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Role of Plant Morphological Characters towards Resistance of Some Cultivars of Tomato against Phytophagous Mites (Acari) Under Green House Conditions

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Abstract

Tomato, (*Lycopersicon esculentum* Mill) belongs to the family Solanaceae. In Pakistan, tomato crop is attacked by different sucking pests, which ultimately reduce yield to a considerable extent. Among these sucking pests, phytophagous mites are important which causes losses to the tomato crop. The host plant characters affect the magnitude of losses by the phytophagous mites. Therefore, experiment was conducted to find out the effect of different morphological characters, viz., leaf area, leaf hair density, thickness of leaf lamina, hair length, moisture percentage of leaf, plant height, number of leaves/plant of six tomato verities (Money maker, Sahel, Jury, Sweety, Heem Sona and Lyco SS) on mite population. The results proved that Money Maker is a resistant variety against phytophagous mites while Heem Sona & Lyco SS are susceptible varieties. It is concluded that no single factor is responsible in mite population fluctuation but all these factors work in compliment with each other. Thus morphological characters are very important in affecting the mite population.

Key word: *Lycopersicon esculentum* Mill, resistance, phytophagous mites

Introduction

Tomato, (*Lycopersicon esculentum* Mill) is one of the prominent vegetable crops grown all over the world grown under tropical and sub-tropical regions. Tomato is an important vegetable crop of Pakistan and is cultivated over an area of 47.1 thousand hectare with a total production of 502.3 thousand tons (Anonymous, 2007) which is very low as compared to other countries of the world. Tomato is rich source of nutrition. 100 g of tomato contains 0.9 g of proteins, 3.6 g of carbohydrates, 48 mg of calcium, 20 mg of phosphorous, 27 mg of ascorbic acid, 0.4 mg of irons, 0.2 g of fat, 0.5 g of minerals, 0.8 g of fibers, 351 mg of Carotenes, 0.12 mg of Thiamine, 0.06 mg riboflavin, 0.4 mg of Niacin and 20 K cal of energy (Goplan *et a.*, 1980). Tomato is the versatile commodity and can be used in fresh form like salad and processed form like tomato-ketchup, tomato paste and tomato puree (Nielsen, 1994). Tomatoes are very helpful in healing wound because of the antibiotic properties found in ripe red fruit (Conn and Stumph, 1970). Tomatoes and Chillies are the good source of vitamin C (Shammugavelu, 1989).

There are many factors of low yield including pest complex. Mites are one of them. Mites are minute arthropods, small in size, belonging to the order Acrina, sub class Acari of the class Arachnida. They are biologically most diverse and abundant arachnids and worldwide in distribution. They infest particularly cultivated crops, vegetables, fruit plants, ornamental plants, forest trees, shrubs and wild vegetation (Evans 1992).

Phytophagous mites belonging to the families Tetranychidae, Tenuipalpidae, Transonamidae and Eriophyidae cause serious damage to agricultural crops, fruit plants and vegetables. These mites suck the cell sap with the help of their needle like cheliceral stylets. Their feeding results in stippling, blotching or bronzing of leaves which is generally followed by leaf falls, early dropping of fruits, thus affecting quality and quantity of products (Evans, 1992). Their attack results in premature fruit dropping and small sized fruits with low yield (Jeppson *et al*. 1975).

The indiscriminate use of pesticides has not only caused the resistance in phytophagous mites (Campos and Omoto, 2002) but also has polluted the environment. Integrated pest management is the solution to the problems of resistance and environmental pollution. Use of resistant verities is a component of I.P.M. Morphological characters are very important in affecting the mite population. Plant characters are known to contribute towards host plant resistance (Rebe *et al*., 2004).

Correlation between mites population and physico-morphic plants characters has been reported by several investigators Pavlova and Egamberdiev,

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1990; Warabieda *et al.*, 1997; Ricci and Capelletti, 1998; Krips *et al*., 1999; Saber and Momen, 2005).

Keeping in view the importance of these mites as important agent of serious losses to vegetables and others field crop, the project in hand was taken up to explore the morphological plant characters affecting mite population for giving first hand knowledge to the breeders. For this purpose different morphological plant characters of tomato varieties viz., (Money Maker, Sahel, Jury, Sweety, Heem Sona and Lyco SS) were studied.

Materials and Methods

The present study was conducted to determine the role of plant morphological characters viz., leaf area, leaf hair density, thickness of leaf lamina, hair length, moisture percentage of leaf, plant height, number of leaves/plant on six tomato verities (Money maker, Sahel, Jury, Sweety, Heem Sona and Lyco SS) on mite population. The experiment was conducted during 2008-2009. The nursery was transplanted on 20-11-2008 following Randomized Complete Block Design (RCBD), replicated thrice, with plot size of 2.5m x 2.5m in the experimental area of vegetable section at Ayub Agricultural Research Centre (AARI) Faisalabad under green house conditions.

Count for Mite Population

Data on per leaf adult and nymphal population of mite was recorded early in the morning at weekly intervals, from each replication (plot) of each treatment. Three plants were selected at random from each plot their number of leaves and their height was determined with the help of meter rod in cm.

The population of mite was counted on leave randomly selected from upper, middle and lower portion of the plants. Hand lens was used to note the population of mites. A total of ten observations regarding the population of mite were taken during the course of study. The leaf area (cm^2) was calculated with the help of leaf area meter. The number of hairs on midrib, veins and leaf lamina were counted from the lower side of the leaves with the help of CARL ZEISS binocular microscope from three different places of each leaf. An iron made dye of 1 cm^2 was used to cut the sample.

Length of hair was recorded from midrib, veins and lamina of each leaf. Three samples of hairs each from midrib, veins and leaf lamina of each leaf were taken into account. A sample of hair was pealed off with the help of fine razor and mounted on a microscopic slide in glycerin. The slide was observed under a binocular microscope to determine the length of hair by using an ocular micrometer. At last, factor for ocular micrometer was calculated with the help of stage micrometer. Then this factor was multiplied with the number of divisions recorded from each sample of hair. A cross section of leaves was cut with the help of a fine razor and thickness of leaf lamina was determined from three different places of each leaf with the help of an ocular micrometer under a binocular microscope.

Three samples of 100 grams leaves from upper, middle and lower portions of three different plants were collected from each plot for estimation of moisture percentage in leaves. All the leaves were cleaned with muslin cloth, weighed, classified and kept in a drying oven, running at 70 ± 5 °C for 12 hours. Before keeping in oven the leaves were dried in shade for two days. The dry matter of leaves was weighed and put back into the oven, at the same temperature for another six hours. When the weight of dry material became constant, the moisture percentage was calculated with the help of following formula:

$$\text{Moisture \%age} = \frac{\text{Wt. of fresh leaves} - \text{Wt. of dry leaves}}{\text{Wt. of fresh leaves}} \times 100$$

Statistical Analysis

The data were analyzed by using Stat Package (Statistica). Means were compared by Duncan Multiple Range (DMR) test at 5% level of probability Simple correlation was worked out between mite population and plant morphological characters viz., leaf area, leaf hair density, thickness of leaf lamina, hair length, moisture percentage of leaf, plant height, number of leaves/plant, leaves dry weight.

Results

Leaf Area

The growth behavior of a plant is determined by its leaf area index. Statistically analyzed data pertaining to leaf areas were indicated in (Table-1) which depicted that highly significant differences (F= 113.59, df= 5, P < 0.001) were found to exist among various cultivars of Tomato. Comparison of means revealed that Money Maker (106.58) had maximum leaf area which differed significantly from all other cultivars. Sahel and Jury cultivars showed no significant differences having leaf area 91.25, 82.64, respectively. Jury and Heem Sona (76.13) also showed no significant difference. On the other hand, Lyco SS (57.07) showed significant difference from other cultivars. Minimum leaf area was observed on Sweety (45.00) which is also significantly different from all other cultivars.

Moisture % Age

Moisture %age constituting major portion of the total leaf biomass influence the mite pest activity. It was clear from data pertaining to moisture % age in leaf that no significant differences existed between various cultivars of Tomato as exhibited by (Table-1). The maximum moisture %age (87.44) was found

Table 1 comparison of means of the data regarding the leaf area (cm^2), moisture percentage, thickness of leaf lamina (µm), no. of leaves/ plant, plant height, leaf hair density (cm^{-2})and leaf hair length (µm) in different cultivars of tomato.

Cultivars	Leaf area (CM^2)	Moisture percentae of leaves*ns	Thickness of leaf lamina (µm)	NO. of leaves/ plant	Plant height	Leaf hair density cm^{-2}	leaf hair length µm
Money Maker	106.58a	82.38	128.32a	48.22a	91.33a	850.00a	24.43bc
Sahel	91.25b	83.50	95.54bc	40.55b	87.11a	646.44b	28.04a
Jury	82.64bc	84.22	102.49b	39.89b	90.11a	343.00d	25.54ab
Sweety	45.00e	87.44	82.49d	33.88d	66.78c	519.33c	18.32e
Heem Sona	76.13c	82.61	103.88b	37.22c	74.44b	532.55c	22.21cd
Lyco SS	57.07d	79.11	88.05cd	40.44b	70.11bc	292.89d	19.99de

Means sharing similar letters in the same column are not significantly different by LSD Test at P=0.05

Table 2 Mite population on different cultivars of Tomato for different weeks during 2008-2009

Cultivars	Mite population on tomato for different weeks									
	1*ns	2	3	4	5	6	7	8	9	10 *ns
Money Maker	0.00	0.00b	1.55c	3.10b	3.99c	4.00b	6.89b	4.44b	4.00b	1.22
Sahel	1.55	1.22ab	2.55bc	2.77b	3.77c	6.22ab	8.22ab	6.44bc	5.44b	2.44
Jury	1.55	2.33ab	3.88ab	4.88b	5.40b	5.89ab	8.55ab	7.78abc	3.78b	1.11
Sweety	1.00	1.88ab	3.55abc	4.55a	6.40ab	6.77ab	9.55ab	7.11abc	4.66b	1.11
Heem Sona	1.00	3.21ab	3.88ab	4.33ab	7.30a	6.44ab	11.33a	9.11ab	7.22ab	1.89
Lyco SS	2.11	4.22a	4.77a	5.11a	6.30ab	8.55a	12.22a	10.89a	9.11a	1.67

Means sharing similar letters in the same column are not significantly different by LSD Test at P=0.05

Table 3 Correlation matrix between different morphological characters and mite population

Morphological Characters	Leaf Area	Moisture contents	Thickness of leaf lamina	Leaf/ Plant	Plant Height	Leaf Hair Density	Leaf Hair Length	Mites Population
Leaf Area	-							
Moisture contents	-0.217	-						
Thickness of leaf lamina	0.876*	-0.221	-					
Leaf/Plant	0.825*	-0.499	0.838*	-				
Plant Height	0.919**	-0.057	0.738	0.733	-			
Leaf Hair Density	0.661	0.188	0.679	0.553	0.457	-		
Leaf Hair Length	0.833*	-0.084	0.478	0.513	0.888**	0.36	-	
Mites Population	-0.707444	-0.414651	-0.660516	-0.558343	-0.729865	-0.82335	-0.54429	-

in Sweety followed by Jury (84.22), Shael (83.50), Money Maker (82.38), Heem Sona (82.61) and Lyco SS (79.11).

Thickness of Leaf Lamina

Thickness of leaf is a character that contributes towards resistance and hence effects the mite pest population. It was obvious from data packed in the (Table 1) that differences in thickness of leaf lamina were found to be highly significant (F= 41.02, df= 5, P < 0.001) among various cultivars. Maximum thickness of leaf lamina (µm) was recorded on money maker (128.32 µm) which was statistically different from all other cultivars of Tomato. Sahel (95.54 µm), Jury (102.49 µm) and Heem Sona (103.88 µm) were not significantly different from each other. Similarly Sweety (82.49 µm) and Lyco SS (88.05 µm) were not significantly different. Sweety is the cultivar bearing minimum thickness of leaf lamina (82.49 µm) differed significantly from all other tomato cultivars.

Number of Leaves/Plant

Out of various parameters contributing towards final yield of a crop, the number of leaves/plant is of prime importance. It was evident from the data presented in the (Table 1) that number of leaves per plant were found to be highly significant(F= 79.29, df= 5, P < 0.001) among various cultivars of tomato. The comparison of means revealed that the maximum numbers of leaves were recorded in money maker (48.22) which was not matchable to any other cultivar. It was followed by Sahel (40.55), Jury (39.89) and Lyco SS (40.44) which were statistical at par. Minimum numbers of leaves were observed on Sweety (33.88) which was statistically different from other cultivars.

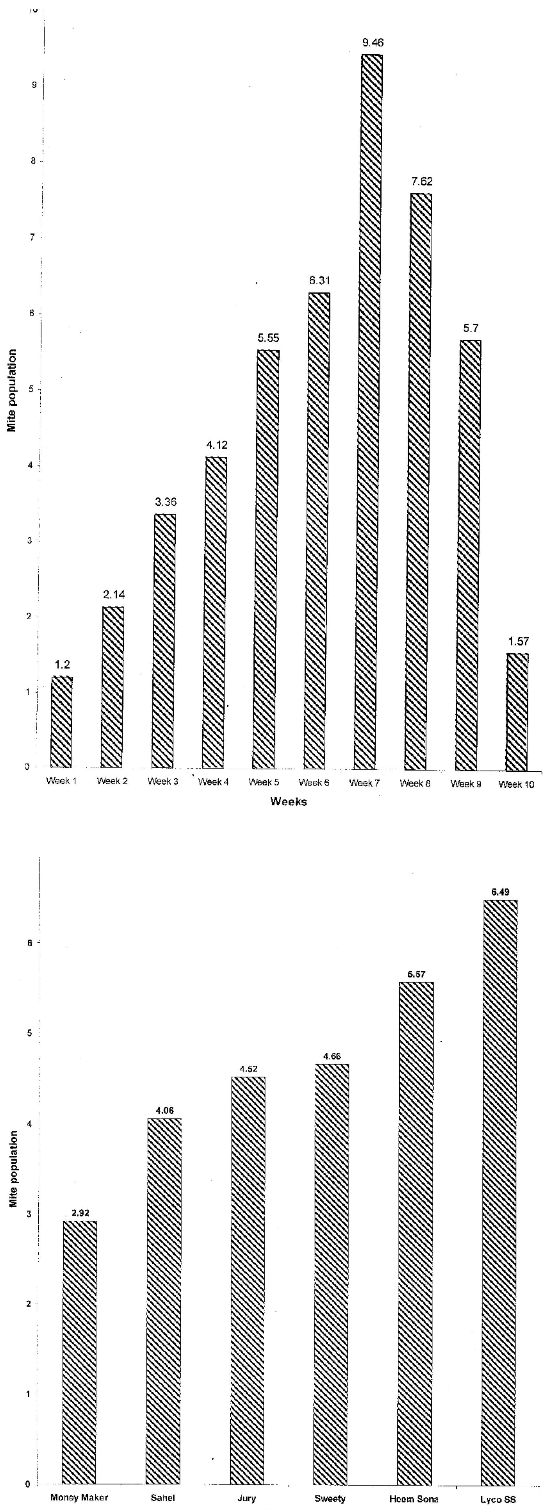

Fig. 1 Mite Population in different weeks

Plant Height

The growth behavior of the plant is largely reflected by plant height which ultimately contributes to final yield of a plant. Statistical results of data pertaining to plant height (cm) were presented in the (Table 1) which depicted highly significant differences (F= 147.06, df= 5, P < 0.001) among various cultivars of tomato. The cultivar Money Maker was ranked 1^{st} in having maximum plant height (91.33 cm) which did not differ from Sahel (87.11 cm) and Jury (90.11 cm). They were followed by Heem Sona (74.44 cm) and Lyco SS (70.11 cm) which also showed non significant difference from each other. The minimum plant height was recorded in Sweety (66.78 cm) which was statistically different from other cultivars.

Leaf Hair Density cm^2

Hair density plays a significant role in fluctuation of the population of mite pest population as it hinders their feeding. The analysis of variance (Table 1) of data regarding hair density on leaf cm^2 of different cultivars of tomato depicted significant differences (F= 282.74, df= 5, P < 0.001) among cultivars. Money Maker (850.00 cm^{-2}) possessed maximum number of hairs which differed significantly from all other cultivars. It was followed by Sahel (646.44 cm^{-2}) which also significantly differed from other cultivars. The cultivars Heem Sona (532.55 cm^{-2}) and Sweety (519.33 cm^{-2}) were found to be non-significant from each other similarly Jury (343.00 cm^{-2}) and Lyco SS (292.89 cm^{-2}) were also found to be non significant, where as Lyco SS showed minimum leaf hair density and significantly different from all other cultivars of tomato.

Leaf Hair Length

Length of hair on tomato leafs has immense importance in resistance process and impairing mite pest population as they become unable to take their mouth parts at the feeding sites. The data regarding length of hair µm on leaf are packed in Table 1). It was clear from the table that highly significant differences (F= 31.67, df= 5, P < 0.001) were found to exist among various cultivars of tomato. The maximum length of hair was observed in Sahel (28.04 µm) which did not differ significantly from Jury (25.54 µm). It was followed by Money Maker (24.43 µm) which differed fromm Heem Sona (22.21 µm), Lyco SS (19.99 µm) and Sweety (28.32 µm). The minimum length of hair (18.32 µm) was observed in Sweety which did not significantly different from Lyco SS.

Mite population in different weeks

Mite population varied during different weeks from 25-02-09 to 29-04-2009 (table 2).Mite population at 25-02-2009 on different cultivars of Tomato showed non-significant differences during first week (F= 1.41, df= 5, P < 0.300), 4^{th} week(F= 1.92, df= 5, P < 0.177), and 10^{th} week(F= 1.21, df= 5, P< 0.371), among all the cultivars of tomato. On the other hand, mite population varied significantly (P < 0.01) during 2^{nd}, 3^{rd}, 5^{th}, 6^{th}, 7^{th}, 8^{th} and 9^{th} week among all the cultivars of tomato.

Overall mite population varied during different weeks (Fig. 1. The maximum mite population was observed during 7th week (9.46) which is significantly different from all other weeks followed by week 8th which is also significantly different. Week 5th, 6th and week 9th showed non significant differences having (5.55), (6.31), and (5.70) respectively. Week 3rd and week 4th also showed non significant difference having (3.36) and (4.12), respectively. Week 1st, 10th and 2nd, and also showed non significance difference having per leaf mite population (1.20), (1.57) and (2.14), respectively. Minimum population was observed during first week which is significantly different from all other weeks.

Different cultivars of Tomato showed resistance against mite population due to their morphological characters. Data in the Fig. 2 depicted that highly significant differences ($P < 0.001$) were found to exist among various cultivars of tomato against mite population comparison of means revealed that Lyco SS had maximum population (6.49) which differed significantly from all other cultivars of tomato. Sahel, Jury and Sweety showed non significant differences having mite population 4.06, 4.52, 4.66, respectively. Heem Sona also showed significant difference having value 5.57. The minimum population was observed in Money Maker 2.92 which is significantly different from all other cultivars.

Mite population on different cultivars of Tomato for different weeks during 2008-2009 and their interaction

Highly significant differences were recorded in mite population on different tomato cultivars ($F= 36.06$, $df= 5$, $P < 0.0001$). Similarly highly significant population differences were recorded in different weeks ($F= 104.62$, $df= 9$, $P < 0.0001$). Interaction between different cultivars and weeks also showed highly significant differences ($P < 0.002$) in mite population while non significant differences were found among replications ($F= 2.86$, $df= 2$, $P = 0.06$)

Correlation matrix between different morphological characters and mite population

The results showed that mite population significantly varied on different tomato varieties. Correlation matrix (Table 3) between different morphological characters against mite population revealed that leaf area showed negative correlation matrix against mite population. The small leaf area is normally ideal for mite population because they do not prefer to cover the long distances in order to get their food. The moisture content also had negative correlation with mite population. Similarly, thicknesses of leaf lamina and plant height represent negative correlation with mite population.

The length of leaf hair also showed negative correlation with mite population which means that long hairs are not preferred. Long hair also produces hindrance in mite movement.

Discussion

The study was carried out to determine the role of morphological characters viz., leaf area, moisture percentage, thickness of leaf lamina, no. of leaves/plant, plant height, leaf hair density (cm^2), leaf hair length and plant height on six tomato varieties (money maker, Sahel, Jury, Sweety, Heem Sona, Lyco SS on mite population. The results exhibited that all the cultivars showed highly significant and some non significant differences against mite population. The population of mite ranged from 2.92-6.49 per leaf bases. The cultivar Lyco SS were found to be susceptible having maximum mite population 6.49 per leaf and cultivar money maker were found to be tolerant having minimum mite population 2.92 per leaf. The morphological plant characters viz., leaf area, moisture % age, thickness of leaf lamina, no. of leaves/plant, plant height, leaf hair density (cm^{-2}), leaf hair length and plant height differ highly significant among various cultivars of Tomato. The results correlation between morphological plant characters and mite population reveals that most of the combinations were found to be non significant and negative correlation was determined between morphological plant characters and mite population.

The result regarding correlation between morphological plant characters and mite population revealed that most of the combinations were found to be non significant. Mite population showed negative correlation with leaf area. Minimum leaf area is an important plant factor having significant influence on mite population. The large leaf area in cultivars has a negative influence while small leaf area has positive influence on mite population. This may be due to the fact that mite has to travel large area for mating which is not preferred by mite, Krips *et al*. (1999).

Moisture %age also showed negative correlation with mite population. But it does not play a significant role in mite population. The moisture %age of leaf had influenced all stages of *Tetranychus urticae*. These results are in agreement with the findings of Olouni-Sadeghi *et al*. (1988).

Leaf thickness is also very important factor influencing mite population and showed significantly negative correlation with mite population (-0.6605). The results agree with Saber and Momen (2005) who reported that leaf toughness and thickness are very important factors, which affect the reproduction and development of mite population.

Mite population also showed negative correlation with number of leaves/plant and plant height. These results can not be compared with any of the workers because they did not work out correlation between number of leaves/plant and mite population.

It was observed during the course of study that cultivars having maximum number of leaves/plant height showed minimum mite population.

Leaf hair density plays a prominent role in mite population. Mite population showed negative correlation with hair density (-0.8233). These results showed that mites did not prefer hairy leaves which create hindrances. Hairy leaves also restrict the movement of mite. Same type of results were reported by Krips *et al*. (1999) who are of the opinion that walking speed of *Phytoseius persimilis* (Phytoseidae: Acarina) was the highest on the cultivars with lowest leaf hair density. According to Price *et al*. (1980) the leaf features such as hairiness can hinder the searching of predators and parasites. Similar results have been reported by Ricci and Capelletti (1998). The length of hair also showed highly significant negative correlation with mite population which means long hairs are not preferred by mites. Long hairs also create hindrance in searching efficiency. These results are inline with those given by Krips *et al*. (1999).

Population fluctuation of mite on different dates of observation revealed highly significant results. Maximum population was observed during 7th week in the month of April. Similar results have been reported by Haque and Akira Kawai (2002).

It can be concluded that no single factor is responsible in mite population fluctuation but all the factors work in compliment with each other. These morphological plant characters are very important in affecting the mite population.

Pavlova and Egamberdiev (1990) showed negative correlation between mite population and hair length. Mite population had also negative correlation with thickness of leaf lamina. Warabieda *et al.* (1997) observed the correlation between leaf pubescence on lower surface of apples, strawberries and spider mite population. They found that higher number of hairs on the lower surface of apple and strawberry leaves had negatively affected population density of spider mites.

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