed maximum population (113 per tiller) followed by brassica (105), berseem (98) and alfalfa (83 per tiller). Second week of March was the most favorable period when 11.48 per tiller of aphid population counted in wheat monoculture, while no specimens were noticed after the first week of April. The coccinellid and syrphid fly showed a maximum population of 1.3 and 1.1 per plant in wheat monoculture respectively in the third week of March, The garlic (1.1/plant) and brassica (0.8/plant) showed maximum population while minimum population of coccinellid recorded in berseem (0.6 per plant) and alfalfa (0.5 per plant). Similar population level was reported in different strip cropping for syrphid fly. Our findings suggest, the strip intercropping promote species composition; richness and abundance in general and predators in particular.

INTRODUCTION

Monoculture cultivation of genetically homogeneous groups over long period of time promote the adaptations of various insect pests (Altieri and Rosset, 1995) and enable them to locate their host plants more easily than in mixed cropping (Root, 1973). Strip-intercropping is an important agricultural technique that has been practiced in many parts of the world (Theunissen and Den-Ouden, 1980; Trenbath, 1993) and indigenous people throughout the world for reducing crop losses by insect pests. Historically strip-intercropping has the potential to reduce insect pests, increased production, improve soil fertility and greater use of environmental resources. In many studies by practicing intercropping about 53% of experiments showed reduced insect pests while only 18% increased the pest population than the pure cropping (Francis, 1989). Additionally strip-intercropping enhance the provision of floral richness for insect predators and parasitoids in agro-ecosystem and increase the effectiveness of natural enemies by parasitism, fecundity and longevity (Wratten *et al*., 2002; Tylianakis et al., 2004). Many entomologists and ecologists advocate the strip-intercropping as an important tool in integrated pest management to suppress the insect pests' community and encourage the natural enemies' diversity (Andow, 1991; Landise *et al*., 2000).

Among insect pests aphids (Aphididae: Homoptera) are serious pests of many agricultural crops like oilseeds, fruit trees, vegetables and cereals (Bowling *et al*., 1998; Yahya *et al*., 2017) and occur throughout the world. They may attack on different plant portions including leaves, stems, fruits, roots and are responsible for considerable damage by direct feeding, transmission of viral diseases, injection of toxins and honeydew contamination of different plant parts. The aphid population has been increasing from the last few years and has become as a regular sucking pest of wheat (*Triticum aestivum* L.) crop in Pakistan. Wheat is a major crop with largest area under cultivation in Pakistan and plays a significant role in the livelihood of people. Low yield of wheat per hectare in the country is related to several abiotic and biotic factors including traditional methods of cultivation, low yielding varieties, lack of irrigation, soil fertility problems and incidence of insect pests and diseases. Among insect pests aphids are considered major constraint for increased wheat production in Pakistan (Khattak *et al*., 2007; Aheer *et al*.,

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2006). They cause yield losses either directly (35-40%), sucking the plant sap or indirectly (20-80%) by transmitting viral and fungal diseases (Aslam *et al*., 2005). Management of aphids depends heavily on insecticides and often to the elimination of other control methods. Widespread use of insecticides is not generally worthwhile economically as some insect pests have become resistant and some non-target organisms are adversely affected. Additionally the toxic and chronic effects of pesticides have not only caused environmental and health concerns but also serious lethal effects to the natural enemies of agricultural pests. This shift in control strategy has caused increased interest in long-term biological control techniques to curtail the reliance on insecticides for sustainable agriculture. Strip intercropping has the potential to offer valuable food resources to an agro-ecosystem for the enhancement of beneficial insect population and their fitness (Landise *et al*., 2000; Irvin and Hoddle, 2007) that leads to an effective biological control of insect pests.

In this study population dynamics of wheat aphids and their natural enemies (Coccinelids and Syrphids) were evaluated in strip intercropping of wheat with brassica, alfalfa, berseem and garlic over sole wheat cropping. The study will provide a good understanding of population dynamics will help to determine the role of strip crops as a source of predatory insects to suppress aphid population that is significant for crop protection.

MATERIALS AND METHODS

Study area

Field experiments were carried out in Ayub Agriculture Research Farm, Faisalabad (latitude 31°26'N and 73°06'E, altitude 185 m) during the winter season of 2012-2013 to determine the diversity of aphids with respect to their predators under field conditions. The climate is hot with annual average temperature of 24.5°C and the precipitation is less than 500 mm. The crop rotation at research station includes wheat, cotton, sugarcane, rice, brassica, alfafa, berseem etc. and historically has been managed conventionally.

Experimental design and treatments

The trial was conducted in Randomized Complete Block Design (RCBD) in three replicate blocks having five treatments (T1: strip of brassica sandwiched within wheat, T2: strip of berseem sandwiched within wheat, T3: strip of Garlic sandwiched within wheat, T4: strip of alfalfa sandwiched within wheat, T5 (control): sole cropping of wheat) in each block. In each treatment wheat was planted in east-west orientation in alternate 15 feet wide strips to a sandwiched 30 feet selected crop (brassica, berseem, garlic and alfalfa) with 15 feet length for both crops. All treatment plots were 0.5 m apart and each block was 10 feet apart separated by bare ground. Dates of sowing were November 20 for wheat and for selected crops using as strips. All plots were given identical fertilizers and irrigation and kept free from insecticides, herbicides and weeds. The number of aphids and predators were recorded at 7-day intervals from 24 January to 4 April from each plot. The number of aphids and mummies from ten tillers of randomly selected plants from each replication of each treatment were counted on weekly basis. The sample was taken from three sites in each plot and in each sampling site, ten wheat tillers were randomly selected and were used as a sampling unit, 3 units (30 wheat tillers) were sampled from each plot, and the number of aphids was counted on all tillers. Adults and larvae of coccinellids while the maggots of syrphid fly were recorded from ten plants per replication for each treatment on weekly basis.

Data analysis

The obtained data for predators and aphid population were analyzed using ANOVA with SPSS10.0 software and means were compared using LSD (P = 0.005) test. Excel software was used to draw figures.

RESULTS

The population densities of wheat aphid, coccinelids and syrphid fly were significantly varied among all treatments (Table I). The results showed that the abundance of aphids and predators were significantly different in strip crop and wheat monoculture techniques. Similarly a significant interactive effect of treatments with strip cropping and monoculture techniques was recorded.

Table I.- Analysis of variance regarding different treatments and techniques to aphid and predatory species.

Insects	Effect	DF	F	P
Aphid	Treatments	4*/20**	319.90	0.00
	Techniques†	1*/20**	374.13	0.00
	T×T	4/20	192.87	0.00
Coccinellid	Treatments	4*/20**	29.54	0.00
	Techniques†	1*/20**	429.86	0.00
	T×T	4/20	4.40	0.01
Syrphid fly	Treatments	4*/20**	27.01	0.00
	Techniques†	1*/20**	308.05	0.00
	T×T	4/20	14.92	0.00

*Total treatments; ** Error; †, Strip and without strip crop; d.f = 29.

Regarding per tiller the aphid population was maximum on wheat monoculture when 130 specimens were recorded. Among strips cropping garlic showed maximum aphid population (113 per tiller) followed by brassica (105 per tiller), berseem (98 per tiller) and alfalfa crop (83 per tiller). The second week of March found to be the most favorable period which showed maximum population of wheat aphids (11.48 per tiller) in wheat monoculture. There was considerable drop in population during the last week of March, while no capturing was recorded after the first week of April when the crop becomes matured. Similarly the adults and larvae of coccinelids showed maximum population (1.3/plant) in the third week of March, while reduced during the last week. The garlic (1.1/plant) and brassica (0.8/plant) showed maximum population while minimum population of coccinelids recorded in berseem (0.6 per plant) and alfalfa (0.5 per plant). Similarly the syrphid fly displayed maximum population (1.1/plant) during the third week of March, while decreased during the last week of March.

Table II.- Pair-wise comparison tests for aphid, coccinelid and syrphid fly population for different treatments with strip cropping and non-stripping culture (LSD = 0.05).

Treatments	Aphid		Coccinelid		Syrphid fly	
	Strip	Non-Strip	Strip	Non-Strip	Strip	Non-Strip
Brassica	29.69a	22.90b	0.19c	0.35a	0.14c	0.22a
Berseem	4.13e	12.05c	0.16c	0.32a	0.13cd	0.19b
Garlic	2.09f	9.36d	0.16c	0.33a	0.13cd	0.21ab
Alfalfa	5.09e	8.49d	0.15c	0.35a	0.11d	0.20ab
Control	0.00g	29.62a	0.00d	0.26b	0.00e	0.19b

Comparison tests showed that the overall aphid population found on non-strip cropping was significantly different from the strip cropping culture except the brassica strip which was significantly higher than all other treatments except for non-strip control, where the population was also significantly greater (Table II). Similarly coccinelid population on non-strip crops showed significantly higher population to all strip cropping treatments. The population dynamic of syrphid fly also showed similar trend of significant higher numbers in wheat monoculture compared to strip crop population. There was a positive correlation of aphid with coccinelid population on strip crops, while negatively correlated on non-strip cropping (Table III). Similar trend of correlation was noticed between aphid and syrphid fly population on both strip and wheat monoculture. A significant maximum population of aphid was recorded in brassica strip followed by wheat monoculture treatment (Fig. 1). Garlic strip showed significantly lower level of aphid population to all other strip (except alfalfa) and monoculture cropping system. The results showed that observational dates varied meaningfully in response to coccinelid and syrphid fly species per plant whereas the variation among different treatments revealed slight difference in total capturing. A significant lower level to all other treatments was recorded in wheat monoculture for both predatory species (Fig. 1).

Table III.- Correlation coefficient of aphid with coccinelid and syrphid fly population for different treatments with stripping and non-stripping culture (LSD = 0.05).

Aphid	Coccinelid		Syrphid fly	
	Strip	Non-Strip	Strip	Non-Strip
	+ 0.504 (0.055)	-0.544 (0.036)	+ 0.440 (0.101)	-0.179 (0.523)

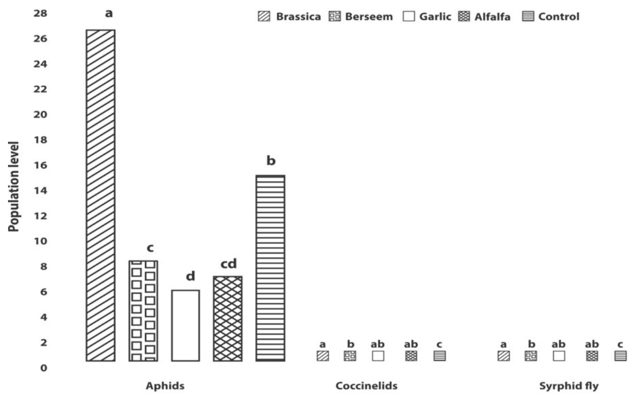

Fig. 1. Population level of aphids and predators in different strip crops (brassica, berseem, garlic, alfalfa and control). Means with same lowercase letters are not significantly different at $\alpha = 0.05$ (LSD test).

DISCUSSION

The distribution, species richness and diversity of predators depend on plant communities, food availability and faunal history. Intercropping system play an important role in predators' diversity that has great impact in biological control especially of important pests like aphids. In the present study we investigated the effect of strip cropping with wheat on population density of aphid and their predator species. Our results provided the evidence that the strip cropping enhances the abundance of natural enemies and resultantly suppresses the aphid population except the brassica strip where both aphid and the predatory population was higher than wheat monoculture. The brassica crop is taller, having different colour, odor and smell to wheat crop that might affect the movement of aphids as well as the predators. This disruptive crop assumption is equivalent to Root (1973) hypothesis that herbivores in polycultures having more difficulties in finding crop plants associated with one or more taxonomically or genetically different plants than finding crop plants in monocultures (Vandermeer, 1989). Finch and Collier (2000) suggested that herbivores tend to land on taller green plants make the main crop less apparent, a useful mechanism of camouflage hypothesis incorporates the visual stimuli (color and height) induces the herbivores to land on plants. Similarly the abundance of aphid population was significantly lower in strip intercropping than wheat sole cropping at both growth stages of wheat noticed by Nassab *et al*. (2013) in his experiments in Iran. Comparable results were recorded by Levie *et al*. (2005) when about 45% of aphid population was reduced by the strip management. In our results garlic showed minimum population of aphids followed by alfalfa and berseem strip cropping. Similar findings of low level of aphid population in garlic strip was recorded by Zhou *et al*. (2013) in China who studied the effect of garlic as active repellent emitted plant or intercropping is beneficial in decreasing pest pressure.

The results showed that aphid infestation started in the last week of January and gradually increased during the vegetative growth of wheat crop and reached its peak in second week of Marchat heading stage of crop when 11.48 specimens were recorded per tiller. The population declined when the crop reached its maturity and there was no capturing after the first week of April. Similar observations to our results were noted by Xiong (1990), who observed that population of aphids increased with the development of wheat and peaked at the heading stage. Our findings are slightly different to Karimullah and Ahmad (1989) who noted a delay onset of aphid infestation during the first week of February. The difference might be due to the temperature fluctuation between the two locations as the temperature play an important role in insect population dynamics and densities (Bernal and González, 1997; Leather *et al*., 1993). Maximum population of coccinelids and syrphid fly were recorded a week after the peak population of aphids during the third week of March. Different natural enemies syrphid fly, coccinellids, *Chrysoperla carnea*, Hymenopterous parasitoids were observed a week earlier in a different study where peak aphid population was in the mid of March (Saleem *et al*., 2009).

Our results showed a positive correlation of predator species and aphid population on strip cropping suggested an indication of natural control of pest population. Current results showed that the predators' population was not conspicuously different among different strip crops but the numbers were significantly higher than the wheat monoculture. Our results are in accordance with Munyuli *et al*. (2007), (2008) and Hongjiao *et al*. (2010) who observed higher species richness and diversity of predators *i.e.,* ladybird beetles, syrphid fly, mantid, spiders, dragonfly, predatory bugs, ground beetles and mites in intercropping systems. This suggests that the intercropping changes the environmental condition, increase in biodiversity that make suitable niche for beneficial insects which promote biocontrol of pests (Andow, 1991; Stiling *et al*., 2003). The addition of second crop can produce a favourable microclimate for natural enemies (Thomas *et al*., 1992; Hossain *et al*., 2002), a place of alternative hosts or prey (Mathews *et al*., 2004) or a provision of plant-based foods (nectar, pollen and honeydew) (Wackers *et al*., 2007). The slight difference in coccinelid and syrphid fly population level among different strip cropping in the current study might be attributed to surrounding habitats, field margins, weedy strips, cultural practices and crop structure could affect the community composition. The presence of field boundaries, crop diversification as well as intercropping could enhance potential mechanism of field predators (Kromp, 1999) and may increase the yield of main crop. Altieri *et al*. (1985) recorded a significantly higher population of Carabidae, Staphylinidae and spiders in the weedy and clover field than in the clean plots.

CONCLUSION

The intercropping systems increase the crop diversity in agro-ecosystems which ultimately affect the abundance of herbivore insects and their natural enemies that can be an important tool to reduce the abundance of aphids. Additionally along with intercropping the habitat type should be focused in the future studies because predators might respond more to the later which is related to the plant species.

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Statement of conflict of interest

Authors have declared no conflict of interest.

REFERENCES

Altieri, M.A., Wilson, R.C. and Schmidt, L.L., 1985. The effects of living mulches and weed cover on the dynamics of foliage- and soil-arthropod communities in three crop systems. *Crop Prot.*, **4**: 201-213. https://doi.org/10.1016/0261-2194(85)90018-3

Altieri, M.A. and Rosset, P.M., 1995. Agroecology and the conversion of large-scale conventional systems to sustainable management. *Int. J. environ. Stud.*, **50**: 165-185. https://doi.org/10.1080/00207239608711055

Aheer, G.M., Munir, M. and Ali, A., 2006. Screening of wheat cultivar against aphids in ecological conditions of district Mandi Bahaudin. *J. agric. Res.*, **44**: 55-58.

Andow, D.A., 1991. Vegetational diversity and arthropod population response. *Annu. Rev. Ent.*, **36**: 561-586. https://doi.org/10.1146/annurev.en.36.010191.003021

Aslam, M., Razaq, M., Akhter, W., Faheem, M. and Ahmad, F., 2005. Effect of sowing date of wheat on aphid (*Schizaphis gramium* Rondani) population. *Pak. Entomol.*, **27**: 79-82.

Bernal, J. and González, D., 1997. Reproduction of *Diaeretiella rapae* on Russian wheat aphid hosts at different temperatures. *Ent. Exp. Appl.*, **82**: 159-166. https://doi.org/10.1046/j.1570-7458.1997.00126.x

Bowling, R.W., Wlide, G.E. and Margolies, D., 1998. Relative fitness of greenbug (Homoptera: Aphididae) biotypes E and I on Sorghum, Wheat, Rye and Barley. *J. econ. Ent.*, **91**: 219-231. https://doi.org/10.1093/jee/91.5.1219

Francis, C.A., 1989. Biological efficiencies in multiple cropping systems. *Adv. Agron.*, **42**: 1-42. https://doi.org/10.1016/S0065-2113(08)60522-2

Finch, S. and Collier, R.H., 2000. Host plant selection by insects- a theory based on appropriate/inappropriate landings by pest insects of cruciferous plants. *Ent. Exp. Appl.*, **96**: 91-102. https://doi.org/10.1046/j.1570-7458.2000.00684.x

Hongjiao, C., Minsheng, Y. and Cui, L., 2010. Effects of intercropping systems on community composition and diversity of predatory arthropods in vegetable fields. *Acta Ecol. Sin.*, **30**: 190-195. https://doi.org/10.1016/j.chnaes.2010.06.001

Hossain, Z., Gurr, G.M., Wratten, S.D. and Raman, A., 2002. Habitat manipulation in Lucerne (*Medicago sativa* L.): Arthropod population dynamics in harvested and 'refuge' crop strips. *J. appl. Ecol.*, **39**: 445-454. https://doi.org/10.1046/j.1365-2664.2002.00729.x

Irvin, N.A. and Hoddle, M.S., 2007. Evaluation of floral resources for enhancement of fitness of *Gonatocerus ashmeadi*, an egg parasitoid of the glassy-winged sharpshooter, Homalodisca vitripennis. *Biol. Cont.*, **40**: 80-88. https://doi.org/10.1016/j.biocontrol.2006.09.004

Karimullah and Ahmad, K.F., 1989. Incidence of the cereal aphid *Sitobion avenae* (F) on different cultivars of wheat. *Sarhad J. Agric.*, **5**: 59-61.

Khattak, G.S.S., Ashraf, M., Zamir, R. and Saeed, I., 2007. High yielding desi chickpea (*Cicer arietinum L.*) variety "NIFA-2005". *Pak. J. Bot.*, **39**: 93-102.

Kromp, B., 1999. Carabid beetles in sustainable agriculture: a review on pest control efficacy, cultivation impacts and enhancement. *Agric. Ecosyst. Environ.*, **74**: 187-228. https://doi.org/10.1016/S0167-8809(99)00037-7

Landise, D.A., Wratten, S.D. and Gurr, G.M., 2000. Habitat management to conserve natural enemies of arthropod pests in agriculture. *Annu. Rev. Ent.*, **45**: 175-201. https://doi.org/10.1146/annurev.ento.45.1.175

Leather, S.R., Walters, K.F.A. and Bale, J.S., 1993. *The ecology of overwintering*. Cambridge University Press, Cambridge, pp. 255. https://doi.org/10.1017/CBO9780511525834

Levie, A., Legrand, M.A., Dogot, P., Pels, C., Baret, P.V. and Hance, T., 2005. Mass releases of *Aphidius rhopalosiphi* (Hymenoptera: Aphidiinae), and strip management to control of wheat aphids. *Agric. Ecosyst. Environ.*, **105**: 17-21. https://doi.org/10.1016/j.agee.2004.06.004

Mathews, C.R., Bottrel, D.G. and Brown, M.W., 2004. Habitat manipulation of the apple orchard floor to increase ground-dwelling predators and predation of *Cydia pomonella* (L.) (Lepidoptera: Tortricidae). *Biol. Cont.*, **30**: 265-267. https://doi.org/10.1016/j.biocontrol.2003.11.006

Munyuli, M.B.T., Luther, G.C. and Kyamanywa, S., 2007. Effects of cowpea cropping systems and insecticides on arthropod predators in Uganda and Democratic Republic of the Congo. *Crop Prot.*, **26**: 114-126. https://doi.org/10.1016/j.cropro.2006.04.010

Munyuli, M.B.T., Kyamanywa, S. and Luther, G.C., 2008. Effects of groundnut genotypes, cropping systems and insecticides on the abundance of native arthropod predators from Uganda and Democratic Republic of Congo. *Bull. Insectol.*, **61**: 11-19.

Nassab, A.D.M., Mardfar, R.A. and Raei, Y., 2013. Effects of wheat-oilseed rape intercropping and fertilizer on *Sitobion avenae* and its natural enemies. *Int. J. Biosci*., **5**: 43-50.

Root, R.B., 1973. Organization of a plant-arthropod association in simple and diverse habitats: the fauna of collards (*Brassica oleracea*). *Ecol. Monogr*., **43**: 95-124. https://doi.org/10.2307/1942161

Saleem, S., Ullah, F. and Ashfaq, M., 2009. Population dynamics and natural enemies of aphids on winter wheat crop. *Pakistan J. Zool*., **41**: 505-513.

Stiling, P., Rossi, A.M. and Cattell, M.V., 2003. Associational resistance mediated by natural enemies. *Ecol. Ent*., **28**: 587-592. https://doi.org/10.1046/j.1365-2311.2003.00546.x

Theunissen, J. and Den-Ouden, H., 1980. Effects of intercropping with *Spergula arvensis* on pests of Brussels sprouts. *Ent. Exp. Appl*., **27**: 260-268. https://doi.org/10.1111/j.1570-7458.1980.tb02973.x

Thomas, M.B., Wratten, S.D. and Sotherton, N.W., 1992. Creation of island habitats in farmland to manipulate populations of beneficial arthropods: Predator densities and species composition. *J. appl. Ecol*., **29**: 524-531. https://doi.org/10.2307/2404521

Trenbath, B.R., 1993. Intercropping for management of pests and diseases. *Field Crops Res*., **34**: 381-405. https://doi.org/10.1016/0378-4290(93)90123-5

Tylianakis, J.M., Didham, R.K. and Wratten, S.D., 2004. Improved fitness of aphid parasitoids receiving resource subsidies. *Ecology*, **85**: 658-666. https://doi.org/10.1890/03-0222

Vandermeer, J., 1989. *The ecology of intercropping*. Cambridge University Press, Cambridge, UK. https://doi.org/10.1017/CBO9780511623523

Wackers, F.L., Romeis-Danvan, J. and Rijn, P., 2007. Nectar and pollen-feeding by insect herbivores and implications for tri-trophic interactions. *Annu. Rev. Ent*., **52**: 301-323. https://doi.org/10.1146/annurev.ento.52.110405.091352

Wratten, S.D., Berndt, L., Gurr, G., Tylianakis, J., Fernando, P. and Didham, R., 2002. Adding floral diversity to enhance parasitoid fitness and efficacy. In: *Proceedings of the first international symposium on biological control of arthropods*. Honolulu, Hawaii, pp. 211-213.

Xiong, C.J., 1990. Study on the relationship between the occurrences of *Rhopalosiphum padi* (L) and the growing period of wheat. *Insect Knowl*., **27**: 5-7.

Yahya, M., Saeed, N.A., Nadeem, S., Hamed, M. and Shokat, S., 2017. Role of wheat varieties and insecticide applications against aphids for better wheat crop harvest. *Pakistan J. Zool*., **49**: 2217-2225. http://dx.doi.org/10.17582/journal.pjz/2017.49.6.2217.2225

Zhou, H.B., Lian, C.J., Yong, L., Francis, F., Haubruge, E., Bragard, C., Jingrui, S. and Dengfa, C., 2013. Influence of garlic intercropping or active emitted volatiles in releasers on aphid and related beneficial in wheat fields in China. *J. Integ. Agric*., **12**: 467-473. https://doi.org/10.1016/S2095-3119(13)60247-6