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Preferential Influence of Wheat Genotypes on the Distribution Pattern and Population Dynamics of Cereal Aphids and Their Natural Enemies in Peshawar Valley

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Abstract.- An experiment was conducted to study the population density of cereal aphids and their natural predators under the effect of different wheat varieties. Ten local wheat varieties were laid in the RCBD design having four replications, each having 2 sub-plots at the New Developmental Farm, Khyber Pakhtunkhwa Agricultural University, Peshawar (NDF, KP-AUP). Data for the aphid population pattern, their predators, aphid parasitoids, and ultimate losses to grain yield and biomass were recorded. Moreover, population distribution pattern on different plant parts was also studied. Result indicated that Saleem-2000 appeared to be the resistant cultivar having minimum aphid infestation (4.65) before booting stage, due to maximum beetle population (0.15). However, after the booting stage, Pirsabak-2004 received the maximum aphid infestation (2.90) due to minimum beetle population plant-^{1} (0.08). Moreover, *R.padi* and *S.avenae*e are the dominant species of aphids during vegetative and reproductive crop stages, respectively. Higher grain yield losses (31.12%) under aphid infestation over the control were recorded in Ghaznavi-98 while Fakhr-e-sarhad (0.74%) showed minimal yield losses.

Key words: Aphid infestation, booting stage, parasitoids, predators, wheat (*Triticum aestivum* L.), yield losses.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the leading food grain crop of Pakistan and being the staple diet of the people (Hussain *et al*., 2015). However, arthropods pests are one of the several factors responsible for limiting yield of wheat crop worldwide. Among these, cereal aphids are gaining attention since their population has increased over the last few years. Aphids damage plants directly by sucking cell sap from plants and indirectly by transmitting diseases. The small size, biology and behavior have made the aphids important pests of vegetable, fruits, ornamental plants and field crops (Hatchett *et al*., 1987; Atwal, 1976).

The predominant species of cereal aphids are rose-grass aphid (*Metopolophium dirhodum* W.), English grain aphid (*Sitobion avenae* F.), bird cherry-oat aphid (*Rhopalosiphum padi* L.), green bug (*Schizaphis graminum* R.) and Russian wheat aphid (*Diuraphis noxia* M.) (Bosque, 2000). Among the aforementioned species, *R.padi*, *S. avenae* and *S. graminum* are abundant in Peshawar valley (Khan, 2005). Kieckhefer and Gellner (1992) evaluated the threshold for significant yield losses as 10 aphids per plant for *R. padi* and *S. anenae* and 15 aphids per plant for *S. graminum.* The yield losses caused by any of the aphid species was in the range of 35-40% at 15 aphids per plant. Mirik *et al.* (2009) measured 50.2-82.9% and 55.4 -76.5% reductions in the grain yield and biomass of winter wheat feeding

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by Russian wheat aphid suggesting significant economic loss from Russian wheat aphid.

To prevent heavy losses by aphids, several control methods have been evolved including cultural, physical, mechanical, biological, chemical and host plant resistance. Host plant resistance to insect, being an integral part of insect management programs, is practiced as an alternative to chemicals for the pest control strategies. Pesticide usage alone causes health and environment hazards as well as pest resistance to chemicals due to their excessive and indiscriminate uses. Conversely, resistant cultivars may also aid in controlling the spread of plant diseases vector by insect (Mamorosch, 1980). As a fact, insect resistant cultivars synergize the effects of biological agents that suppress pest insect population and keep those below the economic injury level. However, in some cases, high levels of plant pubescence in resistant cultivars have detrimental effects on natural enemies (Bergman and Tingey, 1979; Treacy *et al*., 1985). Some insect resistant cultivars having volatile compounds, reduce the effectiveness of natural enemies, act as a repellent to beneficial insects and resultantly drive those away from the plant and their prey (van Emden, 1986). Likewise, anti-xenotic properties (glandular trichomes) in some insect resistant cultivars have also detrimental effects on the leaf-to-leaf dispersal of the predators (Van Haren *et al.*, 1987).

Screening of different wheat genotypes for resistance against cereal aphids, particularly the three predominant aphid species, *i.e. R. padi, S. avenae* and *S. graminum* were conducted by various workers (Khan, 2005). High yielding varieties were found to be more susceptible to cereal aphids, whereas plant height and thousand grain weight had less effect on cereal aphid infestation (Akhter *et al*., 2003). Resistant varieties of barley and sorghum also complemented the activity of parasite, *Lysiphlebus testaceipes* (Cresson), by reducing green bug population and plant damage. Resistant plants had fewer and smaller mummies compared to susceptible plants (Starks *et al*., 1972). In addition, interaction between wheat resistance and *Chrysoperla plorabunda* (Fitch) predation for *D. noxia* suppression was also reported by Frank and Sorenson (2001). Greater mortality was recorded on the susceptible variety due to the entrapment on curled wheat leaves (Farid *et al*., 1997). Cereal aphids do not cross the economic threshold level due to the fact that predators and parasitoids keep their population below the economic injury level (Nawaz, 2000).

Aphid parasitoids have been used extensively against pests and have achieved significant results. Various parasitoids associated with cereal aphids in wheat crop, *Aphidius colemani*, *A. rhopalosiphi* and *A. uzbekistanicus* lead to 10-35 % control under the field condition in Germany **(**Adisu *et al*., 2002). The parasitic wasps *L. testaceipes, Aphilinus mali* and *A. avenaphis* are common aphid parasites that help regulate population (Charlet *et al*., 2002). *Aphidius ervi* and *Aphidius colemani* have been reported as the dominant species of parasitoids whereas *Dieretella rapae* and *Aphidius matricariae* were less prevalent species in Khyber Pakhtunkhwa, Pakistan (Khan *et al*., 2003b). Aphid predators including lady beetles, lacewings and syrphid fly maggots feed on all aphid species and are generally less discriminating than parasitoids. Those thrive under high aphid densities and are therefore, not usually suited for use when aphid number is low (Gillian, 2005). Lady beetles are effective predators as those need to consume many aphids per day for oviposition. Four predominant species of ladybird beetles (ladybugs) on wheat crop were found in Khyber Pakhtunkhwa *i.e*., *Coccinella septumpunctata*, *Menochilus sexmaculata*, *Hippodamia variegate*and *Bromoidis suturalis* (Khan *et al*., 2003a). On the other hand, Syrphid flies and its larvae are predaceous on aphids (Triplehorn and Johnson, 2005). Moreover, *Chrysopa*spp (Neuroptera: Chrysopidae) are also voracious predators of exposed eggs and small larvae of all the lepidopterous pests, aphids and mealy bugs. It has an advantage over egg parasitoids that it feed on both eggs and larvae of pests and also its host range is much broader (Khan, 2005).

Present study aimed at investigating the population dynamics of wheat aphids under the naturally occurring biological control agents (Aphids parasites and parasitoids). The study also focused on the varietal preference of cereal aphid to investigate the biomass/yield losses of certain wheat cultivars under aphid infested conditions.

MATERIALS AND METHODS

To study the effects of different wheat varieties on the spatial and temporal distribution and population densities of various cereal aphids and their natural enemies, a study was carried out at the New Developmental Farm (NDF), Khyber Pakhtunkhwa Agricultural University, Peshawar Khyber Pakhtunkhwa (KP-AUP) from November 2009 till the harvesting of the crop in May 2010.

Test preparation

Commonly grown ten wheat varieties were tested in the experiment. The New Developmental Farm Authorities provided four wheat varieties *viz.* Bakhtawar-92, Uqab, Fakhr-e-Sarhad and Tatara-98, while the Cereal Crop Research Institute (CCRI), Nowshera provided the remaining six varieties *viz.*, Saleem 2000, Pir Sabak-2004, PS-2005, PS-2008, Ghaznavi-98 and Suliman-96.

The experiment was carried out in the randomized complete block design (RCBD). Each treatment was replicated four times. Each replication comprised of two sub plots of 1.2 × 5-meter sizes, one of which was treated (Sprayed) and the other untreated (Check). Row to row, plot to plot and replicate-to-replicate distances were 30cm, 0.5m and 1.5m, respectively.

Aphid population densities

Samples of cereal aphids were collected at weekly interval from germination onward till the maturity of the crop. For this, 3 tillers were selected randomly from two central rows of each treatment, and the number of aphids per leaf of the infested tiller was counted. Mean aphid population per leaf for each treatment was calculated using the F-test and DMR as the range test. The relative abundance of different aphid species was determined and aphids were identified to the species level with the help of available specimen in the Plant Protection Laboratory, KP-AUP and field keys of cereal aphids (Hein *et al*., 2005).

Ear infestation data were collected soon after the booting stage. From each sub plot, three samples were collected from the central two rows and the number of aphids per ear was counted and their means were compared using DMR.

Two types of spatial distribution were studied *i.e.* the spatial distribution of aphids on the plant and the spatial distribution of aphids within the field.

For aphids spatial distribution on the plant, three plants were randomly selected from the central two rows and the number of aphids was counted at the top, middle and bottom leaf of the infested tiller and their means were compared using F-test and DMR as the range test.

For aphid's spatial distribution within the field, five different spots each from the outer margins and from the center of the field were selected for the sampling in the "Z" shape and the number of aphids per leaf was counted and their means were compared using the paired t-test.

For temporal distribution of aphids, weekly data were collected three times a day. The population dynamics of cereal aphids were investigated with respect to time of the day *i.e.* morning, noon and evening.

Aphid predators

The natural enemies associated with the cereal aphids were counted as per the following observations. Eggs, larvae, pupae and adults per plant were taken into account for ladybird beetles. All the different stages of the lady beetles (*Cocinela suptemntata*), syrphid flies (*Ischiodon scutellaris*) and *Chrysopa* spp. (*Chrysoperla carnea*) were collectively considered and counted as ladybird beetles, syrphid flies and *Chrysoperla carnea*, respectively.

Aphid parasitoids

For hymenopterous parasitoids, mummified aphids per leaf were counted. The field-collected mummies were placed in a petri dish for the emergence of parasitoids. All such petri dishes were placed in a still tray on a working table in the laboratory at 25±1°C temperature and 65±5 % R.H. at the Department of Plant Protection, KP-AUP. The emerged parasitoids were collected with an aspirator, and mounted for proper identification and species composition that was studied throughout the cropping season.

The effect of aphid infestation on the biomass/yield of different wheat varieties

For the loss assessment, one of the two adjacent subplots for each variety were sprayed twice with Imidacloprid 25% WP at the rate of 125 gm acre^{-1} in 50 liters of water using knapsack sprayer while the other subplots of the same variety remained untreated. During spraying a 6 meter long and 2 meter high polyethylene sheet was hanged between the two adjacent plots to avoid the insecticide drift effect on the control plot. The yield data of treated and untreated plots were recorded separately and converted to kg ha^{-1} and the difference in treated and untreated plots for grain yield and bio mass was calculated using the paired t-test.

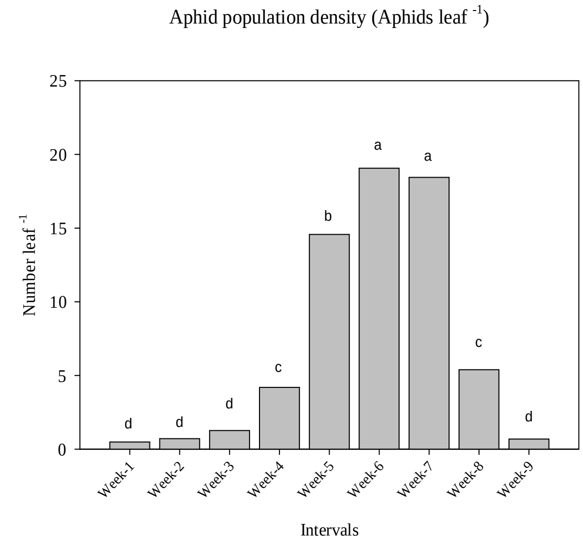
Data regarding the aphid population density, their spatial and temporal distribution and biological control agents' population densities were collected at weekly interval from germination onwards till the crop harvest. The collected data were analyzed using the F- test for the RCB Design and DMR test was applied for mean separation for significant results. The M-STAT- computer package was used for data analyses.

RESULTS AND DISCUSSION

Aphid population density on different wheat varieties

The results regarding aphid population density on different wheat varieties (Fig. 1) revealed that the aphids arrived in the last week of January (30-01-2010) with an initial mean population of 0.48 aphids leaf^{-1}, which increased gradually till the 2nd week of February. Aphid population increased significantly from the 3rd week of February to the 3rd week of March. Peak aphid infestation was recorded in the 1st week of March. Aphid population declined suddenly in the last week of March with a mean of 0.68 aphids leaf^{-1}which came to an end during the 1st week of April (Fig. 1).

Peak aphid infestation on all the wheat varieties was recorded during the 1st and the 2ndweek of March. The overall mean aphid population on different wheat varieties indicated significantly high population (9.66 aphids leaf^{-1}) on variety Uqab that showed its relative susceptibility to aphid infestation.



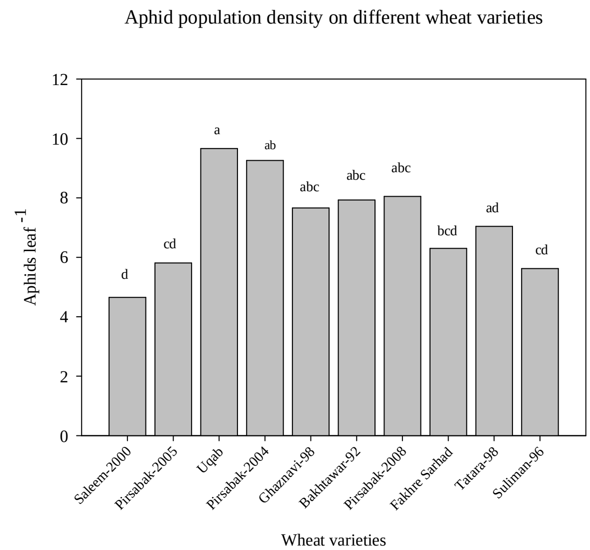


Fig. 1. Aphid population density (aphids ear^{-1}) on different wheat varieties.

This was followed by Pirsabak-2004 (9.26 aphids leaf^{-1}) and Pirsabak-2008 (8.05 aphids leaf^{-1}). But the varieties Saleem-2000 (4.65 aphids leaf^{-1}), Suliman-96 (5.62 aphids leaf^{-1}) and Pirsabak-2005 (5.81 aphids leaf^{-1}) were recorded to be relatively resistant to aphid infestation under field conditions. The remaining wheat varieties showed intermediate response to aphid infestation. These results are in conformity with that of Sattar (2000), who reported that the aphid infestation on wheat crop started in the month of January, reached its peak during the 2nd week of March and persisted till the start of April at Peshawar.

Table I.- Aphid population density (aphids ear^{-1}) on different wheat varieties.

Varieties	Interval (Weeks)			Mean
	Week-8- 20-3-10	Week-9- 27-3-10	Week-10- 3-4-10	
Saleem-2000	4.00	2.47	0.33	2.27
Pirsabak-2005	4.00	2.80	0.07	2.29
Uqab	3.50	4.37	0.00	2.63
Pirsabak-2004	5.32	3.38	0.00	2.90
Ghaznavi-98	2.50	3.27	0.00	1.93
Bakhtawar-92	3.15	3.02	0.07	2.08
Pirsabak-2008	4.00	3.40	0.40	2.60
Fakhre Sarhad	1.50	4.07	0.32	1.97
Tatara-98	2.57	3.62	0.00	2.07
Suliman-96	3.07	1.65	0.00	1.58
Mean	3.36 a	3.21 a	0.12 b	---

LSD value at 5% for interval = 0.68
Means within columns followed by the same letters are not significantly different (P>0.05) using Duncan's Multiple Range test.

Data (Table I) showed a significantly high population density (3.36 and 3.21 aphids ear^{-1}) during the 3rdand 4th week of March, respectively while significantly lower population (0.12 aphids ear^{-1}) was recorded in the 1st week of April. No aphids were observed on ears thereafter. The overall mean aphid infestation on different wheat varieties indicated that the variety Pirsabak-2004 was highly preferred by the aphids with the mean of 2.90 aphids ear^{-1}followed by Uqab (2.63 aphids ear^{-1}) while Suliman-96 was least preferred (1.58 aphids ear^{-1}) during the earing stage. The results also differ with that of Khan (2005) who reported the wheat variety Tatara-98 as resistant against aphids. The possible reason could be the adaptation of aphid with the variety as it has been widely cultivated for the last 5-6 years.

Relative abundance of the aphid species during the cropping season

The field-collected aphids were identified as *Rhopalosiphum padi, Sitobion avenae* and *Schizaphis graminum* (Table II). Initially the population for all the three species was not significantly different till the 2nd week of February. Then the population gradually increased and reached to its peak during the 2nd week of March, which slowly declined and came to an end during the 1st week of April. It is evident from data that *R. padi* was the dominant species (10.09 aphids leaf^{-1}/ear^{-1}) followed by *S. avenae* (7.59 aphids leaf^{-1}/ear^{-1}) while *S. graminum* population (1.62 aphids leaf^{-1}/ear^{-1}) was very low. *R. padi* was the dominant species during the vegetative stage while *S. avenae* constituted a high population during the reproductive stage and *S. graminum* population was very low throughout the cropping season. These results are in agreement with Saleem (2006) and Sattar (2000) who also reported that *R. padi* was the dominant specie during the vegetative stage while *S. avenae* constituted a higher proportion of the population during the earring stage.

Spatial distribution of aphid population on different plant parts

Spatial distribution of aphids on different parts of wheat plant (Table III) showed significantly different results. Initially the number of aphids per leaf was not significantly different. After maturity of the plant, the aphids moved to the top of the plant because of the availability of comparatively more fresh and succulent leaves there. Aphid population on the top reached to its peak during the 1st week of March. Mean aphid population recorded was 7.20, 1.17 and 0.28 aphids leaf^{-1} on the top, middle and bottom parts respectively. A sudden decline of aphid population was recorded during the last week of March. It is evident from the data (Table III) that aphids highly preferred the top leaves throughout the cropping season while the middle and bottom leaves were less preferred. No significant differences were observed in aphid populations regarding their distribution within the field (Fig. 2).

Temporal distribution of aphid population

Data regarding the temporal distribution of aphids (Table IV) showed that it did not vary significantly with respect to time of the day *i.e.* morning, noon and evening. Aphid infestation was recorded in the last week of January, which increased non-significantly up to the 2nd week of February. Peak aphid infestation was recorded during the 1st week of March. A sudden decline was recorded during the last week of March. No aphids were observed in April. The overall mean for the temporal distribution of aphids recorded as 7.20,

Table II.- Relative abundance (aphids $leaf^{-1}ear^{-1}$) of the aphid species during the cropping season.

Species	Intervals (Weeks)										Mean
	1	2	3	4	5	6	7	8	9	10	
R. padi	0.95	1.95	4.12	9.47	24.42	28.72	24.02	6.15	1.16	0.0	10.09a
S. avenae	0.2	0.20	0.07	1.55	17.65	23.15	22.42	5.88	4.42	0.37	7.59b
S. graminum	0.17	0.07	0.0	1.62	1.65	2.95	8.85	0.70	0.21	0.0	1.62c
Mean	0.44d	0.74d	1.40d	4.21c	14.57b	18.27a	18.43a	4.24c	1.93cd	0.12d	---

LSD value at 5% for intervals = 2.440
LSD value at 5% for species = 1.337

Table III.- Spatial distribution of aphid population (aphids $leaf^{-1}$) on different plant parts.

Spatial distribution	Intervals (Weeks)									Mean
	Week-1 30-1-10	Week-2 6-2-10	Week-3 12-2-10	Week-4 20-2-10	Week-5 27-2-10	Week-6 6-3-10	Week-7 13-3-10	Week-8 20-3-10	Week-9 27-3-10	
Top	0.48 d	0.71 d	1.26 d	4.19 c	14.57 b	19.05 a	18.44 a	5.37 c	0.68 d	7.20 a
Middle	0.03 d	0.11 d	0.14 d	0.17 d	0.33 d	5.52 c	0.92 d	2.65 cd	0.63 d	1.17 b
Bottom	0.00 d	0.79 d	0.01 d	0.00 d	0.00 d	0.99 d	0.07 d	0.49 d	0.17 d	0.28 b
Mean	0.17 d	0.53 d	0.47 d	1.45 cd	4.97 b	8.52 a	6.48 b	2.83 c	0.49 d	---

LSD value at 5% for intervals = 1.60
LSD value at 5% for spatial = 0.92
LSD value at 5% for interaction = 2.77
Means within columns followed by the same letters are not significantly different (P>0.05) using Duncan's Multiple Range test.

Table IV.- Temporal distribution of aphid population (aphids $leaf^{-1}$).

Temporal distribution	Intervals									Mean
	Week-1 30-1-10	Week-2 6-2-10	Week-3 12-2-10	Week-4 20-2-10	Week-5 27-2-10	Week-6 6-3-10	Week-7 13-3-10	Week-8 20-3-10	Week-9 27-3-10	
Morning	0.48	0.71	1.26	4.19	14.57	19.06	18.44	5.37	0.68	7.20
Noon	0.26	0.31	1.11	3.85	11.84	18.61	18.82	5.15	0.64	6.73
Evening	0.27	0.24	1.36	3.81	13.07	17.60	16.91	4.70	0.64	6.51
Mean	0.34 d	0.42 d	1.24 d	3.95 c	13.16 b	18.42 a	18.06 a	5.07 c	0.65 d	---

LSD value at 5% for intervals = 1.88
Means within columns followed by the same letters are not significantly different (P>0.05) using Duncan's Multiple Range test.

6.73 and 6.51 aphids $leaf^{-1}$ in the morning, noon and evening, respectively. Khan *et al*. (2003b) investigated the aphid predators at five different sites of Khyber Pakhtunkhwa Province of Pakistan. The peak population of *C. septumpunctata* was recorded in the middle of March. The number then declined and came to an abrupt end by the last week of April. *Menochilus sexmaculata* was the next dominant species after *C. septumpunctata* followed by *Hippodamia convergence* but their populations did not exceed that of *C. septumpunctata* at any point during the study period. The results are partially in agreement with the authors regarding the population trend of the predatory beetles but differ regarding the presence of *Hippodamia convergence* for the obvious reason that they surveyed five different sites of the province of which one is included in this study.

Population density of ladybird beetles on different wheat varieties

Data regarding the ladybird beetle population density (Fig. 3) showed the incidence of ladybugs during the 2nd week of February. Population

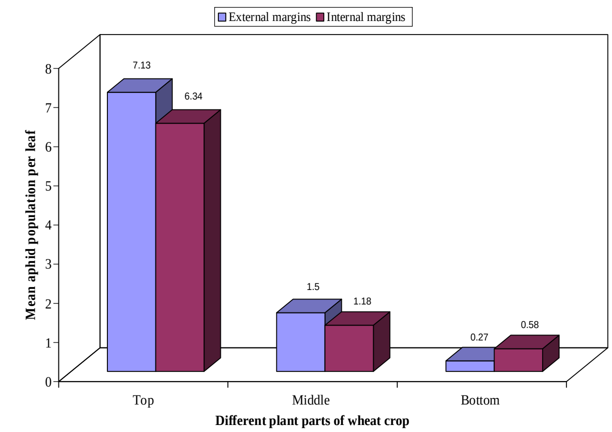


Fig. 2. Spatial distribution of aphids within the field.

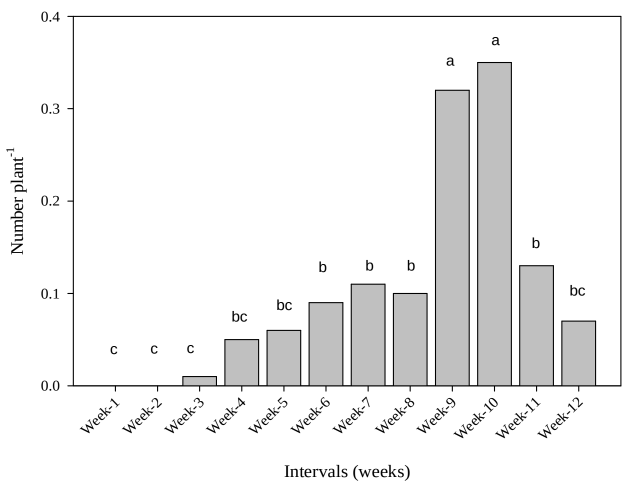


Fig. 3. Population density of ladybird beetles (Beetles plant^{-1}) on different wheat varieties.

increased gradually during the 3rd week of February and reached to its peak during the last week of March and the 1st week of April with overall mean of 0.32 and 0.35 plant^{-1}, respectively. Then the population declined gradually with the mean population of 0.13 plant^{-1}during the 2nd week of April and 0.07 plant^{-1} during the 3rd week of April. Ladybird beetles reduced their activities as their host vanished. The variety Saleem-2000 received the maximum beetles plant^{-1} (0.15) while the lowest population (0.08 plant^{-1}) was recorded on the variety Pirsabak-2004 and Suliman-96. The overall varietal mean population was not significantly different. Rana *et al*. (2007) reported 0.02-0.05 and 0.01-0.06 coccinellids per tiller during 2005-2006 and 2006-2007, respectively which had very low population compared to the present observations.

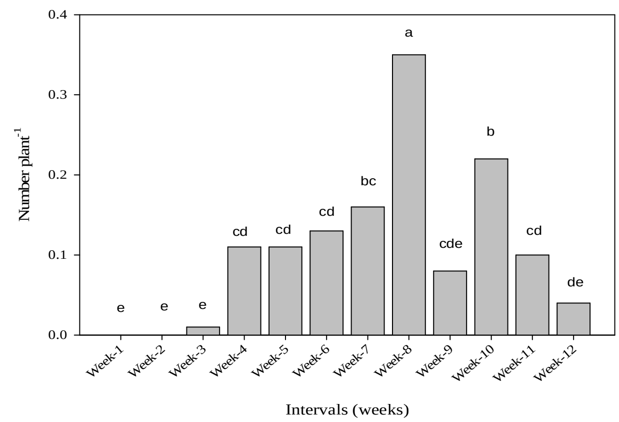


Fig. 4. Green lacewing population density (*Chrysoperla carnea* plant^{-1}) on different wheat varieties.

*Green lacewing population density (*Chrysoperla carnea *plant^{-1}) on different wheat varieties*

Chrysoperla carnea population appeared in the 2nd week of February and gradually increased (Fig. 4). The population reached to its peak during the 3rd week of March with a mean of 0.35 plant^{-1}. This was followed by 0.22 plant^{-1}during the 1st week of April. Then the population lessens gradually with decline of their host population. The variety Ghaznavi-98 had the maximum population (0.17) while the lowest population (0.07) was recorded on variety Pirsabak-2005. The overall varietal mean population was not significantly different. There were similar observations regarding the behavior of *C. carnea* as observed by Gillian (2005), who reported that only larval stages of lacewing were predatory. Older larvae (3rd instar) are particularly voracious and can eat their own eggs, other larvae and even adults if the food is scarce. The results concerning the synergistic effects of aphid suppression on resistant varieties were in contrast to that of Frank *et al*. (2001) which revealed that lacewing in combination with resistant lines showed a synergistic level of pest suppression.

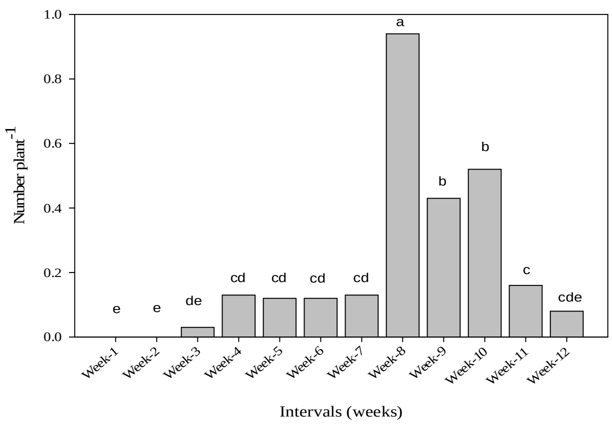


Fig. 5. Syrphid flies population density plant^{-1} on different wheat varieties

Syrphid flies population density on different wheat varieties

Data concerning the population (Fig. 5) showed the incidence of Syrphid flies during the 2nd week of February with a mean population of 0.03 plant^{-1}which slowly increased and reached to its peak (0.94 plant^{-1}) during the 3rd week of March. That was followed by 0.43 and 0.52 during the last week of March and 1st week of April, respectively. Then, population slowly declined till the 3rd week of April and no activities were observed after the last observation (17-04-2010). The maximum Syrphid flies population (0.25) was recorded on the varieties Pirsabak-2005 and Ghaznavi-98 while the lowest population (0.18 S. flies plant^{-1}) was recorded on Pirsabak-2008, although the overall varietal mean population was not significantly different from another. The results regarding the arrival of syrphid flies on the crop did not match with that of Saleem (2006) who reported the first arrival of syrphid flies during the 1st week of March with a mean of 0.70 S. flies row^{-1} foot and their peak population of 1.35 S. flies row^{-1} foot was recorded during the 3rd week of March, while the peak population of Syrphid flies reported was in conformity to the observation. Flower densities, syrphids diversities and density were closely related with each other (Haenke *et al.*, 2009). Haenke and his colleagues also noticed a free movement of the predator from nearby brassica field into the studied wheat field.

Parasitoids population density on different wheat varieties

Data regarding the population densities (Table V) showed that the parasitoids arrived as early as 1st week of February with overall interval mean of 0.02 mummies plant^{-1} which gradually increased and reached to its peak (0.42 mummies plant^{-1}) during the 1st week of March. The population (0.16 mummies plant^{-1}) decreased suddenly during the 7th observation (13-03-2010), which again reached to its peak (0.43 mummies plant^{-1}) during 8th observation (20-03-2010). Then the population declined slowly till 11th observation (10-04-2010). No mummies were recorded during the 12th observation (17-04-2010). The overall varietal mean indicated that the variety Bakhtawar-92 received high population (0.19 mummies plant^{-1}) while the lowest (0.09 mummies plant^{-1}) was recorded on the variety Pirsabak-2004, although the overall means were not statistically different from each other. The present results regarding *A. colemani* as the dominant species and low populations of *D. rapae* and *A. matricariae* were similar to that of Khan *et al*. (2003b) who reported *A. ervi* and *A. colemani* as the dominant species, while *D. rapae* and *A. matricariae*were recorded very less in number. He also observed that the parasitoids got active in mid-February, when aphid population reached to its peak in the field.

Grain yield losses in different wheat varieties

Data (Table VI) showed that four wheat varieties out of ten recorded maximum yield in treated plots, which was significantly higher than those of untreated plots of the same varieties. Maximum grain yield of 3938 kg ha^{-1} was recorded in the variety Bakhtawar-92 in the treated plot compared to 3292 kg ha^{-1} in the same variety in untreated plot showing a difference of 646 kg ha^{-1} due to aphid infestation indicating 21.95% decrease in the yield. This is followed by Pirsabak-2008 with a net loss of 479 kg ha^{-1} (14.55%), Pirsabak-2004 with 458 kg ha^{-1} (14.0% decrease) and Suliman-96 with a net loss of 492 kg ha^{-1} (15.95% decrease). compared to treated plot of the same variety. Wheat variety Fakhr-e-Sarhad observed to be the most resistant (less preferred) showing a loss of 21 kg ha^{-1}

Table V.- Parasitoids population density (mummies plant^{-1}) on different wheat varieties.

Varieties	Intervals (Weeks)												Mean
	Week-1 30-1-10	Week-2 6-2-10	Week-3 12-2-10	Week-4 20-2-10	Week-5 27-2-10	Week-6 6-3-10	Week-7 13-3-10	Week-8 20-3-10	Week-9 27-3-10	Week-10 3-4-10	Week-11 10-4-10	Week-12 17-4-10	
Saleem-2000	0.00	0.00	0.00	0.07	0.30	0.30	0.15	0.32	0.30	0.07	0.07	0.00	0.13
Pirsabak-2005	0.00	0.00	0.00	0.07	0.37	0.65	0.15	0.47	0.00	0.15	0.07	0.00	0.16
Uqab	0.00	0.00	0.00	0.07	0.32	0.15	0.30	0.50	0.00	0.22	0.00	0.00	0.13
Pirsabak-2004	0.00	0.15	0.00	0.07	0.15	0.30	0.07	0.22	0.00	0.07	0.00	0.00	0.09
Ghaznavi-98	0.00	0.00	0.15	0.22	0.30	0.47	0.00	0.40	0.32	0.15	0.07	0.00	0.17
Bakhtawar-92	0.00	0.00	0.00	0.15	0.30	0.47	0.30	0.87	0.07	0.07	0.07	0.00	0.19
Pirsabak-2008	0.00	0.00	0.00	0.07	0.00	0.62	0.07	0.40	0.00	0.15	0.00	0.00	0.11
Fakhre Sarhad	0.00	0.00	0.00	0.30	0.22	0.55	0.22	0.30	0.00	0.07	0.07	0.00	0.15
Tatara-98	0.00	0.07	0.00	0.07	0.25	0.15	0.22	0.32	0.00	0.22	0.07	0.00	0.12
Suliman-96	0.00	0.00	0.15	0.15	0.40	0.50	0.07	0.47	0.15	0.07	0.00	0.00	0.16
Mean	0.00 d	0.02 d	0.03 d	0.13 cd	0.26 b	0.42 a	0.16 bc	0.43 a	0.09 cd	0.13 cd	0.04 cd	0.00 d	---

LSD value at 5% for intervals = 0.11
Means within columns followed by the same letters are not significantly different (P>0.05) using Duncan's Multiple Range test.

Table VI.- Grains yield losses in different wheat varieties due to aphid infestation.

Varieties	Grain yield (kg ha^{-1}) Treated	Untreated	% Increase over control	t-value	Prob.
Saleem-2000	3354	2896	19.26	1.145	0.335
Pirsabak-2005	3146	2625	19.84	9.934	0.002
Uqab	2479	2354	5.31	2.324	0.103
Pirsabak-2004	3729	3271	14.00	1.670	0.192
Ghaznavi-98	3442	2625	31.12	3.353	0.044
Bakhtawar-92	3938	3229	21.95	3.237	0.048
Pirsabak-2008	3771	3292	14.55	5.280	0.013
Fakhr-e-Sarhad	2854	2833	0.74	0.087	0.936
Tatara-98	3533	3336	5.90	0.543	0.625
Suliman-96	3575	3083	15.95	1.329	0.276
Mean	3382.1	2954.5	14.47 %		

(0.74% decrease) in unsprayed plot indicating that the chemical sprayed least affected this variety. This is followed by the variety Tatara-98 with 125 kg ha^{-1} (5.9% decrease) in untreated plot. The lowest yield of 2479 kg ha^{-1} was recorded in variety Uqab with yield difference of 125 kg ha^{-1} (5.31% decrease) compared to the treated plot of the same variety. The overall mean indicated a net loss of 427.6 kg ha^{-1} (14.47% decrease in yield) for all entries. For loss assessment due to aphid infestation, chemical Imidacloprid 25% WP was applied to ten wheat varieties and the results were compared with those of untreated varieties. Mirik *et al*. (2009) measured the yield losses in winter wheat caused by feeding of Russian wheat aphid, *Diuraphis noxia* (Mordvilko), and evaluated that aphid reduced grain yield of 52.2 to 82.9% indicating that winter wheat suffers significant economic loss from Russian wheat aphid.

Biomass losses in different wheat varieties

Data regarding the biomass loss assessment (Table VII) showed that it did not vary significantly in treated and untreated plots. Maximum biomass of 9521 kg ha^{-1} was recorded in variety Bakhtawar-92 treated plot as compared to 8625 kg ha^{-1} of same variety in untreated plot showing a difference of 896 kg ha^{-1} due to aphid infestation, indicating (12.70% decrease in biomass). This was followed by Pirsabak-2004 with net loss of 771 kg ha^{-1} (9.46% decrease), Saleem-2000 with a net loss of 1166 kg ha^{-1} (15.67% decrease) in untreated plot. Lowest biomass losses were observed in Pirsabak-2005 with 416 kg ha^{-1} (5.51% decrease) in untreated plot showing its tolerance to aphid infestation. That was followed by the variety Uqab and Tatara-98 with net loss of 396 kg ha^{-1} (6.31% decrease) and 583 kg ha^{-1} (7.38% decrease), respectively. Maximum biomass losses were observed in variety Ghaznavi-98 with 1229 kg ha^{-1} (18.43% decrease) compared to the treated plot. This was followed by variety Saleem-

2000 with 1166 kg ha^{-1} (15.67% decrease) and Suliman-96 with 791 kg ha^{-1} (11.0% decrease) compared to the treated plot. The overall results showed a mean loss of 750 kg ha^{-1} (10.15% decrease) in biomass in all varieties compared to the treated plots. Mirik *et al*. (2009) reported the biomass losses ranging from 55.4 to 76.5% that were in contrast to the present observation where the overall biomass losses in the unsprayed field were 11 % compared with treated (sprayed) fields.

Table VII.- Biomass losses of different wheat varieties due to aphid infestation.

Varieties	Biomass (kg ha^{-1})		% increase over control	t-value	p-value
	Treated	Untreated			
Saleem-2000	8604	7438	15.67	0.975	0.401
Pirsabak-2005	7958	7542	5.51	0.568	0.610
Uqab	6667	6271	6.31	1.903	0.153
Pirsabak-2004	8917	8146	9.46	2.109	0.125
Ghaznavi-98	7896	6667	18.43	2.578	0.082
Bakhtawar-92	9521	8625	12.70	1.030	0.379
Pirsabak-2008	8146	7417	9.82	0.874	0.446
Fakhr-e-Sarhad	7188	6667	7.81	1.938	0.148
Tatara-98	8479	7896	7.38	0.547	0.622
Suliman-96	7979	7188	11.00	2.502	0.088
Mean	8135	7385	10.15 %		

Means within column followed by the same letters are not significantly different (P>0.05) using Duncan's Multiple Range test.

CONCLUSION

As per the results, it is concluded that before booting, Saleem-2000 and Suliman-96 were the most resistant cultivars to aphid infestation under the field conditions in comparison to the Pirsabak-2004 which was the most susceptible variety. However, the variety Suliman-96 was least preferred during the earing stage. Moreover, the 2nd week of March was verified as the most critical period for the maximum aphid infestation on wheat crop, starting from January and continued till April under Peshawar conditions.

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