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Evaluation of different potato varieties against potato aphid, *Myzus persicae* (Sulzer)

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Abstract
The present research work was conducted on population density of *Myzus persicae* (Sulzer) under field conditions and used Antixenosis and Antibiosis tests in different potato varieties against *M. persicae* under controlled conditions. Potato varieties viz, Bartina, Paramount, Karuda, Roko, Delia red and Ronaldo were arranged in Completely Randomized Block Design having three replications, while in glass house these varieties were replicated ten times in Completely Randomized Design for antibiosis and antixenosis tests. The overall mean number of *M. persicae* on different varieties revealed significant differences. Among these varieties, maximum infestation of *M. persicae* (2.7 aphids leaf^{-1}) were incurred on Delia red, followed by Karuda, Bartina, Paramount and Roko, with mean number of 2.5, 2.0. 2.0 and 1.8 aphids leaf^{-1}, respectively. Minimum mean *M. persicae* infestation (1.6 aphids leaf^{-1}) was observed on variety Ronaldo. Initially *M. persicae* population was low with mean 0.7 aphids leaf^{-1} that gradually enhanced as the time proceeded and highest infestation (3.3 aphids leaf^{-1}) was observed at 4th week (18th April). After that, decreasing trend in aphids was observed and the lowest number of aphid (1.6 Aphids leaf $^{-1}$) was recorded on 7th week (10th May). Furthermore, the maximum yield (31.93 Tons (t) /ha) was obtained from Ronaldo followed by Roko (30.50 t ha^{-1}), Bartina (29.73 t ha^{-1}), Karuda (27.45 t ha^{-1}) and Paramount (27.31 t ha^{-1}). Minimum yield, 26.61 t ha^{-1} was found on variety Delia red. Negatively significant correlation was found between aphids population and total yield production. Overall variety Ronaldo showed excellent response in reducing aphids infestation and total yield production in t ha^{-1}. In antixenosis test, none of the potato varieties revealed significant resistant towards *M. persicae*, after 12, 24 and 48 hours. In antibiosis test variety Ronaldo showed significant resistant towards *M. persicae* compared to all the potato varieties.

Keywords: *Myzus persicae*, population trend, potato varieties, antixenosis and antibiosis

1. Introduction

Potato (*Solanum tuberosum* L.) is herbaceous annul plant belongs to family *Solanacea* and genus *Solanum* and is grown in more than 100 countries, under temperate, subtropical conditions [1]. Potato is the world's most important food crop ranked 4th in production after rice, maize and wheat [8]. The total world potato production is estimated at 346.80 million tons in 2012. In Pakistan annually three potato crops are grown annually in autumn and spring in the plane areas while during summer in hilly areas. The area under cultivation of potato crop is 169.1 thousand hectares in Pakistan, while in Khyber Pakhtunkhwa the area under potato cultivation is 7.2 thousand hectares with a production of 4160.1 and 105.6 thousand tons respectively [33].

Insect pests that attack on potato crop includes wireworms, cutworms, white grubs and aphids, which adversely affect the crop yield. Among all these, potato aphid, *Myzus persicae* (Sulzer) is the most important insect pest of potato crop [40, 38]. *M. persicae* is tremendously cosmopolitan species and distributed worldwide and highly polyphagous, and having a host range of more than 400 in 40 different with families of plant, including economically important crop plants. *M. persicae* causes damage in the potato crop by causing both the direct (by sucking cell sap) and indirect losses to crop by transferring diseases dwarfing and curling the leaflets and by dwarfing and spindling the tops. The death of whole plant was also noted at many situation [7, 39]. The *M. persicae* species caused direct damage to plants by feeding on phloem sap and even cause indirect damage by transmitting several viral diseases, especially the potato virus Y (PVY), potato virus X (PVX), and potato leafroll virus [34]. The estimated yield loses by *M. persicae* 38.8-60% in spring potato crop and 7.5-15.7% in autumn in crop [24]. Twenty five *M. persicae* per three compound leaves plant^{-1} is the empirically established threshold level of this aphid on potato crop [15]. The threshold of *M. persicae* is mainly depend on the variety, the disease prevalence is associated with *M. persicae,* growth of plant stage and use of potato at the end, the threshold level may vary from 2 to 100 aphids 25 leaves^{-1} [42].

M. persicae can be controlled by various methods viz, chemical, physical, biological, host plant resistant and mechanical methods. Bio-agents can control the population of the *M. persicae* to reaches above threshold level then, but when aphids are present in large number it can be extremely injurious for the potato crop. At this point, the use of chemical is the only option for the suppression of this pest [21]. But widespread use of insecticides to control *M. persicae* and selection pressure has resulted in developing resistance to the insecticides. The development of insecticide resistant biotypes and other harmful effects of chemical control methods to the environment require alternative control strategies [30].

The use of host plant resistant is one of the alternative control methods for this aphid. Two type (antixenosis and antibiosis) of plant resistance against insects are eminent [35]. Antixenosis stimulate the variation of insect behaviour which can leads to detain acceptance and eventually the rejection of the plant as a host. Strong antixenosis present in the plant can leads to starvation of the insects. While, antibiosis resistant doesn't affect insect behaviour but can reduce in the intrinsic rate of natural increase of the populations (r_m). Antibiosis also alters its life history traits of insects [29]. Several factors in potato plants may contribute to its resistance to aphids, such as the availability of resistance factors at the mesophyll/phloem tissues or on the plant surface. In addition, the age and different parts of the plant and infection of potato crop with PLRV virus can influence the aphid population on plant. Various researchers have worked on different aspects of varietal resistance against insect pests [17, 16]. Plant resistance also varies with nutritional quality of phloem sap (primary plant metabolites) or on the amount and nature of secondary metabolites [5, 25, 18]. So far, resistance of several wild potatoes and their related accessions and also some commercial cultivars have been assessed to *M. persicae* and some of them have shown various degree of resistance to the aphid [3, 28].

The use of resistant cultivars in potato fields will help to reduce direct aphid damage and virus transmission and enhance production yield, which is valuable to develop a successful integrated pest management (IPM) programme for the potato aphid. Keeping in view the importance of potato crop and damage caused by *M. persicae*, the present study is designed, to find out the population abundance of potato aphid, *M. persicae* in different potato varieties and to determine Antixenotic and Antibiotic mechanism of resistant to *M. persicae* in the mentioned varieties

2. Materials and Methods

This experiment was conducted in the spring season potato crop at ARI Mingora Swat during, 2017. The mentioned six varieties was planted in Completely Randomize Block Design (RCBD) with three replications. Row to row distance were kept constant. Each sub plot was having four rows and ten plants. All agronomic practices were kept constant throughout the growing season. The weekly data of population density of *M. persicae* was recorded from the date of initial aphid infestation up to crop harvesting [37].

2.1 *M. persicae* population Estimate

Aphids were counted on three leaves on each tagged plant in the top, middle and bottom portion of randomly selected three plants, from each plot, avoiding the border plants. Mean aphid population leaf^{-1} was calculated at the end of the season. The data were recorded on the same plants on weekly basis.

2.2 Yield data

At the end of the season, yield data was recorded in kg/plot then converted into tones/ hectare.

2.3 Screening Assay

Potato varieties against *M. persicae* were screened to determine antixenosis and antibiosis mechanism in all tested varieties.

2.4 *M. persicae* culture

The virginoparous female *M. persicae* was collected from the potato field and ware reared on the locally grown susceptible potato variety (Desiree) under photoperiod of 14: 10 hours (L: D) at temperature of (20±1) to induce parthenogenesis.

2.5 Free Choice Test (Antixenosis)

The free choice test was conducted by using Complete Randomized Design and with 10 replications. Pots size (50cm d X 60cm h) were filled with soil, Fertilizer and Farm yard manure was be used as per requirements. Single plant of each variety was grown in circular pattern keeping the same distance from the center in a single pot. 60 aphids (same size) was collected from aphid culture with soft brush and was released on a filter paper in the middle of pot at 4-6 leaf stages of the plants. The number of aphids were counted after 12hrs, 24hrs and 48hrs interval to determine the preference and non-preference behavior of the *M. persicae* [31, 27].

2.6 Non-Choice Test (Antibiosis)

Antibiosis test was conducted by determining from the mean *M. persicae* progeny on the infected plant of each variety within replication. Seed of each variety was planted singly in separate pot (25cm height × 30cm diameter) that was arranged in a completely randomized design having 10 replications. At four to six leaf stage, a single leaf from the plant was caged. The cage was prepared from two pieces of plastic foam (0.8cm thickness and 15cm inner diameter) and a mesh of nylon on the exterior side for ventilation. The cage was closed with clips once after releasing the fourth instar aphid nymph (P1) inside a cage. Two observations of P1 aphid on each plant were made daily until its reproduction. Once the 1st nymph (F1 aphid) from the reproductive P1 was produced, its time (in days) was noted and afterwards P1 was shifted to another leaf of the same plant that was caged in the same way as mentioned earlier. Similarly, when the F1 aphid produced its 1st nymph, its time (in days) was noted and also the number of nymphs produced by P1 (M_d) were enumerated. M_d and d for each plant was considered using the formula of [6], where $r_m = 0.738 (\log_e M_d)/d$. The r_m (intrinsic rate of increase) for each plant was considered, where M_d indicate total number of offsprings of P1 the mother of F1, while (d) is the time interval of F1 aphid from birth to production of 1st nymph. The mean regression slope of md/d for four aphid species has a value of 0.738 [44].

2.7 Analysis of data

Statistix software version 8.1 was used for analysis of the data and mean were compared while using least significance difference (LSD) test $P \leq 0.05$ [19].

3. Results

3.1 Population abundance of *Myzus persicae* leaf^{-1} on different Potato varieties

Table- 1 showed the mean number of aphids, time intervals and their interaction on different potato varieties. The data of overall mean number of aphids observed on different varieties shows that maximum (2.7 aphids leaf^{-1}) were observed on Delia red, followed by Karoda (2.5 aphids leaf^{-1}), Bartina (2.0 aphids leaf $^{-1}$), Paramount (2.0 aphids leaf $^{-1}$) and Roko (1.8 aphids leaf^{-1}) variety. Minimum mean number of *M. persicae* (1.6 aphids leaf^{-1}) were recorded on Ronaldo variety. The overall mean data about the time intervals showed that, at start the mean population of *M. persicae* was low (0.7 aphids leaf $^{-1}$), and boosted as with passage of time forward and highest population (3.3 aphids

leaf $^{-1}$) was obsersved at 4th week (18th April). After that, population initiated to reduce and the lowest number of aphid (1.6 aphids leaf $^{-1}$) was noted on last week 7th (10th May).
The interaction regarding the potato varieties × time interval (Weeks) showed that highest mean aphid infestation were observed at 4th week (18th April) (3.3 Aphids leaf $^{-1}$), trailed by 3rd and 5th week (10th and 26th April) (2.7 Aphids leaf^{-1}) and least mean number of aphids (0.7 Aphids leaf^{-1}) were recorded in 1st week (25th March). Maximum aphid population (4.1 Aphids leaf^{-1}) were observed at 4th week (18th April) for Delia red and Karuda variety followed by Paramount (3.3 Aphids leaf^{-1}) 3rd week of April, while lowest number of aphids (0.5 Aphids leaf^{-1}) was observed for Paramount and Ronaldo variety at 1st week, 25th March.

3.3 Yield data (t ha^{-1})
Fig-1 showed that highest yield (31.93 Tonnes (t) /ha) was recorded for Ronaldo followed by Roko (30.50 t ha^{-1}), Bartina (29.73 t ha^{-1}), Karoda (27.45 t ha^{-1}) and Paramount (27.31 t ha^{-1}). Lowest yield (26.61 t ha^{-1}) was found on variety Delia red.

3.4 Correlation of Population abundance of *M. persicae* with Potato Yield
Correlation analysis between Aphids and yield of different varieties are present in table-2. Results showed significant negative relation with r^2 =0.8812.

3.5 Antixenosis
In antixenosis test, no significant difference among the tested potato varieties was observed after 12, 24 and 48 hour post infestation period. There was no antixenosis resistance in the tested potato varieties against *M. persicae*. However highest number of *M. persicae* was attracted to Ronaldo variety and lowest number was attracted to Bartina variety.

3.6 Antibiosis
In total progeny production (Table-3), Minimum number (22.2) of progeny were produced by aphid on variety Ronaldo. *M. persicae* produced (26.4) on variety Roko, (29.3) on variety Bartina and Paramount and (37.7) of progeny on variety Karoda. While maximum number (40.8) of progeny were produced on variety Delia red and Karoda.
In pre reproduction time (days) maximum days (7.89) were taken by *M. persicae* on variety Ronaldo to produce its first off spring. It was followed by 7.8 days on variety Roko, 7.3 days on variety Bartina and 6.7 days on variety Paramount. While minimum number of days (6.3) were taken by *M. persicae.*
The rate of intrinsic increase (r_m) values of *M. persicae* indicated significant differences among the tested varieties. The lowest r_m value was recorded on variety Ronaldo (0.12), trailed by Roko (0.13), Paramount (0.16) and Bartina (0.17), while highest r_m (0.18) was recorded on variety Karuda and Delia red.

4. Discussion
A research study was carried out to investigate the population abundance of *M. persicae* under field condition and to test antixenotic and antibiotic properties of different potato varieties under controlled environment at Agricultural Research Institute (North), (ARI) Mingora, Swat, during spring, 2017.
Throughout the globe potato is cultivated for food and feed concern and it also carriages a substantial economic status due to its nutritious and therapeutic value [20].
The main risk to agriculture globally is insect pest that cause vast yield and financial losses in potato each year. *M. persicae* is the key insect pest of potato crop which causes huge yield losses in potato crop by suckling directly on cell sap and spreading viral disease [10].
In the recent research, overall mean number of *M. persicae* on mentioned different varieties showed significant difference among each other. The maximum aphids infestation (2.7 Aphids leaf^{-1}) were observed on Delia red, trailed by Karoda, Bartina, Paramount and Roko (2.5, 2.0. 2.0 and 1.8 Aphids leaf^{-1}), and minimum mean number of (1.6 Aphids leaf^{-1}) infestation were observed on Ronaldo. Similar results was founded by [1] who recorded population of aphids on different potato varieties at weekly intervals throughout the growing season and they observed significant differences in their tested varieties. [36] founded that population of *M. persicae* significantly increased during the first four weeks. *M. persicae* was first recorded when its density was 0.61 aphids leaf^{-1} and then population steadily increased with significant differences till 3rd week march with 4.22 aphid leaf^{-1}. Population density of *M. persicae* was highest during the 4th week after which it declined.
In the present study population abundance of *M. persicae* at different time interval on different potato varieties showed a significant difference between potato varieties. In the early weeks of scrutiny the mean number of aphids was recorded low, as time proceed the mean number of aphids incidence were improved and highest 3.3 aphids leaf^{-1} was observed on the 4th week. After that mean infestation started to decrease and lowest population was recorded on week 7th May (2nd week). Ronaldo variety showed admirable response against aphids. The results are similar with the finding of [36] found that the aphid population increased with time till week 4th, where the highest population was recorded. Afterwards the pest population declined, perhaps due to poor foliar growth, very high temperature (30-38 °C) and bad weather conditions. These results settle with those of [37, 44, 22] who stated that plants become incompatible for aphids, either by maturing or by the injury inflicted by the insects and therefore multiplicative rate of the pest population declines. [9, 42] reported that adversarial changes in food quality and weather could result in very deprived existence of aphid.
In the present study regarding total yield showed significant difference among the varieties, the highest yield (31.93 Tonnes (t) ha^{-1}) was found on variety Ronaldo followed by Roko (30.50 t ha^{-1}), Bartina (29.73 t ha^{-1}), Karoda (27.45 t ha^{-1}) and Paramount (27.31 t ha^{-1}). Least yield (26.61 t ha^{-1}) was found on variety Delia red. The results of present studies are in conformity with the finding of [14] who stated that various potato cultivar significantly different from each other in regarding yield in t ha^{-1}. The results also agree with the finding of [26] who reported varietal yield response in regard with the aphid infestation are significantly different among the potato varieties.
In the current study it was examined that aphid infestation showed negative significant correlation (r^2) with the yield. Similar results were found in a field trail by [11] who reported significantly relation for yield with *M. persicae*.
In antixenosis test, none of the tested potato variety showed significant antixenotic resistant towards against *Myzus*

persicae. This correlates to the work done by [31] investigated potato cultivars for resistance components and finding none of the tested cultivars having antixenoses resistance. However, highest number of *M. persicae* was attracted to Ronaldo variety and lowest number was attracted to Bartina variety. Several morphological and chemical traits such as trichomes on the plant surface or the toughness of the epidermic tissues and the presence of chemical compounds in the sieve tubes may influence the host acceptance by aphids [40, 13, 4].

In current anitibiosis test, total progeny production of *M. persicae* on different potato varieties are significantly different among the tested varieties, Minimum number (22.2) of progeny were produced by aphid on variety Ronaldo. While maximum number (40.8) of progeny were produced on variety Delia red and Karoda. Similar results was founded by [35, 31] revealed significant difference in progeny production of aphids on different potato varieties.

The pre reproduction time (days) of *M. persicae*, are significantly different among the varieties. Maximum days (7.89) were taken by *M. persicae* on variety Ronaldo to produce its first off spring. Followed by 7.8 days on variety Roko, 7.3 days on variety Bartina and 6.7 days on variety Paramount. While minimum days (6.3) were taken by *M. persicae.* The rate of intrinsic increase (r_m) values of *M. persicae* indicated significant differences among the tested varieties. The lowest r_m value was recorded on variety Ronaldo (0.12), followed by Roko (0.13), Paramount (0.16) and Bartina (0.17), while highest r_m (0.18) was recorded on variety Karuda and Delia red. Corresponding findngs was stated by [38, 31, 2] who reported significant diffrernce among the developmental time, fecundity and adult longevity of the *M. persicae* on different potato cultivars.

In the present research study, Ronaldo variety showed admirable response in minimizing aphids population and in yield production. Negative significant correlation was detected for aphid infestation with the yield. During the antixenosis test none of the potato variety carried significant resistance, however regarding antibiosis test, variety 'Ronaldo' has shown high resistance to *M. persicae* among all the tested potato varieties.

Table 1: Effect of the Potato varieties, Time intervals (weeks) and their interaction on the average number of *Myzus persicae* (Sulzer) leaf^{-1} in different Potato varieties at the Agricultural Research Institute (North) Mingora Swat, during spring 2017

	# of Aphid leaf^{-1}							
Varieties	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**Mean**
	25-Mar	**02-Apr**	**10-Apr**	**18-Apr**	**26-Apr**	**03-May**	**10-May**	
Bartina	0.7 tu	1.8 kl	2.4 gh	3.0 de	2.7 f	1.8 klmn	1.6 nop	2.0 c
Paramount	0.5 u	1.3 pqrs	2.7 f	3.3 bc	2.8 ef	1.9 kl	1.7 lmno	2.0 c
Karoda	0.8 t	2.2 hi	3.1 cd	4.1 a	3.1 cd	2.2 hij	1.8 klm	2.5 b
Roko	0.6 tu	1.5 nopq	2.2 hij	2.8 ef	2.3 hi	1.6 mnop	1.3 pqrs	1.8 d
Delia red	1.1 s	2.7 ef	3.5 b	4.1 a	3.1 cd	2.2 hij	2.0 jk	2.7 a
Ronaldo	0.5 u	1.3 qrs	2.0 ijk	2.7 fg	2.3 h	1.4 opqr	1.2 rs	1.6 e
Mean	0.7 e	1.8 c	2.7 b	3.3 a	2.7 b	1.8 c	1.6 d	

Means followed by different letter(s) are significantly different from each other ($p \leq 0.05$)

LSD for Varieties at $p \leq 0.05$ = 0.102

LSD for Weeks at $p \leq 0.05$ = 0.110

LSD for interaction of Varieties × Weeks at $p \leq 0.05$ = 0.271

Table 2: Correlation of *M. persicae* with yield of different varieties of Potato plant at Agricultural Research Institute (North) Mingora swat, during spring 2017

Correlation variable	r^2	P-Value
Aphids Density vs potato Tuber yield	-0. 8812	0.0203

Significant at 5% level of probability.

Table 3: Mean values of pre-reproductive period (days), progeny produced (M_d) and rate of natural intrinsic increase (r_m) of *Myzus persicae* (Sulzer) on different potato varieties

Varieties	Pre-reproduction time (days)	Total progeny production (M_d)	Rate of Intrinsic increase (r_m)
Bartina	7.3 b	29.3 d	0.17 a
Paramount	6.7 c	31.3 c	0.16 a
Karoda	6.3 c	37.7 b	0.18 a
Roko	7.8 a	26.4 e	0.13 b
Delia red	6.3 c	40.8 a	0.18 a
Ronaldo	7.9 a	22.2 f	0.12 b
LSD	0.4710	1.4534	0.0293

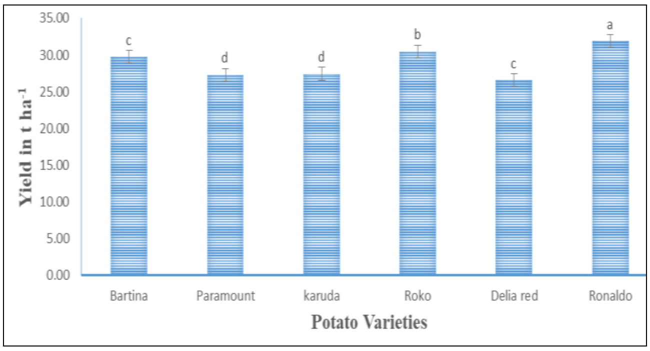

Fig 1: Yield Potato varieties in tones / hectare recorded at Agricultural Research Institute (North) Mingora swat, during spring 2017

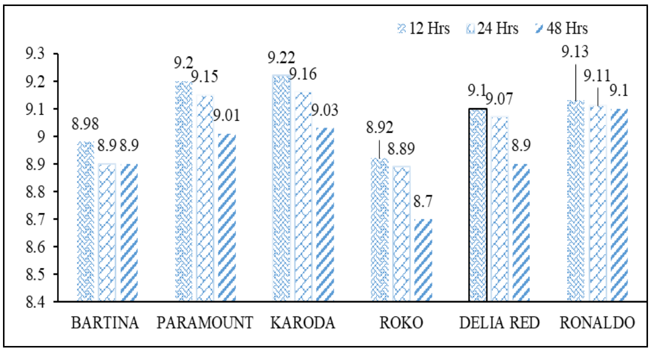

Fig 2: Mean number of aphid, *Myzus persicae* (Sulzer) on different potato varieties at 12, 24 and 48 hours in the antixenosis test in the controlled laboratory condition

5. Conclusions and Recommendation

Conclusions

M. persicae mostly attacked on Delia red variety due to its most preference by aphid while Ronaldo variety showed least preference to aphid attack. In field highest total yield (t /ha) was recorded on variety Ronaldo. Negatively significant correlation was found between aphid infestation and total yield. In antixenosis test, none of the potato variety showed significant resistant. In antibiosis test variety Ronaldo showed significant resistant compared to all the tested potato varieties.

5.2 Recommendations

Uses of resistant variety is effective method for the suppression of pest population. It is recommended to be evaluated in the all other vegetable /fruits /field crop for the management of insect pest population. Variety Ronaldo showed comparatively more resistant which can be combine in IPM programes for the suppression of *M. persicae* infestation.

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7. References

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