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Effects of wheat and barley intercropping ecosystem on the prevalence of aphid (Hemiptera: Aphididae) population in canola (*Brassica napus* L.) crop

Muhammad SARWAR [*1]

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

Abstract

For the enhancement of cultural control, the agricultural practices such as intercropping can profoundly affect the insect pest populations. Studies were undertaken to examine the effects of intercropping wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) with canola (*Brassica napus* L.) on the incidence of aphid (Hemiptera: Aphididae) population and related crop yield. Study observed that aphid *Myzus persicae* (Sulzer), was the most abundant insect pest at the experimental sites and its population differences existed between treatments. Canola intercropped with cereals supported smaller number of aphid per plant and enhanced seed yield than monoculture. Decreased aphid numbers occurred in wheat from intercropping than resulting from barley that led to similar impacts in corresponding crop yield. Increased aphid populations occurred in wheat and barley grown alone than resulting from intercropping with canola leading to similar reduction in corresponding grains yield. Studies on aphid population dynamics with reference to crop phenological stages investigated that the invasion of *M. persicae* was originated during flowering or pod formation stage and peak population was generally found during seed filling growth stage. Further, the ecological factors contributed variations in aphid infestation levels during crop season. Implications of these results for the control of aphid in canola using cereals or vice versa could be argued that can be suitable integrated pest management strategy in agro-ecosystem.

Key words: Aphid, Intercropping, Wheat, Barley, *Canola, Brassica napus*

1. Introduction

As a major human food component, edible oil production and trade are the most significant parameters of global economy. Among rapeseed, Canola (*Brassica napus* L.) is one of the world's leading edible oil crops. Its seed contains less than 20% erucic acid and less than 30 μMg^{-1} of glucosinolates in the oil free meal. Furthermore, canola oil is lower in saturated fats (5-8%) than any other vegetable oil (Raymer, 2002). Damage due to insect pests is a major constraint in the production of *Brassica* crops. Aphids constitute one of the key pests and main phyto-sanitary problems in rapeseed and mustard crops (Sarwar, 2009). Losses due to insect pests on these crops are estimated to be 70-80% in Pakistan. But in case of severe infestation during the year of sporadic attack, there may be no grain formation at all (Khattak *et al.,* 2002). The green peach aphid, *Myzus persicae* (Sulzer), is found throughout the world, where it is viewed as a pest principally due to its ability to transmit plant viruses. Green peach aphid feeds on hundreds of host plants in over 40 plant families (Capinera, 2001). This aphid can attain very high densities on young plant tissue, causing water stress, wilting, and reduced growth rate of the plant. Prolonged aphid infestation can cause appreciable reduction in yield of root crops and foliage crops. Contamination of harvestable plant material with aphids, or with aphid honeydew, also causes losses (Petitt and Smilowitz, 1982). According to some workers, *M. persicae* is among the generalist Brassicaceae feeding aphids (Blande *et al.,* 2008).

[*] *Corresponding author* / Haberleşmeden sorumlu yazar: Tel.: 092-0301-6535526; E-mail: drmsarwar64@yahoo.com

It has been accepted for decades that effective control of inset pests is dependent on the use of insecticides. Insecticides though efficient and working quickly, but are now being reappraised with respect to the environmental hazards that they pose, which has emphasized the need for new methods to control inset pests. There is now tremendous pressure on farmers to use methods of pest control, which do not pollute or degrade the environment. Intercropping usually can serve this purpose. Successful management strategies usually have multiple components and a considerable progress has been made in the utilization of intercropping or simultaneous growing of two or more crops on the same piece of lad that can profoundly affect the insect pests' population resulting increase in seed yield. According to previous findings and observations in field experiments, Kurmvanshi *et al.,* (1994) studied effects of intercropping on oilseeds and pulses with rain fed wheat. Sole oilseeds (safflower), and wheat plus safflower gave the highest net returns. In another field experiment, wheat was intercropped with the legumes or oilseeds. Wheat grain yield was not significantly affected by intercropping experiment (Verma *et al.,* 1996). Losses caused by plant diseases and pests are as old as plants themselves. Changes in cropping patterns including the cultivation of high yielding varieties and hybrids have further added to the problem in some areas. Various strategies to control diseases and pests have been successful to different levels. New biotechnology tools are providing new levels of protection against certain pests and diseases. Intercropping with legumes may be helpful to augment natural enemy population and trap cropping to reduce damage by important pests to main crop (Reddy and Usha, 2004). According to Hummel (2009), intercropping canola and wheat may provide an opportunity for reducing crop damage from root maggot (Diptera: Anthomyiidae, *Delia* spp.) attack without compromising environmental sustainability. Although, information on the association of oilseed crops with cereals for pest control benefits is available in literature, but very few studies have been documented on canola intercropping. So, in this paper, the potential benefits of intercropping of canola with cereals for aphid control were investigated.

2. Materials and methods

Field experiments on the use of wheat and barley intercropping for the incidence of aphid population in canola crop to control aphid infestations were carried out at the field site of Nuclear Institute of Agriculture, Tando Jam-70060, Pakistan.

2.1.Experimental procedure

An improved variety of Canola crop "Hyola-42" was sown on first week of November during the winter season of 2005/ 06. Studies were undertaken to examine the effects of intercropping 1 row of wheat and barley with 2 rows of canola. Conventional tillage practices were done using a moldboard plough and disking followed by a field cultivator to prepare a smooth seedbed. Treatments comprised Wheat (*Triticum aestivum* L. variety T.J.-83) plus Canola (*Brassica napus* L. variety Hyaola-42) intercropping, Barley (*Hordeum vulgare* L.) plus Canola intercropping, and Wheat, Barley and Canola grown alone. The experiment was arranged in a randomized complete block fashion with three replicates, having 2.5 m^2 plot size, which resulted in three rows of crops spaced 9 cm apart. In each row canola was sown, and wheat/ barley were sown in the plots as the intercrops. Both cereal crops as intercrop in canola were sown at the time of sowing of canola. Seedlings were thinned to appropriate spacing after plant emergence. During the season, a row cultivator was used for controlling weeds in the conventional tillage system. No pesticide was used in this experiment site. Nitrogen fertilizer was applied to crop in the form of urea in two splits, half at sowing and half after the first irrigation. Recommended package of agricultural practices was adopted during the crops growing spell. Aphid infestations were allowed to develop on crop naturally and measured at critical crop growth stages.

2.2.Data Collection

The experiment compared the effects of intercropping and mono-cropping on the incidence of the aphid and seed yield. Aphid populations were assessed by estimating the number of aphids/ plant on whole plant. On each sampling date, 5 canola plants were randomly selected from each plot and each plant was sampled by visually examining all plant foliage and counting the number of alate (winged) and apterous (non-winged) aphids present on leaves and inflorescences. In both cereals, the infestation levels of aphids were estimated by randomly selecting 5 plants within each replicate, visually counting the number of aphids separately and particular attention was given to hearts and terminal growing points. Observations on aphid infestations were recorded from week 4 after crop sowing and continued up to week 11 after sowing. Aphid population development was monitored every 10 days intervals and rated by average counts of aphid per plant. Observations were taken to monitor aphid abundance from young and older leaves, and inflorescence of canola at different growth stages. Studies were further undertaken on the population dynamics of aphid in mustard crop with reference to crop phenological stages and climatic condition of field site. The effects of this pest on wheat, barley and canola grain yields and quality were also examined. The plants were hand-harvested from each replicate to obtain seed for yield estimation when the crops fully matured. After threshing, 14 weeks following crop sowing, grain weights of each crop were determined and recorded.

2.3.Statistical analysis

Statistical analyses were conducted using Steel and Torrie (1986) software Institute. The data were subjected to analysis of variance (ANOVA). Mean differences were compared with the LSD and separation was accomplished using Duncan's multiple-range test when P-values were significant at □0.05 probability level.

3. Results

Wheat, barley and canola intercropping experiments conducted observed that aphid *M. persicae* was the most abundant and major insect pest at experimental location, and its population differences existed between treatments. Studies showed that sole cropping had significantly higher incidence of pest as compared to intercropped treatments. The results of the experimental data are shown and summarized in Table 1.

3.1. Aphid population

Significantly the highest aphid incidence (23.47/ plant) occurred when canola were planted as mono-crop at the experimental location. On the other hand, an inconsistent trend was observed in aphid incidence across the location when canola intercropped with cereals. Canola intercropped with wheat supported smaller number of aphid (18.17) per plant followed by barley (14.43 per plant) than monoculture. Decreased aphid numbers per plant occurred in wheat (3.16) from intercropping than resulting from monoculture (3.56). Likewise, the restricted aphid incidence occurred in barley (4.46) simultaneously planted as intercrop, whereas higher incidence occurred (5.66) in mono-cropped. Barley treatments resulted in slightly the exalted number of total aphids counted per plant than wheat treatment. Aphid pressure on both cereal crops was negligible and resulted no significant differences among variables measured.

Table 1. Effects of wheat and barley intercropping on the incidence of aphid in canola crop

S. No.	Treatments		Aphid population/ plant	Yield/ plot (2.5 m^2) (gm)	Yield/ Hectare (Kg)
1.	Wheat plus Canola	Wheat	3.167 d	1177.0 a	4708.00
2.		Canola	18.17 b	795.3 c	3181.20
3.	Barley plus Canola	Barley	4.467 d	840.0 c	3360.00
4.		Canola	14.43 c	816.0 c	3264.00
5.	Wheat alone		3.567 d	1070.0 b	4280.00
6.	Barley alone		5.667 d	828.3 c	3313.20
7.	Canola alone		23.47 a	739.0 d	2956.00
LSD value			2.66	53.78	

Means sharing dissimilar letters in a column are significantly different ($P \leq 0.05$).

3.2. Seed yield

Studies undertaken to examine the effects of intercropping on the incidence of pest's population and its ultimate impacts on related crop yield indicated that yield losses were very significantly related with the population density of aphid. Seed yield was the highest in wheat (1177.0 gm per 2.5 m^2) inter-planted with canola than sole cropping with an overall average yield of 1070.0 gm due to inconsistent trend observed in aphid incidence (Table 1). Barley inter-planted within canola rows led to good mean seed harvest (840.0 gm) than recorded from the sole barley crop (828.3 gm). The magnitude of grain produce was accounted to be significantly higher in canola inter-planted with wheat (795.3 gm) and barley (816.0 gm) as compared with sole canola planting (739.0 gm). These results indicate that sole canola planting may likely to be less competitive for aphid incidence and thus more suitable for pest attack. But inter-planting crops provided an increased competition of aphid incidence for all resources, which managed pest in such a way that increased the intra-specific competition for aphid intensity that led to similar reduction in corresponding crop yield.

3.3. Ecological parameters and aphid population dynamics with reference to crop phenoloy

The population fluctuations of the aphid were studied under field conditions during crop growing season from November 2005 to March 2006. The first aphid colonies appeared during second week of February, which increased gradually, and reached peak numbers during late February to early March. The pest build up started declining thereafter on the mid week of March. Aphid infestation developed during flowering stage or pod formation of the study year was14.00 aphid per plant. Peak population of pest was commonly found during seed filling stage (43.66 aphid per plant). The pod maturing stage accomplished comparatively moderate population (24.66 aphid per plant) compared to the both crop growth stages (Fig. 1).

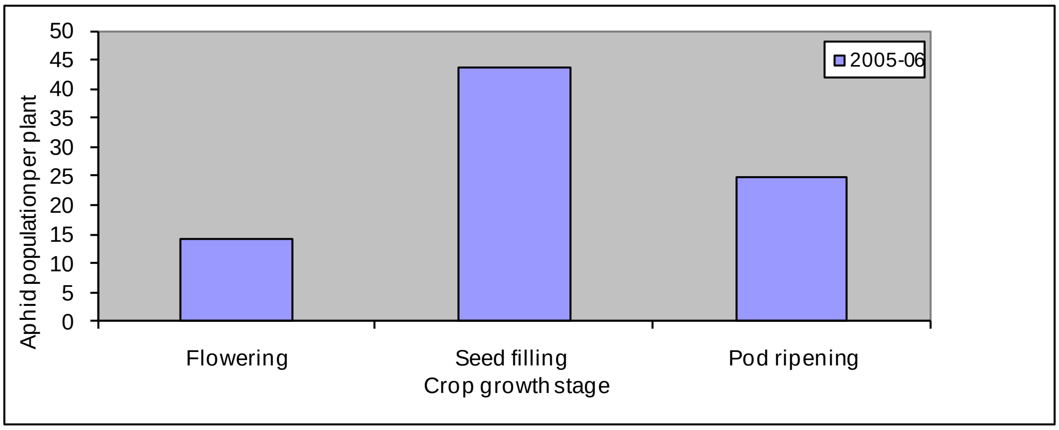

Figure 1. Graph showing aphid population during different growth stages of canola plant

The mean ecological parameters during the cropping season 2005-06 varied considerably (Table 2). Analysis of the pest populations showed that aphid activities appeared during February and March, which fluctuated in a dissimilar pattern in both months. There were noteworthy relationships between aphid population and some climatic factors. The data presented in Table 2, indicated that March experienced increased maximum temperature and minimum temperature, precipitation, bright sunshine hours, wind speed, south-west wind direction, and evaporation; while decreased relative humidity and cloudiness compared to prevailing in February, which appeared to be congenial for the multiplication of the aphid Thus, the increase in aphid population was found to be positively and negatively related, with meteorological data from the start of the infestation, its maximum peak population and decline in abundance at the ending of the experimental period.

Table 2. Ecological data during the crop seasons 2005-06 at the field site

Year/ Month	Temperature (^{0}C)		R.H	Precipitation	Cloudiness	Sun shine	Wind speed		Evaporation
2005-06	Min	Max	%	mm	OCTA	Hrs	Km/hr	Dir	mm/day
November	14.6	32.2	67	00	0.2	9.1	2.3	NE	3.3
December	7.8	26.0	67	00	0.6	8.9	2.5	NE	2.5
January	7.4	24.4	67	00	1.8	8.5	3.5	NE	2.6
February	14.4	28.9	66	00	1.8	8.9	3.2	NE	3.8
March	15.00	33.0	61	1.6	1.2	9.4	4.2	SW	5.2

4. Conclusions

Studies investigated that intercrop has an impact on the incidence of pest, decreased aphid numbers occurred in wheat from intercropping than resulting from barley that led to similar influences in corresponding crop yield. Increased aphid populations occurred in wheat and barley grown alone than resulting from intercropping with canola leading to similar reduction in corresponding grains yield. The current results further ascertained that crop phenological stages have an important impact on population dynamics of aphid and its intensity also influenced by meteorological parameters. Out of different planting systems under investigations, canola plus wheat intercrops demonstrated the vehemence and supremacy of intercropping systems than monoculture due to efficient usage of the available resources. Several workers have often claimed such benefits earlier by reporting an enhanced yield from intercropping. Ahmad and Rao (982) suggested that intercropping is considered to be an effective and potential mean of increasing crop production per unit area and time. It offers considerable yield advantages over sole cropping because of efficient utilization of nutrients essential for plant growth. Study proved that canola intercropped with cereals supported smaller number of aphid per plant, while increased aphid populations occurred in canola, wheat and barley grown as monoculture leading to equivalent impacts on grains yield. It was further observed that wherever, the canola was inter-planted with wheat and barley, grain yield increased, but the yield of seed was badly affected due to higher pest injury in mono-cropping treatments. There was a trend towards decreased aphid numbers and better grain quality occurred on canola from intercropping than grown alone. Singh and Kothari (1997) have reported similar findings while conducting study to determine if intercropping mustard with aromatic plant species could provide an environmentally safe method for aphid control. Aphid infestation on mono-crop mustard was compared with intercrop treatments, intercropping resulted in a significantly lower aphid infestation.

Further, in a field trial, wheat was intercropped with mustard *B. juncea* in different row ratios rates. Grain/ seed yields of both crops were the highest when grown as sole crops. In the intercropping treatments, wheat grain yield was the highest when sown in 8: 2 wheat: mustard ratio and mustard seed yield was highest in the 4: 4 row ratios. These 2 treatments also gave the highest gross returns and land equivalent ratios (Patil *et al.,* 1995). According to Lasker *et al.,* (2004), intercropping of mustard with various other winter season crops including wheat and barley resulted in lower incidence of the aphid than with sole crop of mustard; the minimum incidence was found in mustard-wheat, which was at par with mustard-barley combination. Analysis of the yield data pointed out that although seed yield was significantly higher in sole crop of mustard yet the sale proceeds of the intercrops gave additional monetary returns which accounted for 2.39-3.62 times higher return than that from sole crop of mustard. The present findings can further be compared with other studies on this aspect of intercropping for aphid management where contrasting results were claimed. The wheat and *B. campestris* intercrop did not perform well and was not more profitable than either crop alone (Subedi and Joshi, 1995), and was not as profitable as either sole crop (Subedi, 1997). Yield depressions recorded in canola plus barley intercrops might have occurred due to an imbalance in the essential elements and their reduced concentrations within the plant below the critical ranges as annunciated by Tisdale *et el.,* (2002). Sindagi (1982) gave the view that intercropping brings higher returns due to efficient utilization of space, light, water and nutrients by intercrops. Although there can be slight yield reduction in major crop component but the additional income from other crop increases the total income per unit area. Thus intercropping gives higher net income per hectare than the sole cropping.

Observations on aphid population dynamics with orientation to crop phenological stages scrutinized that the population of *M. persicae* followed different occurrence pattern throughout the crop growth period. Aphid invasion was originated during flowering stage; elevated population generally initiated during pod formation, while pod maturing stage practiced slight population in crop season. The reason might be difference in crop phenology recorded in the current studies. This statement is parallel to practical findings of Sumana *et al.,* (2004), these workers stated similar results where aphid dynamics in mustard crop with reference to weather and phenological stages were reported and showed that mustard aphid (*Lipaphis erysimi*) infestation started during either flowering or pod formation stage. And peak population of aphid was mostly found during seed filling stage. Amer *et al.,* (2009) studied the seasonal abundance of aphids in canola, *B. napus* and explored that appearance of aphids was not uniform from their appearance till maturity of the crop, the reported population difference was due to crop phenology. It was examined that the weather parameters played a crucial role in governing the aphid build up. The precipitation (rainfall), sunshine hours and wind speed along with wind direction (north-east) were negatively related, whereas, the temperature, relative humidity, cloudiness, wind direction (south-west) and evaporation had positive relationship with the aphid population build-up. Afshari *et al.,* (2006) gave similar statement by studying population fluctuation of the aphid, the results showed significant relationships between aphid population, main natural enemies and some climatic factors. However, temperature, daily sunny time and wind speed as abiotic factors were linearly correlated with total aphid population. Dhaliwal *et al.,* (2007), revealed that the incidence, growth and multiplication of mustard aphid are largely influenced by meteorological parameters like temperature, relative humidity, rainfall, wind speed and cloudiness.

From the present studies, the general conclusion is that among the canola-cereals intercropping systems, the canola plus wheat proved to be the most compatible system, which performed efficiently to lower aphid damage and yield losses resulting improved canola production without adversely affecting wheat yield. Knowledge of the aphid abundance in monoculture and inter-culture cropping, aphid population dynamics with reference to crop phenological stages and climate could provide insight to reduce pest's risk. The implication of these results is that using cereals as intercrop in canola or canola crop as border/ barrier around cereals are likely to be successful aphid management strategies. However, extended studies are necessary to determine the exact reproduction sites of aphid's buildup and monitoring of weather parameters in agricultural areas that can be suitable integrated pest management strategy in agro-ecosystem.

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