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Influence of aphid herbivory on the photosynthetic parameters of *Brassica campestris* at multan, Punjab, Pakistan

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Abstract

Two of the regular insect pests, *Brevicoryne brassicae* and *Lipahis eyrsimi* attack on the *Brassica campestris* varieties throughout the growing season at Multan, Southern Punjab, Pakistan. Effect of these aphid species were examined on photosynthesis *Brassica campestris* cultivars, *B. campestris* A, Toria selection A, *B. campestris* PARC and *B. campestris* local under three different insecticide treatments, under RCBD design following split plot experiment in 2012. Populations of both the aphid species imposed their attack up to the mid of March in unsprayed and one spray treated plots respectively. Aphid herbivory caused significant reduction in photosynthetic rate and water use efficiency. Aphid free and single application of insecticide at peak flowering stage resulted in significant increase in photosynthetic rate and water use efficiency. The necessary practice of insecticide should be performed at the critical stage (peak flowering) of plant to optimize the photosynthesis losses and overcome the hazardous use of insecticides with least effect on the natural ecosystem.

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Introduction

Integrated Pest Management (IPM) is the principal essence of pest management and can be characterized as combining the many management tactics to reduce the pest status by minimizing economic and environmental costs. Brassica crops are sown for variety of purposes like fodder, vegetables and edible oil for human consumption. The area and production level of rape and mustard crops recorded in Pakistan during 2002-03 were about 649x10^3 acres, 217x10^3 tons oil seeds and 69x10^3 tons oil (Anonymous, 2002-2003). Aphids are serious insect pests present throughout the rape and mustard growing areas of the country and worldwide. The mustard aphid is a notorious sucking insect pest present worldwide are louse-like, pale-greenish feed on flower buds, shoots, pods etc. The insect is most abundant from December to March and breeds parthenogenetically throughout the season. The females give birth to 26-133 nymphs. About 45 generations are completed in a year. Damage is caused by sucking the cell sap from all the green parts of the plant and especially prefers the inflorescence. The extensive loss of cell sap results in low vigor and stunted growth in plant (Israr, 1986). Ingestion of phloem sap by aphids depends on the nitrogen content of the sap responsible to the cause of direct damage to plant (Wratten, 1978; Vereijken, 1979). Indirect damage may be due to their sugary excreta, honeydew which flourishes the growth of saprophytic fungi which imposed a negative effect on the photosynthesis and leaf duration (Vereijken, 1979). Although natural enemies given the preface with miscellaneous modes of pest foraging and asynchronous life cycles (Sunderland *et al.*, 1997) but their presence is not abundant on the varieties of *B. campestris* to limit the pest populations below ETL. For the sake of IPM implementation, all control measures such as time of sowing, cultural practices, biocontrol agents and at last step is the use of appropriate insecticide is necessary action to carry on this methodology.

The physiological status of the host plant may affect its attractiveness to pests. (Meyer and Whitlow, 1992) reported that spittlebug (*Philaenus spumarius* L.) infestation reduced photosynthesis of goldenrod (*Solidago altissima* L.) Photosynthetic reduction is induced by the "selective-feeder" such as phloem feeder which results in reduction of leaf stomatal conductance (Buxton, 1993).

Previously, many scientists worked on the management of Brassica species by using different management tactics of IPM such as sowing time, insecticides treatments etc. but no work was still reported from Pakistan as well as worldwide to evaluate the effect of aphid feeding on the photosynthetic parameters of the plant under different insecticide treatments.

The basic aim of the experiment was to determine the stage at which the insecticide application is best for the optimum photosynthesis, pest resistance and environment safety.

Material and methods

Conduction of Research trial

The research was conducted during timely growing season of Brassica on 5^{th} November, 2011-2012 at the Agricultural farm of Faculty of Agriculture Sciences and Technology, Bahauddin Zakariya University, Multan in Southern Punjab, Pakistan. The climate of this region is arid and receives about 125mm of mean annual rainfall. There March is a short spring and temperature expands after March sharply (Amer *et al.*, 2009). *B. campestris* varieties, *B. campestris* A, Toria selection a, *B. campestris* PARC and *B. campestris* Local were sown in Randomized Completely Block Design (RCBD) following split plot experiment in three replications by hand poring method into soil. Six rows were designed in each treatment with row to row distance of 90 cm and plant to plant distance 9 cm was adjusted. Distance maintained between replications was 150 cm. All cultural practices were uniformly performed throughout the growing season in all the plots in order to follow the IPM programme. Confidor (Imidacloprid 20 SL) was selected as an insecticide, which is used to keep on its activity in a sequence of nine days interval. Three insecticide treatments were designed for treatment purposes following the split plot experiment. 1st was aphid free, on which three regular continuous sprays were done after seven days interval on 19th , 27th Feb. and 03th March 2012 respectively. Second was aphid protected (one spray at flowering stage) on which one spray is applied only at peak flowering stage of the plant on 19th Feb. 2012. Third was aphid infested (control) without spray whole the season.

Sampling of aphids population

The aphid populations were recorded from six randomly selected plants in every treatment on the basis of weekly intervals from the start of aphid colonization until the crop maturity. The sampling dates of aphids were recorded four times after weekly intervals from 20th Feb. to 15th March 2012. Top 10 cm of the every inflorescence of each selected plant was gently beaten six times by using a 15 cm long stick of pencil thickness. Dislodged aphids were collected on white paper sheet and then counted.

Determination of photosynthetic parameters

For the determination of photosynthetic parameters a special electronically battery operated instrument IRGA (Infrared gas analyzer, Analytical Development Company, Hoddeson, England) was used from the selected plants of each treatment. The parameters which were under study were photosynthetic rate (A), transpiration rate (E), internal carbon dioxide (C_i) and water use efficiency (Wue). For the determination of these parameters two lush green fully exposed to sunlight leaves were selected from the each plant of the every treatment whose were kept under the sensor of IRGA instrument until the stable readings were recorded on the screen. Water use efficiency of each plant was calculated by dividing photosynthetic rate (A) to transpiration rate (E).

Analysis of data

For each sampling date, aphid numbers of six plants from each treatment were averaged to a single aphid count. Mean numbers of aphids, averaged photosynthetic parameters of each treatment were analyzed by performing analysis of variance (ANOVA) and LSD was applied on statistically different data by using Statistics software version 8.1 (Anonymous, 2005).

Results and discussions

Incidence of aphid species

B. brassicae and *L. erysmi* are both potential and voracious pests of brassica family. It was founded that aphid infestation started in the mid of February and remained maximum during the mid of March afterward it started declining exponentially. The distribution of both aphids species were present across all the varieties (Table 1). The present studies are supported by the findings of (Razaq *et al.*, 2011) that both aphid species were founded maximum in the 1st or 2nd week and difficult to found in 4th week of March of timely sown crop in Multan and Bahawalpur. The present results are contrary to the findings of (Sarwar *et al.*, 2004) that aphids population started appearing on the 1st week of February but declined during the first week of March. In present study aphids attack was founded abundant at the flowering stage of plant, when sprayed at that time than their population declined which gradually continued to develop again but at that time plant escaped from their heavy infestation and optimum results should be achieved (Table 2). But their densities on different varieties was statistically different at 5 % level of significance which resembles to the findings of (Sarwar *et al.*, 2004) that field screening of different genotypes against aphids infestation indicated that aphids population and yield performance varied with germplasms and no genotype is found resistant to aphid infestation. The findings of (Royer *et al.*, 2005) also supported us that aphid populations responded to insecticide rate in earlier and middle plantings.

Table 1. Mean aphid population on 10 cm inflorescence of aphid infested (unsprayed plots) on varieties of *B. campestris* at Multan during 2012.

	Sampling dates							
	20-02-2012		28-02-2012		08-03-2012		15-03-2012	
Treatments	***B.b****	***L.e****	***B.b***	***L.e***	***B.b***	***L.e***	***B.b***	***L.e***
***B. campestris* A**	36.80 ±2.83A	35.67 ±2.51B	33.40 ±2.21	42.30 ±5.55B	53.10 ±5.26	17.00 ±6.24B	46.90 ±4.91B	20.70 ±2.89C
Toria selection a	16.77 ±3.19B	76.33 ±6.53A	29.23 ±2.23	35.60 ±5.50B	38.70 ±4.99	25.63 ±3.73A	31.53 ±4.41C	24.53 ±3.10BC
***B. campestris* PARC**	21.20 ±2.64B	23.93 ±3.12B	28.63 ±4.01	37.16 ±2.36B	42.26 ±5.16	29.22 ±4.43A	60.40 ±5.59A	36.16 ±1.87A
***B. campestris* Local**	14.53 ±1.30B	24.16 ±2.86B	33.33 ±3.15	59.17 ±4.22A	47.3 ±3.05	28.90 ±4.93A	50.70 ±3.12B	30.73 ±5.51AB
D.F	(3, 6)	(3, 6)	(3, 6)	(3, 6)	(3, 6)	(3, 6)	(3, 6)	(3, 6)
F-value	15.29	25.26	0.49	7.39	2.31	7.24	15.12	6.12
P-value	0.00	0.00	0.70	0.01	0.18	0.02	0.00	0.03
LSD-value	9.29	19.56	ns	12.69	ns	11.47	12.38	9.96

Means followed by different letters in the columns are statistically different at the significance level of 5 %. ns denotes the non significant difference at significance level of 5 %.

* *B.b* and **L.e* represents *Brevicoryne brassicae* and *Liphaphis erysimi*.

Table 2. Mean aphid population on 10 cm inflorescence of aphid protected (one spray at peak flowering stage) plots on varieties of *B. campestris* at Multan during 2012.

	Sampling dates							
	20-02-2012		28-02-2012		08-03-2012		15-03-2012	
Treatments	***B.b****	***L.e****	***B.b***	***L.e***	***B.b***	***L.e***	***B.b***	***L.e***
***B. compestris* A**	3.06 ±1.16	4.66 ±1.58	10.60 ±1.67B	13.53 ±1.50	13.20 ±2.99C	25.17 ±2.22B	27.06 ±1.75B	20.16 ±1.24C
Toria selection a	4.73 ±1.00	6.80 ±1.53	15.13 ±2.65AB	17.23 ±1.94	14.40 ±2.94BC	14.73 ±2.43B	29.22 ±1.10B	20.21 ±2.08BC
***B. compestris* PARC**	6.20 ±0.52	4.41 ±0.70	18.33 ±1.73A	13.33 ±0.93	20.06 ±1.94AB	30.72 ±3.87A	33.00 ±3.02A	31.62 ±4.10A
***B. compestris* local**	5.90 ±1.50	5.52 ±0.73	20.00 ±1.25A	18.53 ±1.37	21.77 ±3.03A	21.76 ±2.87B	40.22 ±3.37A	19.47 ±2.67AB
D.F	(3, 6)	(3, 6)	(3, 6)	(3, 6)	(3, 6)	(3, 6)	(3, 6)	(3, 6)
F-value	3.27	2.24	3.67	3.23	4.99	7.53	10.20	2.66
P-value	0.18	0.38	0.07	0.18	0.05	0.02	0.01	0.14
LSD-value	ns	Ns	5.70	Ns	8.24	11.47	7.80	9.96

Means followed by different letters in the columns are statistically different at significance level of 5%. ns denotes the non significant difference at significance level of 5 %.

**B.b* and **L.e* represents *Brevicoryne brassicae* and *Liphaphis erysimi*.

Effect of aphid feeding on photosynthetic parameters

The present results of photosynthesis of aphid free and aphid protected were non-significant across the varieties except in *B. campestris* A and *B. campestris* local. Aphid infestation caused reduction in photosynthesis. These results are similar to the findings of (Flynn *et al.*, 2006) that aphid infestation reduced photosynthetic activity under all conditions. Transpiration rate and internal CO_2 results were non-significant at the 5 % level of significance among the different treatments across the varieties. However, water use efficiency was significantly different ($P< 0.05$) (Fig. 1 A-D), (Table 3) respectively. However, the varieties and the interaction among the varieties and insecticide was non-significant ($P>0.05$). The present findings are correlated to the reporting of (Dixon, 1998) that aphid infestation caused reduction in water, amino acids and ions without selection. The results of (Girousse *et al.*, 2005) also supported the present findings that severe short-term aphid infestation (200 young adults over a 24-h period) caused a strong and coordinated reduction in rates of elongation, water and carbon deposition. The present internal CO_2 results are not correlated to the findings of (Hawkins *et al*., 2006) leave from all aphid-infested plants had significantly greater net CO_2 exchange rates in the light than their respective controls.

Table 3. Analysis of varience (Anova) of photosynthetic parameters *Brassica campestris* varieties

Photosynthetic parameters		D.F	F-value	P-value	LSD value
Photosynthetic rate (A)	varieties	3	0.51	0.70	6.00
	Insecticide	2	20.22	0.00	
	variety*insecticide	2	0.98	0.50	
Transpiration rate (E)	varieties	3	1.50	0.30	
	Insecticide	2	2.51	0.12	ns
	variety*insecticide	2	2.11	0.09	
Internal CO_2 (Ci)	varieties	3	1.41	0.31	
	Insecticide	2	0.90	0.40	ns
	variety*insecticide	2	0.21	0.88	
Water use efficiency (WUE)	varieties	3	0.57	0.64	
	Insecticide	2	6.89	0.00	2.52
	variety*insecticide	2	2.64	2.04	

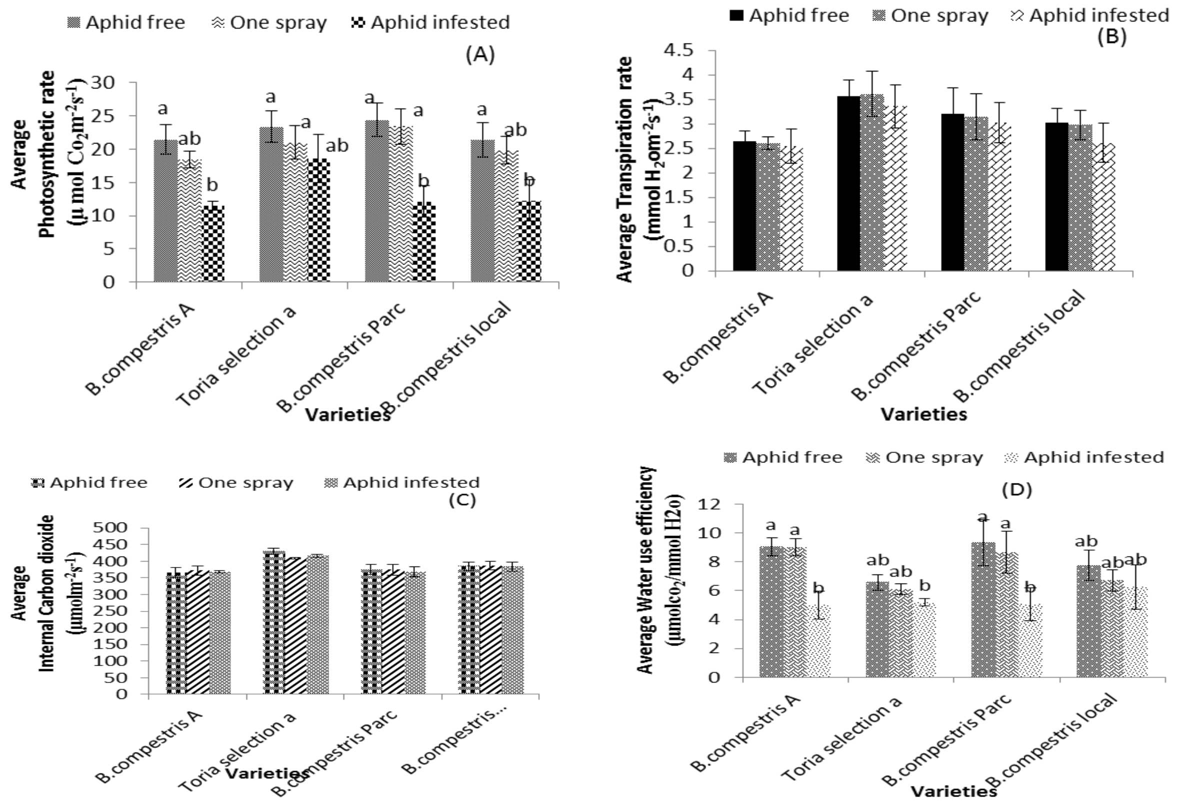

Fig. 1. Effect of aphids feeding on photosynthesis, photosynthetic rate (A), transpiration rate (B), internal CO_2 (C) and water use efficiency (D) of *B. campestris* varieties under different insecticide schemes. Different letters indicates the significant differences between the treatments at $P < 0.05$. Error bars represents ± S.E.

Conclusion

Our experiments proved that selective use of insecticides should be done only at the critical flowering stage of *B. campestris* varieties and other crops for the optimum photosynthesis reduce pest herbivory, pest resistance and save our environment in an ecologically and economically sound manner.

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