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Effect of *Brassica* Strips on the Population of Aphids and Arthropod Predators in Wheat Ecosystem

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Abstract.- Present study was designed to investigate the effects of *Brassica* strip cropping (intercropping) in wheat crop on the population of aphids and its predators in the wheat field. Study was conducted in district Sheikhupura, Pakistan during cropping session 2006-07 and 2007-08 at three different sites. Four treatments *viz*., T1 = a *Brassica* strip of 0.6×67m (40.2 m^{-2}) , T2 = a *Brassica* strip of 1.21×67m (81.7 m^{-2}) area, T3 = a *Brassica* strip of 1.82×67m (121.94 m^{-2}) area, T4 = a *Brassica* strip of 3.65×67m (244.55 m^{-2}) area and control (sole wheat crop was sown) were used in the study. During the study significant difference in number of aphids per tillers was observed among treatments. Highest number of aphids per tiller was recorded in control wheat plot, while lowest in the plot (T4). Highest number of Coccinellids, *Chrysoperla carnea* and araneae (spiders) was recorded in T4 while lowest in control. The maximum 1000-grain weight was recorded in T4 treatment (42.80g) while minimum in control treatment (36.57g). However, T3 treatment showed highest yield (5468kg/ha) followed by T2. The treatment T3 showed highest cost benefit ratio value (1:1.95) while lowest cost benefit ratio (1:1.77) was observed in T4. It is concluded that strip cropping of *Brassica napus* in wheat fields increases predator's population which suppress the aphids population, and enhances the yield.

Keywords: Predators, aphids, strip cropping, wheat, *Brassica*

INTRODUCTION

Aphids are the major insect pests of wheat (*Triticum aestivum* L.) in Pakistan (Hashmi *et al*., 1983; Hamid, 1983; Amjad and Ali, 1999; Aheer *et al*., 2006; Khattak *et al*., 2007). Different species of wheat aphids such as *Sitobion avenae* (F.,), *Schizapis granarium* (Rond.,), *Rhopalosiphum rufiabdominalis* (Sastari), *Rhopalosiphum madis* (Fitch.,) *Metopolophum dirhodum*, *Rhopalosiphum padi*, and *Sitobion miscanthi* were recorded from Punjab, Pakistan (Hashmi *et al.*, 1983; Inayatullah, *et al.*, 1993). Aphids directly suck the cell sap from the plant and indirect losses are caused through transmission of diseases from infected plant to healthy plants, which badly affect the yield (Emden, 1979; Abdulkhairov, 1979; Mohyuddin, 1981; Grima *et al.*, 1993; Raboudi *et al.*, 2002). Aheer *et al.* (1993) reported that 7.19 aphids per tiller reduced the yield of wheat up to 16.38%. However, 15 aphids per tiller caused 30–40% losses in yield (Kieckhefer and Gellner, 1992). Greatest loss of wheat yield was recorded by aphid feeding during the seedling stage. Lower losses were recorded during the booting stage; however no damage was recorded at maturity at same densities of aphids (Kieckhefer and Kantack, 1988).

Densities, and the pest control potential of generalist arthropods predators, are affected by the stand structure, prey availability, disturbance (Landis *et al.*, 2000) and plant diversity (Lavandero *et al.*, 2006) of agricultural fields. Increased habitat diversity in agrarian landscapes also expands the diversity of natural enemy populations, which in turn diminish colonization rates of herbivorous pest species (Landis *et al.*, 2000; Barone and Frank, 2003; Gurr *et al.*, 2003; Lavandero *et al.*, 2006).The population of generalist's predators such as chrysopids, spiders and coccinellids which have the capacity to suppress the population of aphids (Wratten and Powell, 1991; Schmidt *et al.*, 2004) can be enhanced through habitat manipulation. The best habitat manipulation is intercropping which is simple and inexpensive (Vandermeer, 1995). Studies have reported that intercropping of canola (*Brassica napus* L.,) in the wheat fields enhances the population of arthropods predators (Tingey and

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Lamont, 1988; Vandermeer, 1995; Altieri and Nicholls, 1999; Parajulee and Slosser, 1999; Ponti *et al.,* 2007; Sarker *et al.,* 2007). Potential mechanisms of enhanced population of chrysopids and coccinelids in intercropped wheat fields is attributed to the improvement of availability of alternative foods such as nectar, pollen and honeydew for the natural enemies of pests (Patt *et al.,* 1997; Landis *et al.,* 2000; Tylianakis *et al.,* 2004; Lundgren, 2009; Seagraves *et al.,* 2010). Honeydew also functions as contact kairomones for feeding coccinellids, which promotes area restricted search and oviposition (van den Meiracker *et al.,* 1990).

Khan *et al.* (2005) found that grain yield of wheat increased to 1721 kg per hectare with wheat and chickpea intercropping (1:1) as compared to wheat alone (1510 kg per hectare). Iqbal and Ashfaq (2006) reported that intercropping of *Brassica napus* with wheat increased the yield of wheat and reduced losses caused by aphids. Intercropping of *Brassica napus* in wheat also registered higher return than sole wheat crop (Verma *et al.,* 1997; Ali *et al.,* 2009; Khan *et al.,* 2009).

Nonetheless no such study has been conducted in Sheikhupura agro ecological zone under rice wheat cropping systems so far. Therefore, keeping in view the above discussion and importance of intercropping of *Brassica napus* in the wheat fields for the suppression of wheat aphids, the present study was initiated. For this purpose, crop of *Brassica napus* was selected as intercrop and wheat as a major crop.

MATERIALS AND METHODS

Field experiments were conducted at three sites i.e., adaptive research farm Sheikhupura, adaptive research farm Farooqabad and village Bhikie during 2006-7 and 2007-8 cropping season. The distance among the experimental sites was approximately 15 km. At all sites wheat fields of one acre (67.0×60.36m) were selected for the experiments. Each field except control was sown in the middle with a belt of *B .napus* whose length was across the edges but width varies. In treatment 1 (T1) width was 0.6m, treatment 2 (T2) 1.21m, treatment 3 (T3)1.82m and treatment4 (T4) 3.65m. Wheat and Brassica were sown in these fields in the second week of November each year by drill methods. The recommended dose of NPK fertilizers in the form of urea, DAP and sulphate of potash was applied to all treatments. The tank mixture of herbicides (Buctril-M +Chlodinafop) was applied to all treatments in the last week of December each year to control weeds. However, herbicidal shield spray was used near the Brassica strips just to save them from herbicidal drift. Brassica was harvested in 3rd week of March each year whereas the wheat was harvested in the 4th week of April each year.

Collection of specimens

Epigeic spiders were collected by pitfall traps both the years from 1st December through last week of April. Chrysoperla trapping was started from February 10 to last week of April while Lady bird beetles (coccinellids) trapping was started from December 31 to last week of April. Pitfall traps made of cheap and easily available glass bottles (6cm diameter x 13cm deep). During collection, the pitfall traps were buried in the soil up to level of the ground. At each treatment, 20 traps were operated in 5x4 grid pattern. The distance between each trap was 10 m. Pitfall traps were filled with 250 ml of alcohol (75%) and two drops of 5% liquid detergent were added to reduce surface tension. After three days (=trapping session) traps were removed, capped and brought to laboratory. Specimens were washed with alcohol and stored in a mixture of alcohol (70%) and glycerin (30%) with proper labeling of locality, date of collection and other notes of importance. Collection of aphids was done from January 10 through last week of April.

For the collection of foliage predators (coccinellids, *Chrysoperla carnea* and foliage spiders) and aphids, 45 tillers were selected randomly (15 tillers were sampled at dawn, 15 at noon and 15 at dusk) from each site and at each trapping session. Each tiller was searched for three minutes for predators population. In the field, specimens were kept in plastic bags and brought to the laboratory where stored in a mixture of alcohol and glycerine.

The spiders, chrysopids and aphids were identified to the species level and coccinellids to genus level with the help of available literature. The immature specimens were identified only to the generic level. Voucher specimens were deposited at the Department of Zoology, University of the Punjab, Lahore, Pakistan. Each mature specimen that could not be identified was included as species but its genus was not added in total of genera.

Yield assessment

The mean values of yield parameters for two years and three sites were calculated. The wheat data on different yield parameters i.e., number of spikes per m^2, number of grains per spike and 1000 grain weight were collected for each treatment to know the effect of strip cropping of *B. napus* on yield. However, the wheat yield was measured on plot basis (1 acre).The Brassica strips were also harvested and threshed manually. Brassica seeds and wheat grains were weighed and calculated their values as per local market prices to evaluate cost benefit ratio among control (sole wheat) and different treatments used in the study. The yield was estimated on the hectare basis. The increase or decrease of yield over control was calculated by using formula *i.e.* Treatment - control×100/control (Sherawat *et al.*, 2007). The cost and benefit ratio was calculated by dividing total income by total expenditure.

Data analyses

Analysis of variance (ANOVA) was used to compare the density of predators and prey among sites, years and treatments. Pearson's correlation was used to find out the correlation between prey and predators population. Statistical software SPSS 13 version was used to analyze the data.

RESULTS

During both of the study years highest number of aphids per tiller was recorded in control plot as compared to treated plots (Fig. 1B). The density of aphids do not differ among the years and sites (F 1, 300 =3.42; P=0.065 for years and F 2, 300 =2.40; P=0.093 for sites) but significant difference was recorded among treatments (F 4, 270 = 6.11; P<0.005). Statistical analysis showed that spider density was not different among treatments, study years and sites (F 4, 300 =1.43; P = 0.225 for treatments and F 4, 300 = 0.26; P = 0.614 for years

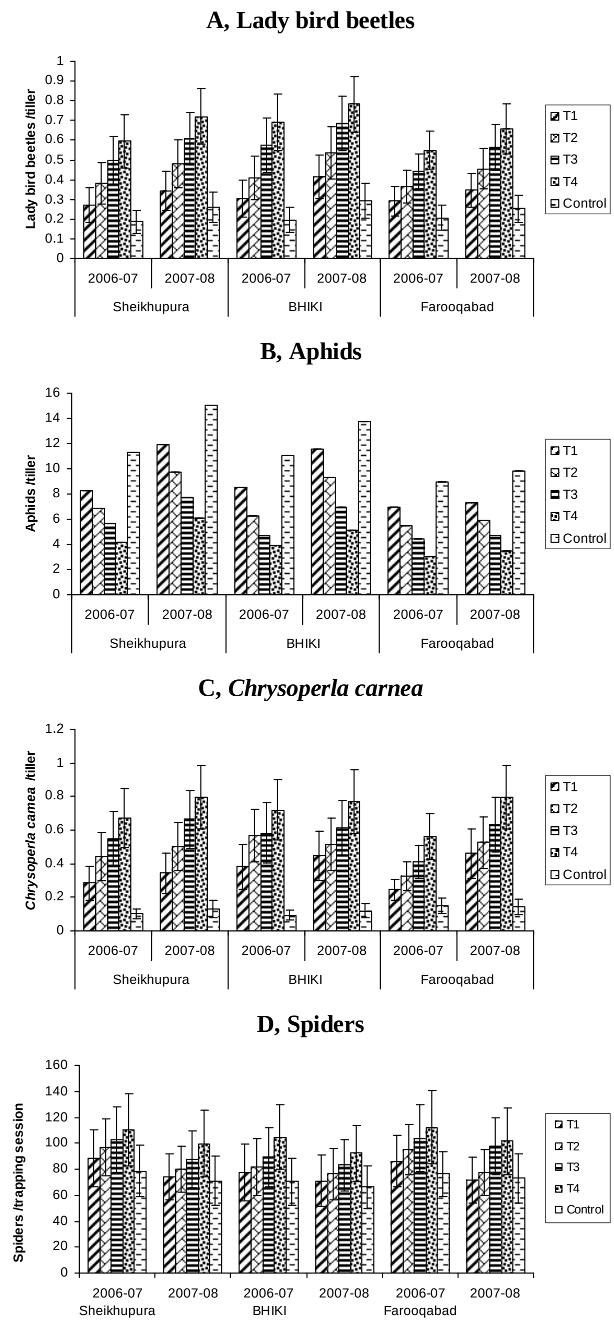

Fig. 1. Population of lady bird beetles (A), aphids (B), *Chrysoperal carnea* (C) and spiders (D) among different treatment and sites.

and F 2, 300 = 0.38; P = 0.68, Fig. 1D). However, correlation was positive between spiders and aphids population (Pearson's correlation = 0.69).

A significant difference in number of

coccinellids per tiller was recorded among treatments and study years ($F_{4,\ 300}$ =15.63; P<0.005 for treatments and $F_{4,\ 300}$ = 5.93; P<0.005 for years, Fig. 1A). While no difference was observed in their densities among sites ($F_{2,\ 300}$ = 1.34; P = 0.262). The highest number of coccinellids was recorded in T4 while lowest in the control at all sites under study. Correlation was positive between coccinellids and aphids's population (Pearson's correlation = 0.47).

The analysis of variance for *C. carnea* population showed that treatment (4) revealed their highest and control plots lowest abundance at all study sites ($F_{4,\ 209}$ =16.36; P<0.005, Fig. 1C). But it did not differ significantly among years and sites ($F_{1,\ 209}$ =3.33 P = 0.069 for years and $F_{2,\ 209}$ =0.41; P=0. = 0.666 for sites). The increase in the density aphids also increases *C.carnea* abundance (Pearson's correlation = 0.75).

Table I.- Weight of 1000 grains and yield in various treatments of *Brassica napus* in wheat field.

Treatments	No. of spike bearing tillers m^{-2}	No. of grains $spike^{-1}$	1000-grain weight (g)	Yield (kg ha^{-1})	% Inc. or dec. over control*
T1	380	41	37.77 b	5048	-1.41
T2	375	40	39.77ab	5338	4.26
T3	374	39	41.75 a	5468	6.80
T4	373	36	42.80 a	4910	-4.10
Control	384	40	36.57 b	5120	-

Treatment - control×100/control

The data of 1000-grain weight of wheat in various treatments are given in Table I. The results revealed a significant difference among various treatments ($F_{4,\ 10}$ =31; P<0.005). The maximum 1000-grain weight was recorded in T4 (42.80g). The minimum 1000-grain weight was observed in control treatment (36.57g). The treatment T1 and control were statistically at par.T3 and T4 were statistically at par followed by T2. There was negative correlation between population of aphids and 1000-grain weight (Pearson's correlation = -0.955), whereas correlation was positive for Coccinellids and *C. carnea* and spiders (Pearson's correlation = 0.485, 0.945 and 0.56, respectively). The highest yield was recorded in T3 and lowest in T4. The economic analysis, yield, variable cost and the cost benefit ratios of aforesaid treatments are given in Table II. The cost benefit ratio of T3 treatment showed highest value (1:1.95) while lowest cost benefit ratio (1:1.79) was observed in T4.

DISCUSSION

In the present study we investigated the effect of Brassica strip cropping in wheat fields on the population density of pest (aphid) and predators. Our study provided the evidence that strip cropping (intercropping) enhances the population of the natural enemies and resultantly suppresses the aphid population. Strip cropping reduces pest pressure and increases yield of the main crop (Vandermeer, 1995; Altieri and Nicholls, 1999; Tingey and Lamont, 1988; Sarker *et al.,* 2007). This finding is in conformity with the results of Ponti *et al.* (2007) and Parajulee and Slosser (1999) who reported canola a better trap crop for enhancing the population of predators. Potential mechanisms of enhanced predator population in intercropped wheat fields is attributed to the improvement of availability of alternative foods such as nectar, pollen and honeydew for the natural enemies (Patt *et al.*, 1997; Landis *et al.*, 2000; Tylianakis *et al.*, 2004). The moist and shadier soil surface microclimate also helps to enhance predators population in the agricultural fields (Zhang and Li, 2003). In general, vegetation diversity has been proposed to disrupt the pest's ability to locate the host plant, to increase mortality of the pest or to repel the pest (Poveda *et al.*, 2008). The Brassica crop is taller than the wheat crop and also has different colour than wheat crop which may disrupt the movements of alate aphids. The Brassica crop also has different odour and smell than the wheat crop which may affects the herbivores. The disruptive crop hypothesis is equivalent to Root's (1973) resource concentration hypothesis and stipulates that herbivores in polycultures will have more difficulties finding crop plants associated with one or more taxonomically or genetically different plants than finding crop plants in monoculture (Vandermeer, 1989). Finch and Collier (2000) proposed that herbivores tend to land on tall green plants, so that using non crop plants to

Table II.- Economic analysis of different treatment of *Brassica napus* on yield of wheat crop.

Treatments	Yield kg ha^{-1}	Additional yield over control (kg ha^{-1})	Income of wheat grain (Rs. ha^{-1})	Income of wheat straw (Rs. ha^{-1})	Income of *B. napus* (Rs. ha^{-1})	Total income (Rs. ha^{-1})	Total expenditure (Rs. ha^{-1})	Cost benefit ratio (CBR)
T1	5048	-72	119890	18930	480	139300	77818	1:1.79
T2	5338	218	126778	20018	960	147756	77842	1:1.90
T3	5468	348	129865	20505	1440	151810	77878	1:1.95
T4	4910	-210	116613	18413	2880	137906	77917	1:1.77
Control	5120	-	121600	19200	-	140800	77806	1:1.81

Wheat @ Rs.950 per 40 kg, wheat straw @ Rs. 150 per 40 kg, Brassica grain@ Rs.1500 per 40 kg.

make the crop "less apparent" by adding more green or taller plants is a useful mechanism to camouflage the crop proposed visual camouflage hypothesis also known as the "apparency hypothesis" incorporates the visual stimuli (color and plant height) that induce herbivores to land on plants. Tahvanainen and Root (1972) suggested that non host plants confer protection to the crop by releasing "odor masking" substances into the air making the crop "invisible" to the herbivores. Uvah and Coaker (1984) reported that non host plants emit odors that repel the herbivore. Plant diversity tends to intensify the impact of natural enemies, thus contributing to the relative infrequent pest-outbreaks often associated with, natural communities and mixed crop ecosystems (Huffaker, 1962). Parajulee *et al*. (1997) reported that the canola crop had higher predator numbers than wheat, suggesting that it would be a better winter inter-crop in wheat, for enhancing predator numbers.

Negative correlation between seed yield and aphid infestation in the present study is in accordance with the findings of Tingey and Lamont (1988) who observed significant decrease in yield with the increase of aphids infestation in the field. Host plants have direct effect on the herbivores through their physical and chemical properties (Gurr and Wratten, 1999). The intercropping creates barrier and causes disruption of host findings for herbivores and could be a feasible explanation for the low density of aphids in the wheat field (Chabi-Olaye *et al.,* 2005; Bjorkman *et al.,* 2007). Vandermeer (1989) speculated that the purpose of intercropping is to generate beneficial biological interactions between the crops and it can increase yields, more efficiently use available resources, reduce weed infestation, insect and disease pressures and provide greater biological and economic stability.

The economic aspect of this study (Table II) revealed that all intercropping combinations substantially improved the crop income over sole crops but highest return of Rs.151810 was obtained from treatment (T3) followed by (T2) Rs.147756 and lowest return was obtained from T4 treatment Rs.137906. For cost benefit ratio (CBR) intercropping treatment T3 produced higher CBR (1:1.95) than all other treatments whereas, T4 produced the lowest CBR (1:1.77). Our results are in conformity with Khan *et al.* (2009) who reported that wheat intercropped with rapeseed produced more returns than sole wheat. However, reduction in returns of treatment (T4) was due lower yield of wheat crop as compared to other treatments. Ali *et al.* (2009) also reported maximum benefit cost ratio (1.67) and net profit (Rs.48628/ha) was recorded in wheat Brassica intercropping systems. Verma *et al*. (1997) reported that intercropping of wheat and Indian mustard gave maximum net return, and benefit-cost ratio.

It is concluded from the present study that intercropping of *B. napus* in wheat helped to enhance predators' population in the fields which in turn suppressed aphid population, thus resulted in natural biological control of aphids. However, low yield of wheat in T4 as compared to control was due to more reduction in the area of wheat. Reduction in the yield of wheat crop in (T1) as compared to control may be attributed to very small area of Brassica which could not attract predators and resulted in inefficient suppression of the aphid population.

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