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Bionomics of Aphids and their Parasitoid in Selected Wheat Varieties Grown Under Homologous Ecological Conditions

Sohaib Shahid,[1] Ahmed Zia,[2]* Muhammad Naeem[3] and Falak Naz[2]
[1] *Engro Foods Limited, Plant Site, Barrage Road, Sukkhur*
[2]*- National Insect Museum, National Agricultural Research Centre, Islamabad*
[3]*- Department of Entomology, PMAS Arid Agriculture University, Rawalpindi*

Abstract.- The population dynamics of aphids and their associated parasitoids on two different varieties of wheat crop *i.e.* GA-2002 and AS-2001 in a homologous agricultural ecosystem was studied. Both varieties were sown at experimental fields of Pir Mehr Ali Shah Arid Agriculture, University Rawalpindi in three replications under completely randomized design. Three aphid species (*Sitobion avenae, S. graminum* and *Rhopalosiphum padi)* and one parasitoid wasp, (*Diaeretiella rapae*) was recorded at both the varieties. Peak population size was observed during mid March which declined in the second week of April each year. Significantly greater numbers of aphids were recorded on spike as compared to leaves and stem. Nymphs were significantly higher than the alate form and the adult females. Statistical comparison showed significantly higher number of aphids and reduced the parasitic rate at variety GA-2002. Variety AS-2002 is therefore recommended as the right variety over that of variety GA- 2002.

Key Words: Wheat, aphid, parasitoid, parasitism.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop of Pakistan that help the increasing of GDP to the country's economy (Chowdhry *et al*., 1998). It is grown over an area of 8.033 million hectares, and engaged 33 percent of total cultivated area of the country. Due to various factors low yield in wheat has been observed in past. Among these insect attack is main contributing factor with considerable damage caused by aphids (Agarwal and Datta, 1999).

Aphids are minute insects that often legion due to their capacity to proliferate tremendously (Jones and Jones, 1984). They cause serious damage to agricultural crops by sucking cell sap and injecting toxic saliva into plant tissues. They secrete honey dew which facilitates growth of sooty mould which ultimately hinders photosynthesis process of attacked plants (Zia *et al*., 2010). Their attack sometimes results in foliage disfiguring by crippling of shoot and deformation of buds (Becker, 1997). Fourteen species of aphids have been recorded attacking wheat crop. Among these *Sitobion avenae, Rhopalosiphum maidis, R. padi* and *Metopolophium dirhodum* are common ones (Popov *et al*., 1988).

* Corresponding author: saiyedahmed@yahoo.com
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Both physical and biological factors affect aphid population density (Naeem, 1996). Cereal aphids are attacked by wide range of parasitoids and predators (Naeem *et al*., 2002). Aphid population can be successfully managed through release of solitary endoparasites, yet little is known about their diversity in relation to landscape complexity (Thies *et al*., 2005). Naeem *et al.* (2002) stated that most of the parasitoids have been reported under four families *i.e.* Braconidae, Aphelinidae, Encyrtidae and Cecidomyiidae.

Keeping in view the contribution of wheat to national GDP of the country and factors behind its low yield, it was planned to study population trends in aphids and their associated parasitoids attacking wheat crop.

MATERIALS AND METHODS

Two varieties of wheat, GA-2002 and AS-2001 were sown in late November, 2007 at research farms of Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi. Both varieties were sown under similar ecological conditions. The experiment plots set away from each other by 500 meters to avoid possible shift of aphid species during the study. In early January, twenty four plants were randomly selected from twenty four blocks by selecting one plant from each block. The aphids and their parasitoid wasps were collected from the

selected plants once a week from January, 2007 to April, 2008.

Aphids were first counted during 8th week of January. While the aphids population reached the high population density, counting the individual ear by ear rather than plant by plant. This peak was consistent among alates, apterous adults and nymphs. Collected aphids were identified following taxonomic literature of Blackman and Eastop (2000) and Hassan (2009). However, identification of parasitoids was carried out through taxonomic keys by Hayat (1983), Stary (1966) and Raychaudhuri (1990). Aphids and their parasitoids were sampled through leaf, stem and inflorescence survey techniques as below,

Leaf surveys

Sampling activities continued from March until the aphid population decreased and collapse in the end to early April. Healthy aphids were kept in glass vials preserved in 70% ethanol. However mummified aphids were collected and kept in glass vials and at room temperature waiting for the parasites emergence. The glass vials covered with muslin cloth, the rim of the lid was held tightly so as to avoid escape of emerged parasitoids. These glass vials were kept at room temperature until the parasitoids emerge. Parasitoids were killed by keeping them in refrigerator and were set on mounting cards for taxonomic identification thereafter.

Stem and inflorescence surveys

Sampling from stem was carried out at start of activity period (early January) and continued until collapse of aphid populations (March end to early April). From inflorescence samples were collected only at peak population time. Ears were selected to measure aphid densities. Percent parasitism was calculated by following formula:

$$\text{Percent Parasitism} = \frac{\text{No. of Mummies}}{\text{No. of Aphids + No. of Mummies}} \times 100$$

Collected data were analyzed by using statistical package for social studies (SPSS12). Descriptive statistics (Mean, S.D and S.E) and ANOVA model were used for logical conclusions. Graphical representations of results were made through Microcal Origin 6.0 programme.

RESULTS

Observations were collected at two wheat varieties *i.e.* GA-2002 and AS-2001 for associated aphids and their parasitoids. Results for different parameters are summarized as below.

Aphid population recorded

At variety GA-2002, a total of 54895 aphids were recorded. Among these 3885 were alate and 51010 were apterous. Out of total collected specimens three species were identified as *Sitobion avenae, Schizaphis graminum, Rhopalosiphum padi*. Among these percent species composition for *Sitobion avenae* was 63.6%, for *Schizaphis graminum* was 25.5% and *Rhopalosiphum padi* was 9.9%. Percent population for alate aphids was 15.9% and apterous were 84%. However a total of 14129 aphids were found at variety AS-2001 of which 1051 were alate, 5171 were adults and 7907 were nymphal stages. Three same species were found at variety AS-2001 *i.e. Sitobion avenae, Schizaphis graminus* and *Rhopalosiphum padi*. Percent species composition for *S. avenae* was 71%, *S. graminum* was 21.5% and *R. padi* was 7%. Percent population for alate was 13.5%, adults were 36.7% and nymphs were 49.3%. *Sitobion avenae* was recorded as dominant species within both varieties (Table I).

Table I.- Composition (%) of aphid forms on wheat crop.

Aphid species and their morphs (Alate, Apterous Adults & Nymphs)	GA-2002 (n=54,714)	AS-2001 (n=14,129)
Sitobion avenae	63.6	71
Schizaphis graminum	25.5	21.5
Rhopalosiphum padi	9.9	7

Aphid mummies recorded

At variety GA-2002, 273 mummies were counted of which 196 were closed and 77 were opened. While at AS-2001, 429 mummies were counted of which 386 were closed and 43 were opened. Percent parasitism recorded for alate and adults were 0.49% and 2.94% at varieties GA-2002

& AS-2001 respectively. Parasitism rate is proportion of aphids and their nymphs that were attacked by parasitoids in total aphid counts. Collected parasitoid specimens were identified as *Diaeretiella rapae* (Braconidae: Hymenoptera).

Phonologies observed at variety GA-2002

Population density for aphids was monitored on weekly basis. Aphids were first observed on the crop during 18th week (mid-January) and reached their maximum by 22nd week (March end). This peak was observed to be consistent among alate and apterous aphids (Figs. 1A,B). Aphid population was however observed to decline sharply after reaching their peak and ultimately disappeared by the end of March to start of April. Similar trends were seen in alate and apterous aphids (Figs. 1A,B). Mummified aphids (attacked by parasitoids) were first recorded in early February up to April. Highest density of mummies was seen in March when aphid population was also at maximum (Fig. 1C) which shows increased activity of parasitoid during the same period. Number of aphids observed in whole plant surveys (leaf, stem and inflorescence) shows high population trends in apterous (nymphs + adults) from seedling to harvesting stage of crop (Fig. 2). Significant effects were present between the treatments and within blocks in alate aphids [$F_{(12, 935)} = 29.47$, $P < 0.00$]. Significant difference [$F_{(12, 935)} = 30.71$, $P < 0.00$] was found between groups of apterous of aphids. These effects were mostly observed to be significant during 12th week. Analysis of mummified aphids between treatments and within treatments shows that more mummified aphids were found with increased aphid population. These effects were significant between treatments and within blocks as well [$F_{(12, 934)} = 18.02$, $P < 0.00$].

Data was also recorded for population densities of aphids on each plant part individually. Apterous of all species showed increased population on leaves, stem and spikelets as compared to alates (Fig. 3A-C). Increased counts of mummified aphids were also observed with increased aphid population. Statistical analysis shows significant effect of alate [$F_{(2, 935)} = 185.63$, $P<0.00$] and significant difference of apterous aphids between groups and within blocks [$F_{(2, 935)} = 122.57$, $P<0.00$] on leaves, stem and spikelets. Analysis of mummified aphids between treatments showed significant effect [$F_{(2, 934)} = 52.24$, $P <0.00$] for leaves, stem and spikelets.

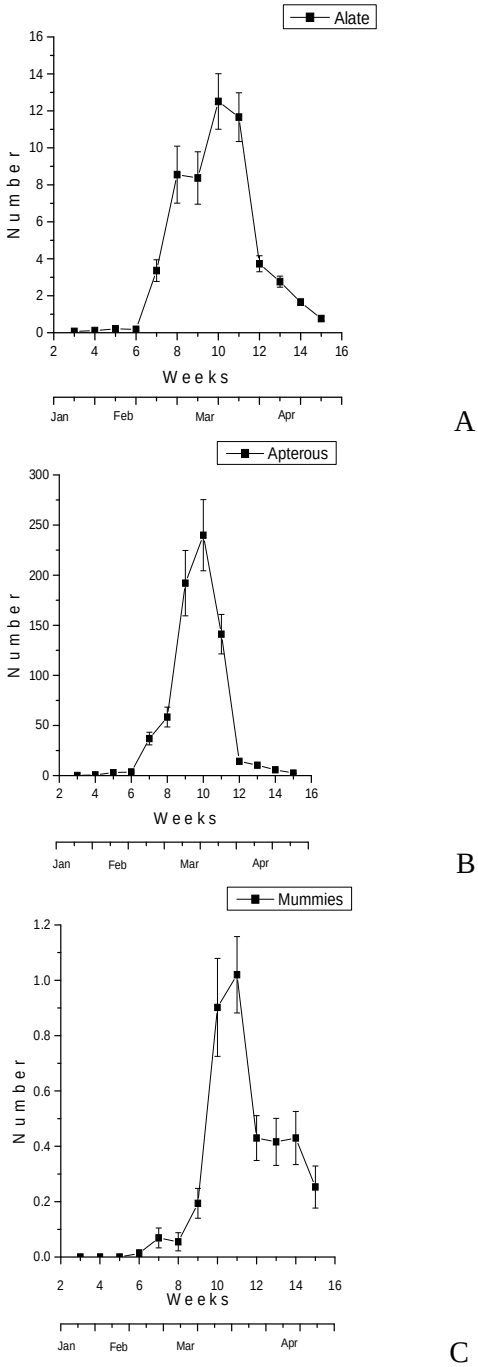

Fig. 1. Population trend of alate (A), apterous (B) and mummies (C) (mean/plant± S.E) on wheat variety GA-2002.

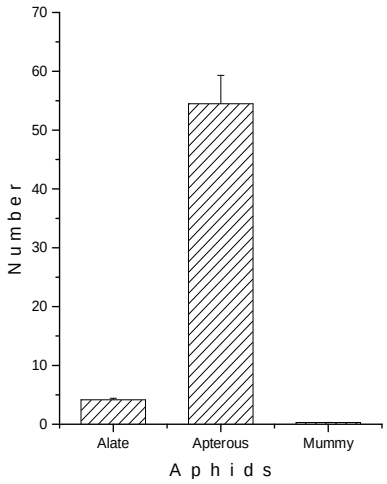

Fig. 2. Number of aphids population (mean/plant ± S.E) on wheat variety GA-2002.

Phonologies observed at variety AS-2001

Population density for aphids was monitored on weekly basis. Similar to as in variety GA-2002 aphids were first observed on the crop during mid-January and reached their maximum as March ends. On reaching peak population reduction in their numbers was observed with population disappearing at the end of March to mid of April. Alates, adults and nymphs showed similar trends (Figs. 4A-C). Mummified aphids were first seen during mid January with highest density observed in mid March (Fig. 4D). Number of aphids observed in whole plant survey (leaf, stem and inflorescence) shows high population trends in nymphs (Fig. 5). Statistical comparison for data collected from whole plant survey shows significant effect of alates [$F_{(13, 1007)} = 49.27$, $P < 0.00$] between treatments on weekly basis. However significant difference were found between treatments of adults and nymphs [$F_{(13, 1007)} = 46.35$, $P < 0.00$], [$F_{(13, 1007)} = 51.01$, $P < 0.00$]. Significant differences of mummified aphids were only observed between treatments and within blocks [$F_{(13, 1007)} = 18.03$, $P < 0.00$].

Data was also taken for population densities of aphids on individual plant parts (leaves, stem and spikelets). Both alates and adults showed significant effect [$F_{(2, 1007)} = 68.9$, $P < 0.00$] and [$F_{(2, 1007)} = 49.79$, $P < 0.00$] respectively and nymphs showed significant difference [$F_{(2, 1007)} = 56.33$, $P < 0.00$]. Mummified aphids were tested between treatment

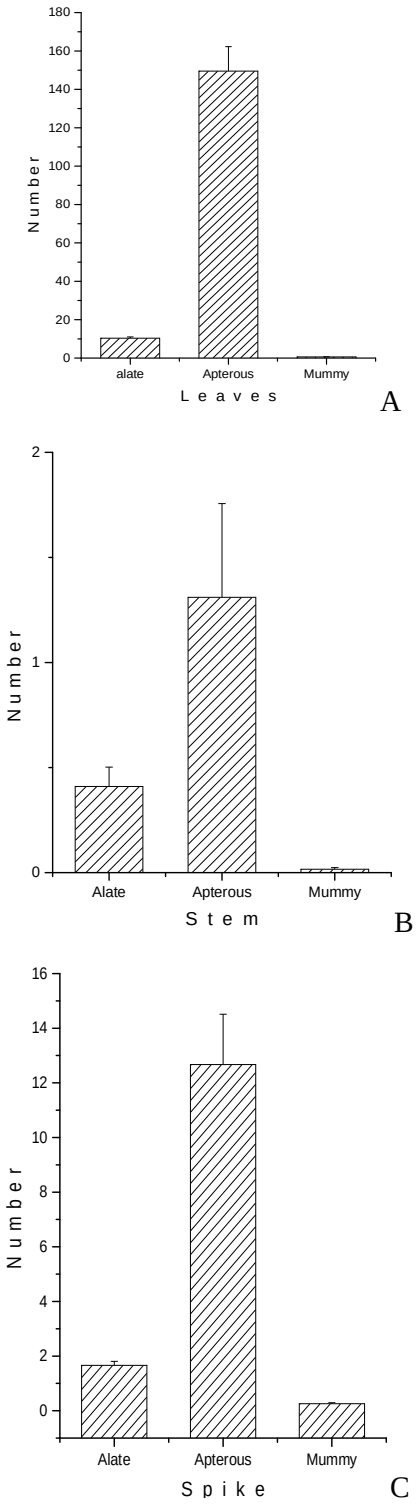

Fig. 3. Number of aphids population (mean±SEM) on leaves (A), stem (B), and spike (C) of wheat variety GA-2002.

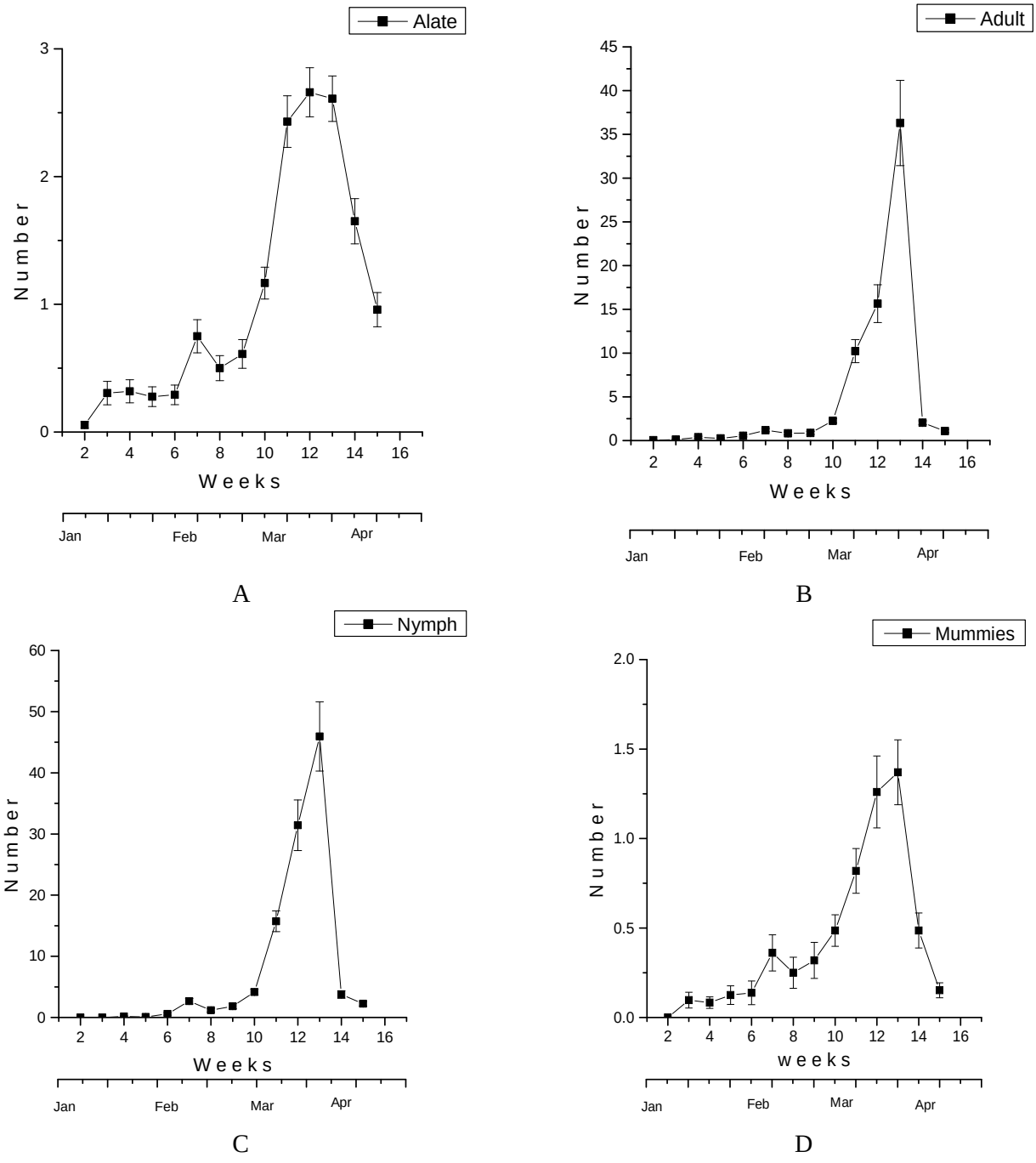

Fig. 4. Population (mean/plant±SEM) trend of Alate (A), adult (B), nymph (C), and mummified aphids (D) on As-2001.

and within blocks statistically. More mummified aphids were found at AS-2001 and effects were also significant [$F_{(2,\ 1007)} = 42.65$, $P < 0.00$]. Nymphs of all species were higher in count at spikelets rather than at stem and leaves (Figs. 6A-C). Reason behind declined aphid population was observed to be the result of increased activity parasitoids.

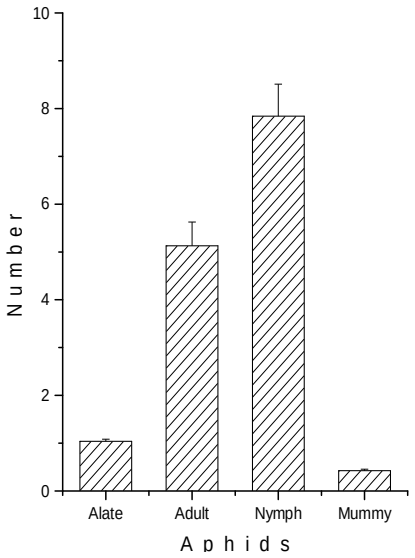

Fig. 5. Number of aphids population (mean/plant ± S.E) on wheat variety As-2001.

Comparison between the densities of aphids on variety GA-2002 and AS-2001

To authenticate the results of this study a comparison was made between both the varieties. Based on whole plant survey numbers of aphid nymphs recorded at GA-2002 were significantly greater as compared to those on AS-2001 (Fig. 7). Highest mean aphid density at GA-2001 was due to low parasitism by parasitoids. However variety As-2001 was maintaining good population of parasitoid which ultimately resulted in reduced aphid activity.

DISCUSSION

In the current experiment two varieties of wheat were sown to study possible activities and impact of parasitoids under similar ecological conditions against attacking aphid species. It was observed that same species of aphids were recorded with variable populations for different life stages in both the varieties. Species recorded include *Sitobion avenae, Schizaphis graminum* and *Rhopalosiphum padi*. Among these *S. avenae* was dominant species in both fields. Population of aphids was observed to reach its peak in early summer *i.e.* from March end to April and at the same time more mummies were recorded in comparison to winter months.

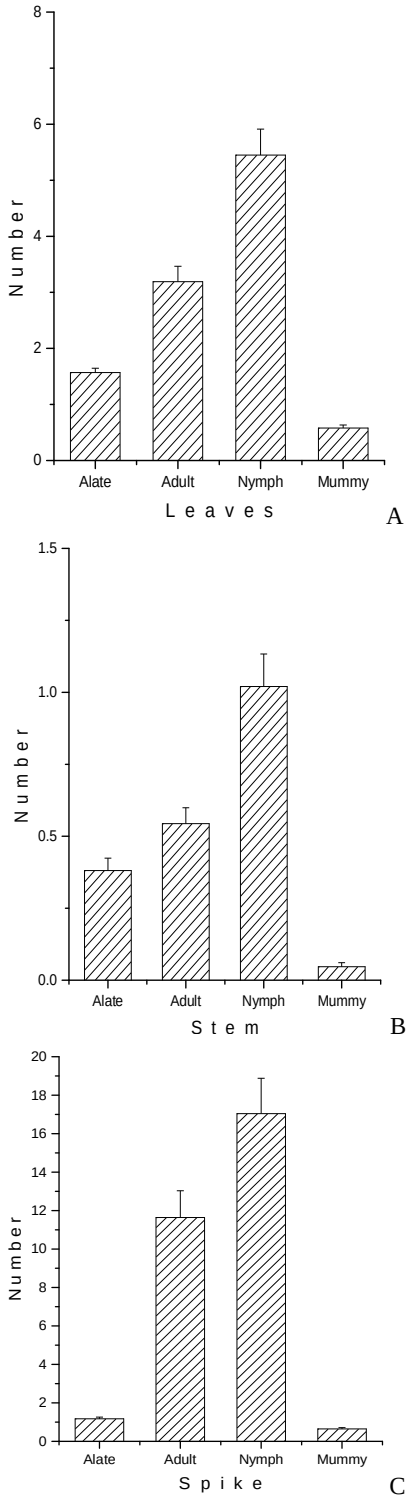

Fig. 6. Number of aphids population (mean/leaves ± S.E) on leaves (A), stem (B) and spike (C) of wheat on variety As-2001.

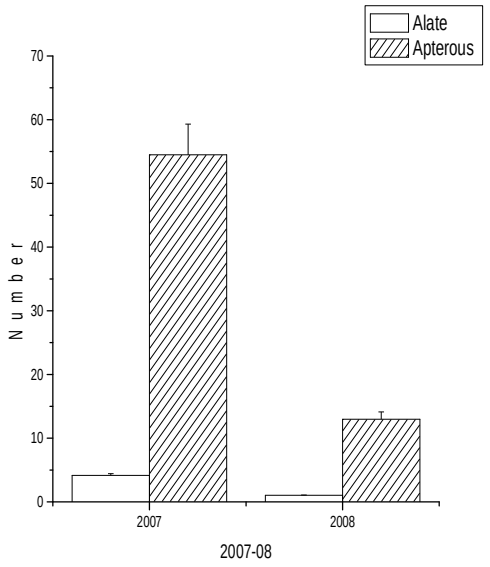

Fig. 7. Comparison of aphids (mean/plant ±S.E) on different wheat varieties based on direct observation during 2007-08.

Results emphacize to grow variety AS-2001 in comparison to GA-2002. Yet less aphid attack was observed in AS-2001 field and more activities of parasitoid were observed in it. Variety GA-2002 showed less population of parasitoid which ultimately resulted in increased aphid attack. Parasitism by *Diaeretiella rapae* highlights the importance of parasitoids in wheat ecosystem by effectively managing aphid population in AS-2001. Variety AS-2001 seems to be preferred by parasitoids by providing suitable conditions for their growth and shelter. In comparison to this GA-2002 was observed susceptible to aphid attack as well as less preferred by parasitoids. At both varieties greater aphid densities were found at spikelets as compared to those on leaves and stems. It shows their preference to attack succulent terminal parts due to more supply of food towards the terminal parts of the plant. It was also observed that in both varieties population of aphids decline at a faster rate as summer passes (March end to start of April). Reduced population of aphids at this stage is the effect of physical factors as well. As the summer starts, crop began to mature and increased heat alongwith other limiting factors badly affect aphid activities.

In similar studies, Fievet *et al.* (2007) recorded three aphid species in wheat crop with variable rate of infestation *i.e. S. avenae* (99.26%), *Metopolophium dirhodum* (66% and *Rhopalosiphum padi* (0.08%). *S. avenae* was most frequent species. According to Muddathir (1976), cereal aphid population decreases as the ear began to develop and leaves ceased to grow. Aphids multiply at a faster rate under favorable conditions to form dense colonies of nymphs and adults on leaves, stem and inflorescence (Hussain, 1983). According to Ahmed and Aslam (2000) aphid is a sucking pest which prefers to insert its stylets in soft parts of the plant to get easy and increased food supply.

Legrand *et al*. (2004) stated that potential of parasitoids for aphid control during summer is much more than in autumn and winter season. According to Stary *et al.* (1998), *Aphidius* sp. has been recorded in Pakistan parasitizing *S. graminum* and *R. padi* attacking wheat crop. Jones and Jones (1984) observed food availability, temperature and humidity as important factors in population build up of aphids. Heat stress due to high temperature causes reduction in the reproductive potential and fecundity of *R. padi* (Richer and Balde, 1993).

CONCLUSIONS

The results in compilation demonstrate importance of parasitoids in wheat ecosystem. Variety AS-2001 showed increased activity of parasitoid thereby providing better aphid control in comparison to GA-2002. Variety AS-2001 is therefore recommended over GA-2002 to get cost effective pest control by involving biological control agents.

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