Research Article

Response of Different Tomato Cultivars against Aphid, *Myzus persicae* (Sulzer) and its Associated Natural Enemies in District Swat

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Abstract | The current study focus on the response of different tomato cultivars against aphid, *Myzus persicae* (Sulzer) and its associated natural enemies at Agricultural Research Institute (ARI) Mingora Swat, during the growing season 2017. The tomato cultivars include Swat local, Rio-Grande early, U-Grande, Rio-Grande late, Tomato BSS-30, 87-5 China and Roma VF. These varieties were sown in Randomized Complete Block Design with three replications. Results of this research showed that aphid population remained constant on different cultivars throughout the experiment. The lowest (3.30 aphids leaf^{-1}) mean number of aphids were recorded on 87-5 China followed by U-Grande (3.72 aphids leaf^{-1}), Tomato BSS-30 (4.22 aphids leaf^{-1}), Roma VF (4.45 aphids leaf^{-1}), Rio-Grande late (4.67 aphids leaf^{-1}) and Swat local (5.11 aphids leaf^{-1}). While, the highest (5.40 aphids leaf^{-1}) were recorded on Rio-Grande early. Initially the population of aphid was found low followed by increase with the passage of time and reached to peak till week 4th (5th May). Then, the population of aphids started declining and lowest population was observed in week 8th (2nd June). Data regarding the natural enemies revealed that, the population of natural enemies was low at the beginning, increased till week 4th (5th May) where highest population was recorded. Afterwards declined trend was observed in the population of natural enemies. The lowest population of natural enemies were recorded in week 8th (2 June). The highest yield (5.70 t ha^{-1}) was obtained from 87-5 china cultivar followed by Rio-Grande late (5.58 t ha^{-1}), Roma VF (5.32 t ha^{-1}), Tomato BSS-30 (5.15 t ha^{-1}), U-Grande (5.11 t ha^{-1}), Swat local (4.94 t ha^{-1}) and lowest yield (4.70 t ha^{-1}) was recorded from Rio-Grande early. Tomato cultivar (87-5 china) was recommended for to use in IPM.

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Introduction

Tomato (*Lycopersicon esculentum* Mill) belongs to the family Solanaceae. The size and shape (round, cylindrical, square, oblong) of tomato fruit is dependent upon the type of cultivars. It has high nutritional value contain vitamin A and C and minerals i.e., phosphorus and iron (Mehfooz, 1990). It is one of the important vegetables mostly used all over the world. Tomato is also use in industries for making paste, juice and ketchup all around the world (AVRDC, 1996).

Tomato is produced in tropical and temperate regions of the globe. Tomato fits well in many cropping patterns. In Pakistan, tomato crop is cultivated on area of 60.7 thousand hectares (ha) with an annual production of 570.6 thousand tones (t). In Khyber

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Pakhtunkhwa, the annual production of tomato is 132 t ha^{-1} cultivated on area of 13.3 thousand ha (FBS, 2015).

Various kind of insect pests such as, Fruit borer, whiteflies, Beetles, and Aphids attack tomato crop. Among all these pests, Aphid *Myzus persicae* (Sulzer) is one of the most serious pests of tomato crop. *M. persicae* belongs to family Aphididae and order Homoptera. Aphids use stylet for sucking sap from the plants and during its (stylet) penetration aphids inject two types of saliva (gelling saliva and watery saliva). These types of saliva help in depositions of plant tissues which also play role in modulating host plant defense (Will et al., 2007).

M. persicae is amongst the most widely recognized polyphagous insect pests. Aphids attack on young tissues mostly at the growing tips. The aphids then spread to entire plant, suck the sap caused downward curl and even with high infestation the plant eventually die. The aphid effect entire plant at above ground surface throughout developmental stages till fruit maturation. *M. persicae* mostly prefer blossoms which also causes blossom drops and fruit distortions. Stunting, twisting or yellowing of plant green foliage is mainly cause by continuous feeding of *M. persicae* Moreover, studies showed that yield is decreased when greater than 50% of plant leaves is infested by aphids (Kuhar et al., 2009).

In addition to direct losses, the aphid is capable of transmitting more than 150 viral diseases in different hosts particularly in Solanaceous vegetables. A few examples are; Potato Leaf roll Virus and Potato Virus Y of Solanaceous plants (pepper, potato and tomato), Cucumber Mosaic Virus and Watermelon Mosaic Virus of cucurbits and Cauliflower Mosaic Virus and Turnip Mosaic Virus of crucifers (Cloyd and Sadof, 1998).

M. persicae depends on environmental conditions which is proved as prime imperative for the implementation of the succeeding crop protection package also in view of modern Integrated Pest Management Programmes (Berlendier et al., 2003). Resistant cultivars are also one of the alternative management techniques for *M. persicae*. Its resistant to *M. persicae* is due to many factors; existence of resistance factors on the plant surface or at the mesophyll/phloem tissues. Different varietal response against insects and pests has been studied by various researchers (Gibson, 1971; Eigenbrode et al., 2002). Amount, nature of secondary metabolites and nutritional quality of cell sap affect the resistance of the plant against pest which is found different in each plant (Gibson and Pickett, 1983; Ave and Tingey, 1986; Karley et al., 2002).

Due to rational use of insecticides, insects has developed resistance to most of insecticides. For harmful effect of pesticides on environment and for the development of resistance in insect pest against insecticides alternative control strategies are needed to adopt (Margaritopoulos et al., 2007). The use of resistant cultivars is one of the alternative ways for controlling insect pests in the fields. The use of these resistant cultivars is not only safe for the environment but also safe for the associative natural enemies.

The present studies were conducted with the objectives to find out the varietal response towards the population abundance of *M. persicae* and its associated natural enemies on different tomato cultivars.

Materials and Methods

An experiment was designed to investigate the response of different tomato cultivars against *M. persicae* and its associated natural enemies under field conditions at Agricultural Research Institute Mingora Swat, during the cropping season 2017.

Field evaluation of tomato cultivars against aphids, M. persicae

Different tomato cultivars (Swat Local, Rio-Grande early, U-grande, Rio-Grande late, Tomato BSS-30, 87-5 China and Roma VF) were brought from local market and sown in the nursery. Field was prepared for transplantation. Seedling was transplanted to the field during late hours of the day. Recommended spaces were followed and balance doses of essential nutrients were applied to all the experimental units. The mentioned different treatments were assigned in Randomized Complete Block design with three replications. The plot size was 4×3m (L×W) consisting of three rows for each treatment (cultivar). Each row was having 8 plants. Area of 60 cm buffer zone was kept between the plots. Regular farming practices were kept constant for each treatment throughout the experiment.

Table 1: *Mean Population density and Time intervals of Myzus persicae (Sulzer) leaf^{-1} on different tomato cultivars at ARI, Mingora Swat, during the growing season, 2017.*

	Time Intervals								
	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	
Cultivars	14-April	21-April	28-April	5-May	12-May	19-May	26-May	2-June	Mean
Swat Local	2.10 f′	3.30 x	5.80 m	9.20 b	9.00 c	6.50 j	3.90 v	1.10 l′	5.11 b
Rio-Grande early	2.23 d′	3.50 w	6.10 l	9.50 a	9.20 b	7.20 h	4.20 u	1.30 j′	5.40 a
U- Grande	1.70 i′	2.20 e′	4.50 s	6.90 i	6.50 j	5.00 q	2.50 c′	0.50 o′	3.72 f
Rio-Grande late	1.90 h′	3.00 z	5.60 n	8.90 d	8.10 f	5.80 m	3.20 y	0.90 m′	4.67 c
Tomato BSS-30	1.30 j′	2.50 c′	4.90 r	8.10 f	7.90 g	5.50 o	2.90 a′	0.70 n′	4.22 e
87-5 China	1.20 k′	2.03 g′	4.20 u	6.40 k	5.80 m	4.40 t	2.10 f′	0.30 p′	3.30 g
Roma VF	1.10 l′	2.80 b′	5.20 p	8.50 e	8.10 f	5.80 m	3.20 y	0.90 m′	4.45 d
Mean	1.64 g	2.76 f	5.18 d	8.21 a	7.80 b	5.74 c	3.14 e	0.81 h	

Means followed by different letter(s) are significantly different from each other ($P \leq 0.05$); LSD for Cultivars at $P \leq 0.05 = 0.0062$; LSD for Weeks at $P \leq 0.05 = 0.0066$; LSD for interaction of Cultivars × Weeks at $P \leq 0.05 = 0.017$.

Table 2: *Mean Population density and Time intervals of Ladybird beetle (Coccinella septempunctata) plant^{-1} on different tomato cultivars at ARI Mingora Swat, during the growing season 2017.*

	Time Intervals								
	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	
Cultivars	14-April	21-April	28-April	5-May	12-May	19-May	26-May	2-June	Mean
Swat Local	1.50 k′	4.10 r	5.30 l	6.10 g	5.30 l	4.50 p	2.80 z	1.16 n′	3.84 d
Rio-Grande early	1.40 l′	4.80 n	6.10 g	6.30 e	6.30 e	4.60 o	2.60 b′	1.60 j′	4.21 b
U- Grande	1.13 o′	3.90 s	6.50 d	6.50 d	7.00 a	4.30 q	2.30 d′	1.80 h′	4.17 c
Rio-Grande late	2.10 f′	3.40 w	6.90 b	5.90 h	6.20 f	4.80 n	2.10 f′	2.70 a′	4.26 a
Tomato BSS-30	1.70 i′	3.20 x	5.30 l	6.70 c	6.50 d	3.80 t	1.90 g′	1.10 p′	3.77 e
87-5 China	1.90 g′	3.50 v	5.60 i	5.40 k	5.50 j	3.60 u	2.20 e′	1.50 k′	3.65 f
Roma VF	1.30 m′	2.90 y	5.20 m	6.20 f	5.90 h	2.90 y	2.40 c′	0.90 q′	3.46 g
Mean	1.57 g	3.68 e	5.84 c	6.15 a	6.10 b	4.07 d	2.32 f	1.53 h	

Means followed by different letter(s) are significantly different. from each other ($P \leq 0.05$); LSD for Cultivars at $P \leq 0.05 = 0.0062$; LSD for Weeks at $P \leq 0.05 = 0.0064$; LSD for interaction of Cultivars × Weeks at $P \leq 0.05 = 0.017$.

M. persicae leaf^{-1}

To study the *M. persicae* population density on seven different tomato cultivars (treatments), the aphids were counted on lower, middle and top reigns of three different randomly selected plants in every replication of each treatment avoiding the border rows of each plot. The data was recorded at weekly intervals. At the end total number of aphids were converted into mean infestation (Saljoqi et al., 2009).

Natural enemies population plant^{-1}

To study the population density of natural enemies i.e. Ladybird beetle, Green lacewing, Syrphid flies and Parasitoid mummies were collected from randomly selected three plants of each cultivar in each replication. The methodology of Saljoqi et al. (2009) was followed for natural enemies data collection with few modifications.

Yield tones t ha^{-1}

The yield obtained from different cultivars were separately weighed in kg plot^{-1} which was then converted into tones ha^{-1} (Usman et al., 2012).

Data analysis

Final data received was analyzed statistically by using STATISTIX. 8.1 version. Means were separated at 5% alpha level of significance.

Results and Discussion

Population abundance of M. persicae leaf^{-1} on different tomato cultivars

The data present in Table 1 indicated that overall mean number of aphids recorded on different cultivars on various time intervals is significantly different.

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Table 3: *Mean Population density and Time intervals of Green lace wing (Chrysoperla carnea) plant^{-1} on different tomato cultivars at ARI, Mingora Swat, during the growing season 2017.*

Cultivars	Time intervals								Mean
	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	
	14-April	21-April	28-April	5-May	12-May	19-May	26-May	2-June	
Swat Local	0.40 f′	2.90 u	4.30 k	5.06 f	4.50 i	3.50 o	0.90 a′	0.50 e′	2.75 a
Rio-Grande early	0.30 g′	2.20 y	4.60 h	5.40 d	4.30 k	3.40 p	0.80 b′	0.40 f′	2.67 c
U- Grande	0.50 e′	2.20 y	4.50 i	5.70 a	4.40 j	3.30 q	0.70 c′	0.30 g′	2.70 b
Rio-Grande late	0.30 g′	2.30 x	4.70 g	5.30 e	4.20 l	3.10 s	0.50 e′	0.20 h′	2.57 e
Tomato BSS-30	0.20 h′	2.40 w	4.40 j	5.70 a	4.10 m	3.00 t	0.60 d′	0.20 h′	2.57 e
87-5 China	0.40 f′	2.10 z	4.20 l	5.50 c	4.00 n	3.20 r	0.30 g′	0.50 e′	2.52 f
Roma VF	0.10 i′	2.60 v	4.10 m	5.60 b	4.50 i	3.10 s	0.80 b′	0.40 f′	2.65 d
Mean	0.31 h	2.38 e	4.40 b	5.46 a	4.28 c	3.22 d	0.65 f	0.35 g	

Means followed by different letter(s) are significantly different from each other (P ≤ 0.05); LSD for Cultivars at P ≤ 0.05 = 0.0041; LSD for Weeks. at P ≤ 0.05 = 0.0047; LSD for interaction. of Cultivars × Weeks at P ≤. 0.05 = 0.012.

Table 4: *Mean Population density and Time intervals of Syrphid flies plant^{-1} on different tomato cultivars at ARI Mingora Swat, during the growing season 2017.*

	Time intervals								
	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	
Cultivars	14-April	21-April	28-April	5-May	12-May	19-May	26-May	2-June	Mean
Swat Local	0.00 e′	1.20 za′	3.30 tu	5.30 op	8.10 f	7.80 g	3.90 q	0.90 b′	3.81 a
Rio-Grande early	0.00 e′	1.30 z	3.60 r	5.40 no	8.30 de	7.50 h	3.50 rs	0.56 c′	3.77 ab
U- Grande	0.00 e′	1.50 y	3.20 uv	5.90 l	8.50 bc	7.30 i	3.30 tu	0.90 b′	3.82 a
Rio-Grande late	0.00 e′	1.70 x	3.50 rs	5.50 n	8.40 cd	6.90 j	3.43 r-t	0.50 c′	3.74 b
Tomato BSS-30	0.00 e′	1.60 xy	3.80 q	5.70 m	8.70 a	6.50 k	3.80 q	0.40 cd′	3.81 a
87-5 China	0.00 e′	1.10 a′	3.40 st	5.16 p	8.20 ef	6.90 j	3.20 uv	0.80 b′	3.59 c
Roma VF	0.00 e′	1.90 w	3.10 v	5.80 lm	8.60 ab	6.40 k	3.60 r	0.30 d′	3.71 b
Mean	0.00 h	1.47 f	3.41 e	5.53 c	8.40 a	7.04 b	3.53 d	0.62 g	

Means followed by different letter(s) are significantly different from each other (P ≤ 0.05); LSD for Cultivars at P ≤ 0.05 = 0.062; LSD for Weeks at P ≤ 0.05 = 0.066; LSD for interaction of Cultivars × Weeks at P ≤. 0.05 = 0.176.

The highest aphids infestation 5.40 aphids leaf^{-1} were recorded on Rio-Grande early followed by Swat local, Rio Grande late, Roma VF, Tomato BSS-30 and U-Grande with 5.11, 4.67, 4.45, 4.22 and 3.72 aphids leaf^{-1} were recorded respectfully. While, the lowest mean numbers of aphids 3.30 aphids leaf^{-1} were observed on 87-5 China.

Mean data of different time intervals revealed that firstly the mean aphid population was low (1.64 aphids leaf^{-1}) and as the time proceeded onward the population enhanced and reached to highest infestation 8.21 aphids leaf^{-1} till week 4th (5th May). After that, infestation started on the declined rate and the lowest (0.81 aphids leaf^{-1}) number of aphid was recorded on last week 8th (2nd June).

In almost all interactions initially the aphid population was low and it increased with the passage of time. Highest mean number of aphid was recorded on most of the interactions at 4th week. The decline rate of aphid infestation was observed from 4th week till the last week of data collection. Highest mean of aphid infestation (9.50 aphids leaf^{-1}) were observed at 4th week (5th May) on the Rio-Grande early followed by Swat local in the same week (4th) with infestation of 9.20 aphids leaf^{-1} respectively. While, the lowest mean number of aphids 0.30 aphids leaf^{-1} were recorded on 87-5 China at 8th week (2nd June).

Population abundance of C. septempunctata plant^{-1} on different tomato cultivars

The results in Table 2 regarding the overall mean number of *C. septempunctata* recorded on different

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tomato cultivars at various time intervals indicated significant difference. The highest population 4.26 *C. septempunctata* plant^{-1} were recorded on Rio-Grande late, followed by Rio-Grande early, U-grande, Swat local, Tomato BSS-30, and 87-5 China with 4.21, 4.17, 3.84, 3.77 and 3.65 *C. septempunctata* plant^{-1} were recorded, respectfully. Lowest (3.46 *C. septempunctata* plant^{-1}) mean number of *C. septempunctata*, were observed on Roma VF.

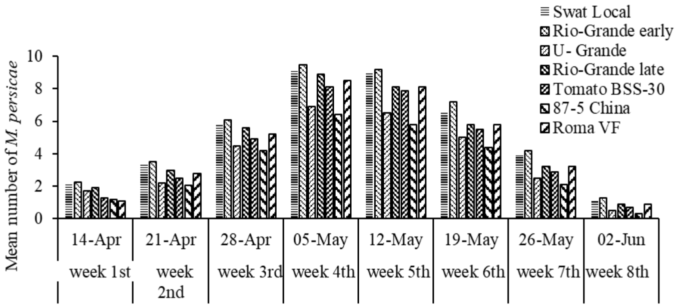

Figure 1: *Mean Population density and Time intervals of Myzus persicae (Sulzer) leaf^{-1} on different tomato cultivars at ARI, Mingora, Swat during the growing season, 2017.*

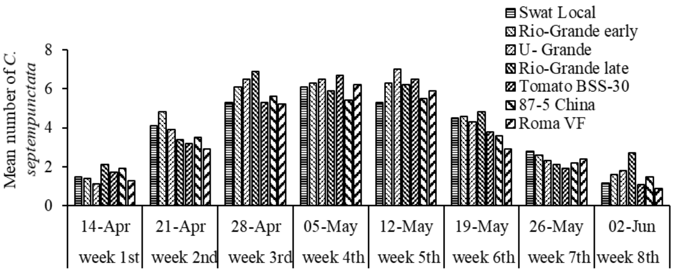

Figure 2: *Mean Population density and Time intervals of Ladybird beetle (Coccinella septempunctata) plant^{-1} on different tomato cultivars at ARI, Mingora, Swat during the growing season, 2017.*

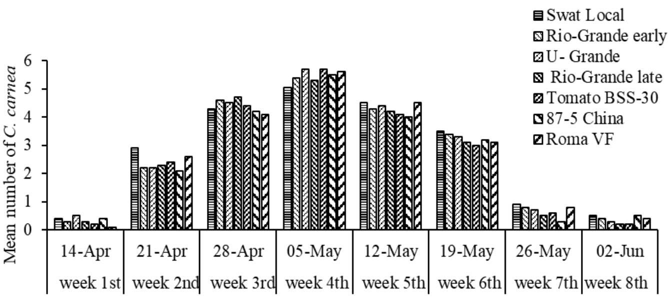

Figure 3: *Mean Population density and Time intervals of Green lace wing (Chrysoperla carnea) plant^{-1} on different tomato cultivars at ARI, Mingora, Swat during the growing season, 2017.*

The findings *C. septempunctata* population on various time intervals showed that firstly the mean population of *C. septempunctata* was low 1.57 *C. septempunctata* plant^{-1} and increased as time proceeded onward. Highest (6.15 *C. septempunctata* plant^{-1}) population of *C. septempunctata* was observed at 4th week (5th May). After that the population started to declining and lowest (1.53 *C. septempunctata* plant^{-1}) was recorded at last week 8th (2nd June).

The interactions of *C. septempuncatata* population on various tomato cultivars and time intervals revealed that highest (7.00 *C. septempunctata* plant^{-1}) was recorded on U-Grande at 5th week (12th May) followed by same (week 5th) where 6.50 and 6.20 *C. septempunctata* plant^{-1} were recorded on Tomato BSS-30 and Rio-Grande late respectively. While, the lowest population of *C. septempunctata* 0.90 *C. septempunctata* plant^{-1} was recorded at week 8th (2nd June) on Roma VF.

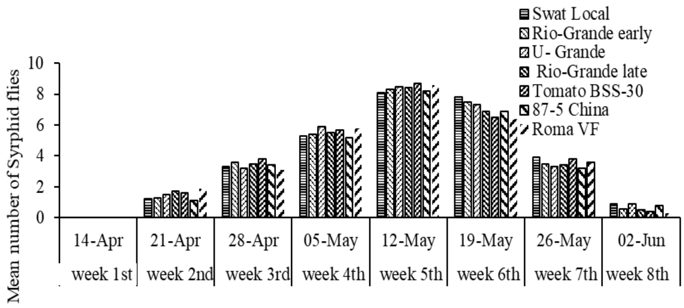

Figure 4: *Mean Population density and Time intervals of Syrphid flies plant^{-1} on different tomato cultivars at ARI, Mingora, Swat during the growing season of 2017.*

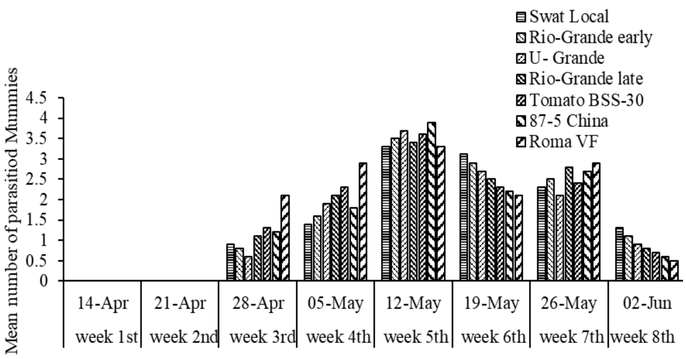

Figure 5: *Mean population density and Time intervals of Parasitoid mummies plant^{-1} on different tomato cultivars at ARI, Mingora, Swat during the growing season of 2017.*

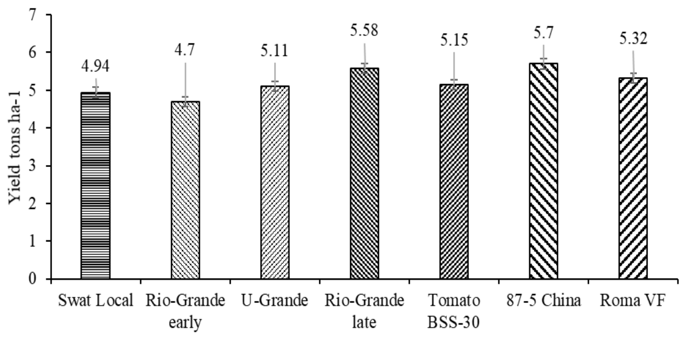

Figure 6: *Yield of Tomato cultivars in tones/ hectare without chemical insecticides application recorded at Agriculture Research Institute ARI, Mingora Swat during active growing season, 2017.*

Population abundance of Green lace wing (Crysoperla carnea) plant^{-1} on different tomato cultivars

Table 3 showed significant difference in the population abundance of *C. carnea* on different tomato cultivars with various time intervals and in their interactions. The highest population 2.75 *C. carnea* plant^{-1} was recorded on Swat local followed by U-grande, Rio-Grande early, Roma VF, Tomato BSS-30 and Rio-Grande late with 2.70, 2.67, 2.65, 2.57 and 2.57 *C. carnea* plant^{-1} respectfully. Lowest mean number of *C. carnea*, 2.52 *C. carnea* plant^{-1} were observed on 87-5 China.

On various time intervals, the population of *C. carnea* was firstly low 0.31 *C. carnea* plant^{-1} and enhanced as time proceed onward. Population of *C. carnea* was on the peak 5.46 *C. carnea* plant^{-1} at 4th week (5th May), after that, population started decline and the lowest number of population 0.35 *C. carnea* plant^{-1} was noted on week 8th (2nd June).

In almost all interactions, initially *C. carnea* population was low. The highest (5.70 *C. carnea* plant^{-1}) population of *C. carnea* was recorded at 4th week (5th May) on U-Grande and Tomato BSS-30 followed by 4th week where 5.60 *C. carnea* plant^{-1} were recorded on Roma VF. While, the lowest mean population of *C. carnea*, 0.20 *C. carnea* plant^{-1} was recorded in 8th week (2nd June) on Rio-Grande late and Tomato BSS-30.

Population abundance of Syrphid flies plant^{-1} on different tomato cultivars

Results in Table 4 revealed the response of different tomato cultivars with various time intervals and their interaction towards the mean number syrphid flies. The data concerning the overall mean. number of syrphid flies noted on different tomato cultivars showed significant difference. The highest population 3.82 flies plant^{-1} were recorded on U-grande followed by Swat local, Tomato BSS- 30, Rio-Grande early, Rio-Grande late and Roma VF cultivar with 3.81, 3.81, 3.77, 3.74 and 3.71 flies plant^{-1} respectfully. Lowest mean number of syrphid flies (3.59 flies plant^{-1}) was observed on 87-5 China Cultivar.

The overall mean of syrphid flies on time intervals showed that initially the syrphid flies appeared in week 2nd with low population (1.47 flies plant^{-1}) and increased as time proceed, the population increased and reached to peak (8.40 flies plant^{-1}) on week 5th (12th May). After that, population started on decline rate and the lowest number of population 0.62 flies plant^{-1} was recorded on last week 8th (2nd June).

The interactions of different cultivars and time intervals showed that, highest (8.70 flies plant^{-1}) mean of syrphid flies were observed at week 5th (12th May) on Tomato BSS-30 followed by week 4th where, 8.60 and 8.50 (flies plant^{-1}) on Roma VF and U-Grande respectively. While, the lowest (0.30 flies plant^{-1}) mean population of syrphid flies were recorded in 8th week (2nd June) on Roma VF.

Population abundance of Parasitoid mummies plant^{-1} on different tomato cultivars

Table 5 revealed significant difference in the population of Parasitoid mummies plant^{-1} on different tomato cultivars with various time intervals and in their interactions. The data regarding the overall mean number of parasitoid mummies counted on different tomato cultivars showed that highest population 1.72 mummies plant^{-1} were observed on Roma VF, followed by Rio- Grande late, Rio-Grande early, Tomato BSS-30, Swat local, and 87-5 China cultivar with 1.65, 1.55, 1.55, 1.54 and 1.51 mummies plant^{-1} were recorded, respectfully. Lowest mean number of parasitoid mummies 1.48 parasitoid mummies plant^{-1} was observed on U-Grande.

The overall time intervals revealed that, first parasitoid mummies was first recorded on 28th April with mean number of 1.14 mummies plant^{-1}. Parasitoids mummies population boosted as time proceed onward. The highest (3.52 mummies plant^{-1}) were counted at 5th week (12th May) after that, population started to declining and the lowest (0.84 mummies plant^{-1}) was counted on 8th week (2nd June).

In all interactions, the highest (3.90 parasitoid mummies plant^{-1}) mean parasitoid mummies were observed at 5th week (12th May) on 87-5 China cultivar followed by week 5th where 3.70 and 3.60 (mummies plant^{-1}) on U-Grande and Tomato BSS-30 respectively. The lowest mean parasitoid mummies 0.50 (mummies plant^{-1}) were recorded in 8th week (2nd June) on Roma VF.

Yield data (t ha^{-1}) in cultivars without chemical application

The result in Table 6 showed that highest yield (5.70 t ha^{-1}) was obtained form 87-5 China followed by Rio-Grande late (5.58 t ha^{-1}), Roma VF (5.32 t ha^{-1}),

Table 5: *Mean Population density and Time intervals of Parasitoid mummies plant^{-1} on different tomato cultivars at ARI Mingora Swat, during the growing season of 2017.*

Time Intervals									
	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	
Cultivars	14-April	21-April	28-April	5-May	12-May	19-May	26-May	2-June	Mean
Swat Local	0.00 t	0.00 t	0.90 p-r	1.40 no	3.30 cd	3.13 de	2.30 ij	1.30 no	1.54 bc
Rio-Grande early	0.00 t	0.00 t	0.80 q-s	1.60 mn	3.50 bc	2.90 ef	2.50 g-i	1.10 o-q	1.55 bc
U- Grande	0.00 t	0.00 t	0.60 rs	1.90 k-m	3.70 ab	2.70 f-h	2.10 j-l	0.90 p-r	1.48 c
Rio-Grande late	0.00 t	0.00 t	1.10 o-q	2.10 j-l	3.40 b-d	2.50 g-i	2.80 fg	0.80 q-s	1.65 ab
Tomato BSS-30	0.00 t	0.00 t	1.30 no	2.30 ij	3.60 a-c	2.30 ij	2.40 h-j	0.70 rs	1.55 bc
87-5 China	0.00 t	0.00 t	1.20 op	1.80 lm	3.90 a	2.20 i-k	2.70 f-h	0.60 rs	1.51 c
Roma VF	0.00 t	0.00 t	2.10 j-l	2.90 ef	3.30 cd	2.10 j-l	2.90 ef	0.50 s	1.72 a
Mean	0.00 f	0.00 f	1.14 d	2.00 c	3.52 a	2.54 b	2.52 b	0.84 e	

Means followed by different letter(s) are significantly different from each other ($P \leq 0.05$); LSD for Cultivars at $P \leq .0.05 = 0.117$; LSD for Weeks at $P \leq .0.05 = 0.125$; LSD for interaction of Cultivars × Weeks at $P \leq 0.05 = 0.331$.

Tomato BSS-30 (5.15 t ha^{-1}), U-Grande (5.11 t ha^{-}1) and Swat local (4.94 t ha^{-1}), Lowest yield (4.70 t ha^{-1}) was obtained from Rio-grande early.

Table 6: *Yield of Tomato cultivars in tones/ hectare without chemical insecticides application recorded at Agriculture Research Institute ARI Mingora Swat, during active growing season 2017.*

Cultivars	Yield tons ha^{-1}
Swat Local	4.94 d
Rio-Grande early	4.70 e
U-Grande	5.11 c
Rio-Grande late	5.58 a
Tomato BSS-30	5.15 c
87-5 China	5.70 a
Roma VF	5.32 b

Means followed by different letters in column are significantly different at 5% of probability; LSD for Yield at $\leq 0.05 = 0.158$.

Field evaluation of tomato cultivars against aphids, M. persicae

The study regarding the response of different tomato cultivars towards *M. persicae*, its associated natural enemies was conducted under field condition, at Agricultural Research Institute ARI, Mingora, Swat, during growing season 2017.

The data regarding the overall mean number of aphids recorded on different tomato cultivars showed significant difference. The highest (5.40 aphids leaf^{-1}) aphids infestation were observed on Rio-Grande early, followed by Swat local, Rio Grande late, Roma VF, Tomato BSS-30 and U-Grande cultivar with 5.11, 4.67, 4.45, 4.22 and 3.72 aphids leaf^{-1}, respectfully. Lowest (3.30 aphids leaf^{-1}) mean numbers of aphids were observed on Cultivar 87-5 China. These finding are in line with co-researchers (Saljoqi et al., 2003; Alvarez et al., 2006) who also reported significant difference in population abundance of *M. persicae* on different cultivars of various crops (potato and wheat) respectively. The variation in population of aphids on different cultivars may be because of various chemical and physical factors i.e., glycoalkaloids, amino acid, nutrient level, mutation, process of evolution, transgenic events, olfactory cues, hard leaf surface/ plant tissue and trichomes etc. (Lee et al., 1999; Saljoqi et al., 2003; Alvarez et al., 2006).

Overall mean data regarding the population abundance of *M. persicae* on various time intervals indicated that, firstly the mean aphid population was low (1.64 aphids leaf^{-1}) and boosted as the time proceed onward. Highest infestation (8.21 aphids leaf^{-1}) was observed at 4th week (5th May), after that, infestation started to declining and the lowest (0.81 Aphids leaf^{-1}) mean number of aphid was recorded in week 8th (2nd June). These finding are agreed with the results of Saljoqi (2009) who reported same population pattern of *M. persicae* on potato crop. In almost all interactions, initially the aphid population was low and it increased with the passage of time. Highest mean number of aphids were recorded on most of interactions at 4th week. The decline rate of aphid infestation was observed from 4th week till the last week of data collection. These findings are also agree with (Saljoqi and Van Emden, 2003) who reported that population of *M. persicae* decrease

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due to poor foliage. Similarly, Houghes (1963), Way (1968) and Dixon (1992) also demonstrated that raise in the temperature and poor weather conditions also adversely affect the population of the aphids.

The results showed that population of natural enemies (Ladybird beetle, Green lace wing, Syrphid flies and Parasitoid mummies) was present throughout the study period in the field was highest at 4^{th} Week. After that, the population gradually decreased till last week of data collection. Similar result is founded by Saljoqi (2009), that population of natural enemies (*C. septempunctata, Chrysoperla carnea*, syrphid flies and parasitoid mummies) were highest at 4^{th} Week, after that declining occurred in the population of natural enemies till the last week of data collection in potato crop. The predation activity of *C. septempunctata* was present in the field throughout the experimental period (Rafi et al., 2005) These results are also in line with (Katsarou et al., 2005; Sausna et al., 2006) who reported that the population of lady bird beetle (larvae) is mainly depending availability of the prey (food).

The variation was founded in population of *C. carnea* where its population was started with low density and increased significantly till week 4^{th} (5^{th} May) and then declined was recorded in its population till the Week 8^{th}. Results are agree with (Minks and Harrewijin 1987; Saljoqi, 2009) who stated that fluctuation in the population of aphids and its natural enemies (*C. carnea*) in similar pattern on various crops. The population of green lace wing decreased due to unavailability their prey *M. persicae* (Pham et al., 2001).

Similarly, syrphid flies were initially recorded at 2^{nd} Week. The maximum mean number of syrphid flies were recorded at 5^{th} week and then population of syrphid flies decreased till the crop harvest (8^{th} week). Our findings are in contrast with finding of Saljoqi (2009) who reported the population of syrphid flies in similar pattern in potato crop.

The population of parasitoid mummies was first recorded at Week 3^{rd} where its mean population was low afterwards, reached to peak at 5^{th} Week and then declining recorded in population till 8^{th} week. Similar finding was stated by Saljoqi (2009) who stated parasitoid mummies increased with time may due to availability of host (Aphids) and then their population decreased due to unfavorable environmental condition and unavailability of the host.

The highest yield (5.70 t ha^{-1}) was obtained form 87-5 China followed by Rio-Grande late (5.58 t ha^{-1}), Roma VF (5.32 t ha^{-1}), Tomato BSS-30 (5.15 t ha^{-1}), U-Grande (5.11 t ha^{-1}) and Swat local (4.94 t ha^{-1}). Lowest yield (4.70 t ha^{-1}) was obtained from Rio-grande early cultivar. Similar results regarding the yield of different varieties are also reported by Olaniyi et al. (2010) who reported significant difference in the yield of various tomato varieties. During the reproductive period the tomato yield is more effected by biotic and abiotic factor (Picanco et al., 2007). These results are also in line with Basedow et al. (2002) who demonstrated that the yield of tomato is effected by sucking insect pests.

Conclusions and Recommendations

The population of *M. persicae* was found highest on Rio Grande early cultivar while, minimum population of aphids was on 87-5 China cultivar which showed comparatively more resistance toward the aphids. All most all natural enemies population was found higher where high population of aphids was recorded and vice-versa in the studied varieties. The use of cultivars having least aphid infestation for minimizing the pest population in the field is an effective method. 87-5 China cultivar showed comparatively more resistance against *M. persicae* which can be used in IPM programs for the management of *M. persiace*. More over further investigations are needed for determining the category of resistance in 87-5 China cultivar towards the *M. persicae*.

Novelty Statement

The current research focus on use of cultivars having least aphid in-festation for minimizing the pest pop-ulation in the field is an effective method. 87-5 China cultivar showed comparatively more resistance against *M. persicae* which can be used in IPM programs for the man-agement of *M. persicae*.

Author's Contribution

Ahmad-Ur-Rahman Saljoqi: Designed experiment, technical and language check.
Imtiaz Khan: Analysed data and help in writing and editing.
Bashir Ahmad: Review the manuscript for technical and language.
Fazal Maula: Analyzed data.

Sardar Hussain: Carried out the field work.

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