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Population Dynamics of *Aphis gossypii* (Glover) and its Associated Natural Enemies in Different Okra Varieties

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Abstract.-An experiment to study the population dynamics of *Aphis gossypii* (Glover) and its associated natural enemies in different okra varieties was conducted at Malakander Research Farm of KPK Agricultural University Peshawar during 2009. Seven okra varieties including Saba Pirie, Ark Anamika, Pusa Sawani, Local Multani, Hybrid Nirali, Green Star and Sarhad Green were used in the experiment. Data was collected at weekly intervals for eight weeks, from first week of June to the last week of July for mean percent infestation of *A. gossypii* and its associated natural enemies. The data revealed that lowest mean percent infestation of 2.25% was recorded on Hybrid Nirali, while Sarhad Green was mainly attacked by *A. gossypii* with mean percentage of 3.39%. *A. gossypii* population increased during 1st to 4th week and ranged from 2.85% to 3.68%. It decreased during 4th to 8th week interval from 3.68% to 2.42%. The population of ladybird beetle was recorded lowest (1.25%) in Hybrid Nirali, while Sarhad Green afforded the highest numbers with mean percentage of 2.21%. The population of ladybird beetle increased by 2.76% ranging from 1.05% to 3.81% during 1st to 4th week intervals but gradually decreased (3.34%) ranging from 3.81% to 0.47% during 4th to 8th week intervals. The population of green lacewing was found lower at 0.87% in Hybrid Nirali, while higher in Green Star with 1.79%. The population of green lacewing gradually increased (1.95%) ranging from 0.95% to 2.90% during 1st to 4th week intervals but gradually decreased at 2.81% ranging from 2.90% to 0.09%, during 4th to 8th week intervals. Lowest population of Syrphid fly (0.62%) was recorded in Hybrid Nirali, while highest percentage (0.96%) was noted in Sarhad Green. No Syrphid Fly was found during 1st and 8th week intervals, the population of Syrphid Fly increased at 2.33% ranging from 0.00% to 2.33% during 1st to 4th week intervals but gradually decreased at 2.33% ranging from 2.33% to 0.00% during 4th to 8th week intervals. The data showed that Hybrid Nirali gave higher yield of 8980 kg ha^{-1} as compared to other okra varieties. It was concluded that Hybrid Nirali yielded more and also found comparatively more resistant to the attack of *A. gossypii* as compared to all other varieties.

Key words: *Aphis gossypii*, ladybird beetle, green lacewing, syrphid fly, okra varieties

INTRODUCTION

Okra (*Hibiscus esculentus* L.) is an important vegetable in the tropics and sub-tropics. In Pakistan area under okra cultivation in 2007-08 was reported to be 14780 ha and its production was found to be 111565 tones, while Khyber Pakhtunkhwa having an area of 2077 ha under okra cultivation produced 17972 tones of okra (MINFAL, 2007).

In Pakistan yield of okra is very low. The main factors responsible for the low yield are low yielding varieties, poor soil fertility, weeds, diseases and insects (Dhaliwal, 2004).

Among insect pests, aphids especially *Aphis gossypii* (Glov.) is considered one of the most important pests of okra (Dhaliwal, 2004). The aphids are soft bodied insects which suck the cell sap from the leaves, secrete lots of honey dew on the leaves, weakening the plants and reducing both quantity and quality of the fruits. In addition to okra the aphids also feed on a variety of plants including the cucurbits, cotton, citrus and fruits. It also feeds on strawberry, beans, beets, spinach, eggplant, asparagus, a number of ornamental plants and many weeds (Atwal, 1994).

The role of natural enemies for the management of insect pests is one of the important methods, because it is relatively safe, longer lasting, economical, and environment friendly. Lady bird beetle, Syrphid fly and green lacewing are important predators of *A. gossypii* in okra crop (Hiroshi, 2002). Apart from this, parasitoids also play an important role in the management of *A. gossypii* population (Nucleo, 2007).

Host plant resistance is an important component of integrated pest management (Kogan, 1988; Saljoqi *et*

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al., 2012). In the context of IPM, host plant resistant needs serious attention. Highly resistant varieties will pressurize the pest population to select for resistance breaking strains. On the other hand, partial plant resistance will exert a lesser selection pressure on the pest population (Philogene, 1984). Moderate levels of resistance have many advantages in relation to IPM. Among the most desirable features of plant resistance from an ecological point of view are its specificity to a pest or complex of pest organisms, cumulative effect, persistence, harmony with the environment, ease of adoption and compatibility with other components in pest management. A partially resistant variety could provide the foundation upon which other management measures could be built (Adkisson and Dyck, 1980). This can be used as an adjunct to other control measures and interact well with other components of IPM, *i.e*. chemical and biological control measures (Saljoqi and van Emden, 2003a,b; van Emden, 1987).

This study was initiated to study the population dynamics/trend of *A. gossypii* along with its associated natural enemies in different available okra varieties. Also to study the effect of aphid infestation on the yield of different okra varieties.

MATERIALS AND METHODS

An experiment to study the population dynamics of *Aphis gossypii* (Glover) and its associated natural enemies in different okra varieties was conducted at Malakander Research Farm of Khyber Pakhtunkhwa Agricultural University Peshawar during 2009. The okra varieties, Saba Pirie, Ark Anamika, Pusa Sawani, Local Multani, Hybrid Nirali, Green Star and Sarhad Green were used. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Seven okra varieties (treatments) were used in the experiment. The crop was sown on 28th May, 2009. Each sub plot size was having a size of 3x5m^2. There were six rows in each sub plot allotted for each treatment. There were 15 plants in each row. Row to row distance was 75 cm, while plant to plant distance was 15 cm. A buffer zone of 60 cm wide was kept between the plots to isolate them from one another. Field was ploughed thoroughly with cultivator and disked well for breaking the clods before sowing the seeds. The seed were sown in flat plots. The first irrigation was given immediately after sowing and the second after germination. Hoeing, weeding and other cultural practices were done uniformly for all the treatments (varieties).

Population dynamics of A. gossypii

The population dynamics of *A. gossypii* was studied in seven different treatments by counting the number of *A. gossypii* on the three leaves, top, middle and lower region of four randomly selected plants in each treatment, in each replication, avoiding the boarder rows from each plot. Data were collected at weekly intervals. The collected data were converted into mean percent infestation.

Population dynamics of natural enemies of A. gossypii

In order to study the population dynamics of natural enemies of *A. gossypii* in different okra varieties, the data were collected on number of natural enemies *i.e*. Lady bird beetle, green lacewing and Syrphid on four randomly selected plants by using the same method as described for the determination of aphid population.

Identification of natural enemies

The collected specimen of natural enemies was identified in the Biological Control Laboratory of Department of Plant Protection, Khyber Pakhtunkhwa Agricultural University, Peshawar.

Comparative resistance in different okra varieties

Comparative resistance was based on mean percent infestation of *A. gossypii* in different okra varieties. The varieties which showed least mean percent infestation were considered comparatively more resistant than the rest of varieties.

Yield of okra in each treatment (variety)

The okra fruits were picked up at every 4 days interval, when they attained about 6-9 cm size. At the end of crop the yield of all individual pickings were summed up together to determine the total yield of okra fruit plot^{-1}. The data were converted into kg ha^{-1}.

Data analysis

The recorded data were analyzed statistically according to RCB design by taking treatment and time

intervals as two different factors upon obtaining significant differences, Dunkan's Multiple Range (DMR) test was employed for the means comparison (Gomez and Gomez, 1984).

RESULTS

Infestation of A. gossypii

Data pertaining to mean percent infestation of *A. gossypii* population is presented in Table I. Lowest mean percent infestation (2.25%) of *A. gossypii* population was noted in Hybrid Nirali, followed by Saba Pirie (2.82%). Mean percent infestation of 3.02%, 3.11% and 3.11% was found in Ark Anamika, Pusa Sawani and Local Multani, respectively. Highest mean percent infestation of 3.39% was recorded in Sarhad Green, followed by Green Star with attack of 3.34%. Mean percent infestation of 1.14% ranged from 3.39% in Sarhad Green to 2.25% in Hybrid Nirali. It is observed that Hybrid Nirali was the low infested variety, while Sarhad Green was highly infested variety of okra damaged by *A. gossypii*.

Aphis gossypii population was significantly affected by time intervals. The lowest mean percent infestation of 2.42% was observed during 8th week interval, followed by 7th week interval (2.63%). Mean percent infestation of 2.85%, 3.06% and 2.86% was found during 1st, 2nd and 6th week intervals, respectively. The highest mean percent infestation of 3.68% was noted during 4th week interval. It was followed by 3.32% and 3.23% during 3rd and 5th week intervals, respectively. Mean percent infestation of 1.26% by *A. gossypii* ranged from 3.68% during 4th week interval to 2.42% during 8th week interval (Table I).

When the association of varieties with week intervals was taken into an account, it was revealed that mean percent infestation of 1.27% was found in Saba Pirie ranging from 3.47% to 2.20% during 4th to 8th week interval. Mean percent infestation of 1.36% was recorded in Ark Anamika ranging from 3.73% to 2.37% during 4th to 8th week interval. Pusa Sawani and Local Multani showed the infestation of 1.30% and 1.20% ranging from 3.80% to 2.50% and 3.70% to 2.50% during 4th and 8th week interval, respectively. Lowest mean percent infestation of 0.64% was noted in Hybrid Nirali ranged from 2.67% to 2.03% during 4th and 8th week interval. Mean percent attack of 1.50% and 1.50% was recorded in Green Star and Sarhad Green ranged from 4.13% to 2.63% and 4.23% to 2.73% during 4th and 8th week intervals (Table I).

The data showed that variety Hybrid Nirali was merely infested by *A. gossypii* population with mean percent infestation of 2.25%, while Sarhad Green was prominently attacked by *A. gossypii* with mean percent infestation of 3.39%. Moreover, *A. gossypii* population was increased during 1st to 4th week interval ranged from 2.85% to 3.68%, while the infestation was decreased as it ranged from 3.68% to 2.42% during 4th to 8th week interval (Table I).

Population dynamics of ladybird beetle

The data (Table II) revealed that lowest mean percent population (1.25%) of ladybird beetle was noted in Hybrid Nirali, followed by Saba Pirie (1.54%) and Ark Anamika (1.54%). Mean percentage of 1.79% and 1.96% was found in Green Star and Pusa Sawani, respectively. Highest mean percentage (2.17%) of ladybird beetle was recorded in Local Multani. Mean percentage of 0.96% for ladybird beetle ranged from 2.21% in Sarhad Green to 1.25% in Hybrid Nirali. The collected data showed that the mean population of ladybird beetle was lower in Hybrid Nirali, while this trend was higher in Sarhad Green.

The population density of ladybird beetle was significantly affected by time intervals. The lowest mean percentage (0.47%) of ladybird beetle was observed during 8th week interval, followed by 7th week interval (0.81%). Mean percentage of 1.05%, 1.90% and 1.19% was recorded during 1st, 2nd and 6th week intervals, respectively. The highest mean percentage of 3.81% was noted during 4th week interval. It is followed by 2.86% and 2.14% during 3rd and 5th week intervals, respectively. Mean population (3.34%) of ladybird beetle ranged from

Table. I- Mean percent infestation (%) of *Aphis gossypii* (Glover) population in different okra varieties at different time intervals (weeks) at Malakander Research Farm of Khyber Pakhtunkhwa Agricultural University Peshawar during 2009.

Varieties	Time interval (week)								Mean
	06-6-2009 1st Week	13-6-2009 2nd Week	20-6-2009 3rd Week	27-6-2009 4th Week	04-7-2009 5th Week	11-7-2009 6th Week	18-7-2009 7th Week	25-7-2009 8th Week	
Sabaz Parie	2.77	2.93	3.17	3.47	3.10	2.60	2.33	2.20	2.82 c
Arka Anamika	2.70	3.07	3.40	3.73	3.20	3.00	2.70	2.37	3.02 b
Pusa Sawani	3.03	3.23	3.17	3.80	3.33	3.07	2.77	2.50	3.11 b
Local Multani	2.93	3.20	3.37	3.70	3.37	3.07	2.80	2.50	3.11 b
Hybrid Nirali	2.07	2.17	2.50	2.67	2.33	2.13	2.07	2.03	2.25 d
Green Star	3.23	3.43	3.80	4.13	3.63	3.03	2.80	2.63	3.34 a
Sarhad Green	3.23	3.37	3.83	4.23	3.63	3.13	2.93	2.73	3.39 a
Mean	2.85 d	3.06 c	3.32 b	3.68 a	3.23 b	2.86 d	2.63 e	2.42 f	-

LSD value at 5% level for varieties, 0.117; LSD value at 5% level for intervals, 0.125.
Means followed by the same letters are none significantly different at 5% level of probability using DMR test.

Table II.- Mean percent population of ladybird beetles in different okra varieties at different time intervals (weeks) at Meander Research Farm of Khyber Pakhtunkhwa Agricultural University Peshawar during 2009.

Varieties	Time interval (week)								Mean
	06-6-2009 1st Week	13-6-2009 2nd Week	20-6-2009 3rd Week	27-6-2009 4th Week	04-7-2009 5th Week	11-7-2009 6th Week	18-7-2009 7th Week	25-7-2009 8th Week	
Sabaz Parie	0.33	1.00	2.67	3.33	2.00	1.67	1.00	0.33	1.54 be
Arka Anamika	1.00	1.33	2.00	3.33	2.00	1.33	1.00	0.33	1.54 be
Pusa Sawani	1.00	2.67	2.33	4.00	2.33	1.33	1.33	0.67	1.96abc
Local Multani	1.33	2.33	3.33	4.67	2.67	1.33	1.00	0.67	2.17 a
Hybrid Nirali	0.33	1.00	2.67	2.67	2.00	0.67	0.33	0.33	1.25 c
Green Star	1.67	2.67	3.33	4.33	1.33	0.33	0.33	0.33	1.79abc
Sarhad Green	1.67	2.33	3.67	4.33	2.67	1.67	0.67	0.67	2.21a
Mean	1.05 d	1.90 c	2.86 b	3.81 a	2.14 c	1.19 d	0.81 de	0.47 e	-

LSD value at 5% level for varieties, 0.438; LSD value at 5% level for intervals, 0.469.
Means followed by the same letters are none significantly different at 5% level of probability using DMR test.

3.81% during 4th week interval to 0.47% during 8th week interval (Table II).

The interaction between varieties and week intervals was found non-significant (Table II). The data showed that lowest mean percent population (2.34%) of ladybird beetle was noted in Hybrid Nirali ranged from 2.67% to 0.33% during 3rd and 4th to 7th and 8th week intervals. Mean percent population (3.00%) of ladybird beetle was found in Saba Pirie and Ark Anamika ranging from 3.33% to 0.33% during 4th to 8th week interval. The mean percent population (3.33% and 3.66%) of ladybird beetle was noted in Pusa Sawani and Sarhad Green ranged from 4.00% to 0.67% and 4.33% to 0.67% during 4th to 8th week interval, respectively. The highest mean percent population (4.00%) of ladybird beetle was noted Local Multani and Green Star ranged from 4.67% to 0.67% and 4.33% to 0.33% during 4th and 8th week interval, respectively.

The data revealed that the population of ladybird beetle was lower as 1.25% in Hybrid Nirali, while higher in variety Sarhad Green with mean percentage of 2.21%. In addition, the population of ladybird beetles was evenly increased (2.76%) ranging from 1.05% to 3.81% during 1st week to 4th week intervals but gradually decreased (3.34%)

Table III.- Mean percent population of Green lace wing in different okra varieties at different time intervals (weeks) at Malakander Research Farm of Khyber Pakhtunkhwa Agricultural University Peshawar during 2009.

Varieties	Time interval (week)								Mean
	06-6-2009 1st Week	13-6-2009 2nd Week	20-6-2009 3rd Week	27-6-2009 4th Week	04-7-2009 5th Week	11-7-2009 6th Week	18-7-2009 7th Week	25-7-2009 8th Week	
Sabaz Parie	0.67	2.00	2.33	2.33	1.33	0.33	0.33	0.00	1.17 be
Arka Anamika	1.00	1.67	2.67	3.00	1.33	0.67	0.33	0.33	1.37 abc
Pusa Sawani	1.00	2.00	2.33	2.67	1.00	0.67	0.33	0.00	1.25 be
Local Multani	1.00	2.00	2.33	3.33	1.67	1.00	0.67	0.33	1.54abc
Hybrid Nirali	0.33	0.33	2.33	2.33	1.33	0.33	0.00	0.00	0.87 c
Green Star	1.33	2.00	4.00	4.00	2.33	0.67	0.00	0.00	1.79 a
Sarhad Green	1.33	1.00	2.67	2.67	2.00	1.33	0.00	0.00	1.37 abc
Mean	0.95 c	1.57 b	2.67 a	2.90 a	1.57 b	0.71 cd	0.24 de	0.09 e	-

LSD value at 5% level for varieties, 0.465; LSD value at 5% level for intervals, 0.497.
Means followed by the same letters are none significantly different at 5% level of probability using DMR test.

Table IV.- Mean percent population of syrphid fly in different okra varieties at different time intervals (weeks) at Malakander Research Farm of Khyber Pakhtunkhwa Agricultural University Peshawar during 2009.

Varieties	Time interval (week)								Mean
	06-6-2009 1st Week	13-6-2009 2nd Week	20-6-2009 3rd Week	27-6-2009 4th Week	04-7-2009 5th Week	11-7-2009 6th Week	18-7-2009 7th Week	25-7-2009 8th Week	
Sabaz Parie	0.00	0.00	1.67	2.33	1.33	0.67	0.00	0.00	0.75
Arka Anamika	0.00	0.33	1.67	2.67	1.33	0.33	0.00	0.00	0.79
Pusa Sawani	0.00	1.00	1.67	1.67	0.67	0.33	0.00	0.00	0.67
Local Multani	0.00	0.67	1.33	2.33	1.00	0.67	0.33	0.00	0.79
Hybrid Nirali	0.00	1.00	1.00	1.33	1.00	0.67	0.00	0.00	0.62
Green Star	0.00	1.33	1.67	2.33	1.00	1.00	0.00	0.00	0.92
Sarhad Green	0.00	1.00	1.67	3.67	1.00	0.33	0.00	0.00	0.96
Mean	0.00 e	0.76 cd	1.52 b	2.33 a	1.05 c	0.57 d	0.05 e	0.00 e	-

LSD value at 5% level for intervals, 0.347.
Means followed by the same letters are none significantly different at 5% level of probability using DMR test.

ranging from 3.81% to 0.47% during 4th week to 8th week intervals (Table II).

Population dynamics of green lacewings

The data regarding the population dynamics of green lacewing associated with *A. gossypii* population in different okra varieties is presented in Table III. The data showed lowest mean percent population (0.87%) of green lacewing was noted in Hybrid Nirali, followed by Saba Pirie (1.17%) and Pusa Sawani (1.25%). The population (1.37%) of green lacewing was found in Ark Anamika and Sarhad Green. The mean population (1.54%) of green lacewing was found in Local Multani. Highest mean percentage (1.79%) of green lacewing was recorded in Green Star. Mean percentage of 0.92% for green lacewing ranged from 1.79% in Green Star to 0.87% in Hybrid Nirali. The data showed that mean population of green lacewing was lower in Hybrid Nirali, while this tendency was higher in variety Green Star.

The population of green lacewing was significantly affected by time intervals. The lowest mean percent population (0.09%) of green lacewing was observed during 8th week interval, followed by 7th week interval (0.24%). Mean percentage of 0.95%, 1.57%, 1.57% and 0.71% was recorded during 1st, 2nd, 5th and 6th week intervals, respectively. The highest mean percentage of 2.90% was noted during 4th week interval. It is followed by 2.67% during 3rd week interval. Mean percent population (2.81%) of green lacewing ranged from 2.90% during 4th week interval to 0.09% during 8th week interval (Table III).

The interaction of varieties and week intervals was found non-significant. The data showed that no green lacewing was found on okra varieties during 8th week interval except Local Multani showing the mean percentage of 0.33%. The lowest mean percent population (1.67%) of green lacewing was noted in Sarhad Green ranging from 2.67% to 1.00% during 3rd and 4th to 2nd week intervals. Mean percent population (2.00%) of green lacewing was found in Hybrid Nirali and Saba Pirie ranging from 2.33% to 0.33% during 3rd and 4th to 1st, 2nd, 6th and 7th week intervals, respectively. The mean percent population (2.67% and 2.34%) of green lacewing was noted in Ark Anamika and Pusa Sawani ranging from 3.00% to 0.33% and 2.67% to 0.33% during 4th to 7th and 8th week intervals, respectively. The highest mean percent population of 3.33% and 3.00% of green lacewing was noted in Green Star and Local Multani ranging from 4.00% to 0.67% and 3.33% to 0.33% during 3rd and 4th to 6th and 8th week intervals, respectively (Table III).

The data revealed that the population of green lacewing was lower (0.87%) in Hybrid Nirali, while this population was higher in variety Green Star with mean percentage of 1.79%. In addition, the population of green lacewing was partially increased (1.95%) ranging from 0.95% to 2.90% during 1st week to 4th week intervals but gradually decreased (2.81%) ranging from 2.90% to 0.09% during 4th week to 8th week intervals (Table III).

Population dynamics of syrphid fly

The Table IV showed that lowest mean percent population (0.62%) of syrphid fly was noted in Hybrid Nirali, followed by Pusa Sawani with mean percentage of 0.67%. Mean percentage of 0.79% of syrphid fly was found in Ark Anamika and Local Multani. The mean percent population of 0.75% of syrphid fly was noted in Saba Pirie. The highest mean percent population of 0.96% of syrphid fly was found in Sarhad Green, followed by Green Star with a mean percentage of 0.92%. Mean percent population of 0.34% of syrphid fly among varieties ranged from 0.96% in Sarhad Green to 0.62% in Hybrid Nirali. The data revealed that the mean percent population of syrphid fly was lower in Hybrid Nirali, while this trend was higher in Sarhad Green.

Time week intervals significantly affected the mean percent population of syrphid fly. No syrphid fly was recorded during 1st and 8th week intervals. The lowest mean population (0.05%) of syrphid fly was observed during 7th week interval, followed by 6th week interval (0.57%). Mean percent population of 0.76% and 1.05% was recorded during 2nd and 5th week intervals, respectively. The highest mean percent population (2.33%) of syrphid fly was noted during 4th week interval, followed by 3rd week interval with mean percentage of 1.52% (Table IV).

The interaction between varieties and week intervals was found non-significant (Table IV). The data showed that lowest mean percent population of 0.66% of syrphid fly was noted in Hybrid Nirali ranging from 1.33% to 0.67% during 4th and 6th week intervals. Mean percent population of 1.66% and 2.44% of syrphid fly was found in Saba Pirie and Ark Anamika ranging from 2.33% to 0.67% and 2.67% to 0.33% during 4th to 6th week intervals. The mean percent population of 1.34% and 2.00% of syrphid fly was noted in Pusa Sawani and Local Multani ranging from 1.67% to 0.33% and 2.33% to 0.33% during 4th to 6th and 4th to 7th week intervals, respectively. The highest mean percent population (3.34%) of syrphid fly was noted in Sarhad Green ranging from 3.67% to 0.33% during 4th to 6th week interval.

The data (Table IV) showed that the population of syrphid fly was lower (0.62%) in Hybrid Nirali, while higher population of syrphid fly was noted on Sarhad Green with mean percentage of 0.96%. Furthermore, no syrphid fly was found during 1st and 8th week intervals, however, the population of syrphid fly was evenly increased (2.33%) ranging from 0.00% to 2.33% during 1st week to 4th week intervals but gradually decreased (1.65%) ranging from 2.33% to 0.00% during 4th week to 8th week intervals.

Total yield (kg ha^{-1})

The data concerning to total yield of okra is presented in Figure 1. Significant differences for total yield among okra varieties were observed. Mean values of the data indicated that highest total yield of 8980 kg ha^{-1} was recorded in Hybrid Nirali, followed by Saba Pirie with total yield of 8622 kg ha^{-1}. Mean total yield of 7180 kg ha^{-1} was observed in Ark Anamika. Local Multani ranked 4th with mean yield of 6825 kg ha^{-1}, followed by Pusa Sawani with total yield of 5427 kg ha^{-}

[1]. Green Star gave 4405 kg yield ha^{-1}. The lowest mean total yield of 3842 kg ha^{-1} was recorded in Sarhad Green.

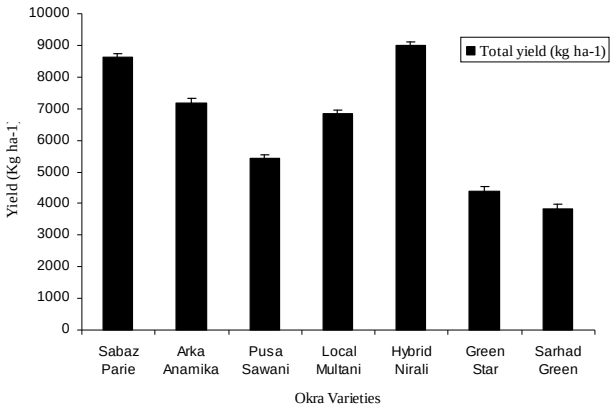

Fig. 1. Total yield (ka ha^{-1}) in different okra varieties at Malakander Research Farm, KPK Agriculture University, Peshawar during 2009.

DISCUSSION

In the present work the number of aphids counted on the top, middle and bottom leaves of a plant was presented as the number of aphids on three leaves which was then converted to aphid population leaf^{-1}, avoiding border rows. The limitation of this type of sampling of *M. persicae* is the difference in the leaf areas of different portions of plants. However, overall such a method enables an easy determination of relative average aphid populations leaf $^{-1}$with maximum accuracy. This is not the only method available; only lower leaves may be chosen at random and the population expressed as aphids per 100 leaves (Davies, 1934), counting all leaves of selected plants (Adams, 1946), beating individual plants over a cloth for collection of aphids (Moericke, 1941). The within-plant aphid distribution is currently believed to be connected to plant nutrition, plant growth, and temperature (Van de Burg, 1997; Meyers *et al*., 2005; Desneux *et al*., 2006). Hu *et al*. (1992) discovered a positive correlation between nitrogen content and the concentration of aphids on the top leaves. Similarly, reproduction of aphids can depend upon the level of soluble nitrogen in their host plants (Dixon and McKay, 1970). Actively growing leaves serve as sinks for nitrogen and other nutrients in different plants (Staswick, 1994). The present method has also used by previous workers for measuring aphid populations in different insecticide trials in potato crops (Singh and Verma, 1985; Saljoqi and van Emden, 2003a,b).

Data pertaining to mean percent population of *A. gossypii* revealed that okra varieties were found significantly different among each other for *A. gossypii* population. The data showed that Hybrid Nirali showed comparatively more resistance against *A. gossypii* infestation as compared to other okra varieties. Shannag *et al*. (2007) reported that infestation by *A. gossypii* on different okra varieties reduced the yield. It is suggested that *A. gossypii* completed their life cycle during 1st to 4th week intervals and thus population reduction started afterwards. Reaumur (2009) stated that a newly born aphid becomes a reproducing adult within about a week and then can produce up to 5 offspring per day for up to 30 days. The data revealed that time intervals played a vital role in the reduction of pest infestation. The increase of aphid density from 1st to 4th week interval (month of June) may be due to favorable environmental conditions. The unfavorable environmental condition declined the population later on. Heavy rain during second week of July might be the cause of reduction in *A. gossypii* population. Leite *et al*. (2007) reported that rainfall can reduce the *A. gossypii* population significantly. These results are in agreement with the findings of Ranitha and Nandihalli (2007) who confirmed the peak incidence of *A. gossypii* during the first week of July. Patel and Rote (2008) also reported that peak incidence of *A. gossypii* was noticed during first week of July.

Among the natural enemies the lady bird beetle population was first observed in the field in larger number as compared with all other natural enemies. The ladybird beetle population trend during different time intervals as well regarding the varietal response was almost the same as recorded for *A. gossypii*. Initially low population of ladybird beetle was recorded. Peak population was recorded during the 4th week. Later on decrease in the ladybird beetle population was recorded. These results are in line with the findings of Henry and Mass (1995) who reported that the most important aphid predator is the ladybird beetle. Ames *et al*. (1996)

stated that the *A. gossypii* are attacked by a number of ladybird beetles. Germano *et al*. (2007) also reported that natural enemies, especially ladybird beetles is one of the important factors that most contributed to aphid reduction.

The population trend of green lacewing and Syrphid fly was also observed in the same pattern just like ladybird beetle during different time intervals and also in respect of varietal response. The difference among their pattern is that the ladybird population was recorded in larger number followed by green lacewing and then the Syrphid fly. Reddy (2002) also suggested that odors from okra, are attractive to *C. carnea.* Leite *et al.* (2005) reported that *Chrysoperla* spp. is one of the most important factors in reducing the aphid population in okra plants. Ames *et al*. (1996) reported that *A. gossypii* are attacked by a number of syrphid fly which reduce its population.

The data showed that *A. gossypii* population affected the total yield of okra varieties. Hybrid Nirali was found the highest yielding variety which was recorded comparatively more resistant to *A. gossypii* attack as compared with all other varieties. The Sarhad Green showed the lowest yield where highest *A. gossypii* population was recorded. These results are in agreement with the findings of Shannag *et al.* (2007) who reported that infestation of *A. gossypii* on okra varieties reduced total yield.

CONCLUSION

Hybrid Nirali was found comparatively more resistant to *A. gossypii* infestation and high yielding variety. Natural enemies *i.e.* ladybird beetles, green lacewings, and syrphid flies may also contribute towards reduction of aphid population. This needs further study for confirmation.

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