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MORPHOLOGICAL AND BIOCHEMICAL CONSTITUENTS INFLUENCING APHIDS AND WHITEFLIES TOLERANCE IN TOMATO GENOTYPES

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Abstract

Effects of morphological and biochemical constituents on the population of sucking insect pests infesting tomato plant were evaluated. Among the twenty genotypes evaluated under field condition at different seasons (summer, kharif, rabi), it revealed that the genotypes namely BRDT-1, EC 620421, *Solanum peruvianum*, EC 538455 and *S. cheesmaniae* had minimum number of aphid and whitefly population throughout all the three seasons due to their morphological traits like more trichome density and thick stem diameter as well as the presence of biochemical attributes like phenol and tannins which were present in those genotypes at higher concentration. The higher content of leaf chlorophyll had resistance effect against the population of aphid and whitefly, while total sugar content did not have any significant effect on resistance.

Introduction

Tomato (*Solanum lycopersicon* L.) is one of the major and remunerative vegetable crops which provide an excellent amount of vitamin C and E. India ranks second in tomato production after China (FAO 2017). Tomato is attacked by large number of insect pests including sucking pests like Whitefly (*Bemisia tabaci* Genn.) and Aphid (*Aphis gossypii* Glov.) from emergence in the seed bed until its harvest. Whitefly alone can cause 10 - 90% damage depending upon the severity of the infestation and crop stage (Setiawati *et al.* 2009).

Plant metabolites play a major role in the adaptation of plants to the changing environment and in overcoming stress constraints. Earlier reports suggested that the phenols have been documented to serve as defense compound through various means such as repelling the feeding by *B. tabaci* (Hagg *et al.* 2013). The biochemical component of leaf like total phenol exhibits a negative correlation with the sap sucking insects' infestation (Helmi and Rashwan 2015). Tannins are also considered to be the most important secondary plant compounds involved in plant defense against insects and diseases (Swain *et al.* 1979). Leaf damage by whitefly have significant and negative correlation with the tannin content (Mwila *et al.* 2017). The most prominent tomato plant morphplogical characters that contribute to whitefly antibiosis are glandular trichomes (Muigai *et al.* 2002). Trichome density have negative correlation with the eggs, nymphs and adults of whitefly and that of aphid population (Taggar and Gill 2012, Amin *et al.* 2017). The identification of morphological and biochemical characteristics from insect resistant genotypes is of most practical significance. Considering the previous research findings the present investigation was undertaken to assess the morphological and biochemical traits of tomato genotypes for their relative resistance against sucking insect pests.

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Materials and Methods

The present experiment was conducted at Vegetable Research Plot, Bihar Agricultural College, Sabour during three seasons (summer, kharif and rabi 2018) under in field condition and biochemical studies was conducted in Laboratory of Horticulture, of the same college. A total of 20 genotypes of tomato were collected from various parts of India (Table 1). These were screened for their relative resistance against aphid and whitefly. The trial was laid out in Randomized Block Design (RBD) having plot size 2m x 2m with spacing of 50 cm x 50 cm and replicated thrice. The populations of whiteflies and aphids were recorded by counting the number of adults from top, middle and bottom leaves of each of ten randomly selected plants per plot during early morning hours at weekly intervals.

Morphological characteristics like stem diameter (mm) and trichome density (number per cm^2) were recorded according to the method outlined by Wagh *et al*. (2012) from five randomly selected plants in each replication. Total leaf chlorophyll (mg/g) was calculated following the method outlined by Arnon (1949).

Biochemical traits like total phenol content (mg CE/100 g fw) was estimated spectrophotometrically using Folin-Ciocalteau reagent (FCR) (Singleton *et al*. 1999), total sugar content was determined by Fehling's method (Sadasivam and Manickam 1992) and tannin was estimated by Folin-Denis method (Ram and Mehrotra 1993). The experiment was laid out in Randomized Block Design. The values of critical difference (CD) were analyzed at 5% level of significance.The analysis of variance (ANOVA) was set as explained by Gomez and Gomez (1983). After an ANOVA, mean separation was done following Duncan multiple range tests for comparison test.

Results and Discussion

There was a difference in the number of aphid and whitefly population among the different genotypes tested under field condition. It revealed that the mean number of aphids in *Solanum peruvianum* (0.59 per leaf) and EC 620421 (0.60 per leaf) showed least aphid population as compared to other genotypes, whereas, mean maximum number of aphid population was recorded with VRT-101A (0.79 per leaf) and Sun Cherry (0.78 leaf) (Table 1). In case of mean whitefly population, the minimum population was noticed in the genotypes EC 620421 (0.51 per leaf) and *Solanum peruvianum* (0.58 per leaf), whereas maximum population was observed in BRDT-3 (0.82 per leaf) and CLN 1621L (0.78 per leaf) (Table 1).

The maximum stem diameter was observed in the genotypes BRDT 3 and Arka Vikas whilst minimum stem diameter was noticed in WIR 3956 (Table 2). However, correlation study revealed that stem diameter had significant and positive correlation with both aphid and whitefly (r = **0.368 and **0.267) population (Table 3). The present findings are in conformity with the results reported by Rohilla *et al*. (1990) who found that the thickness of stem between the epidermis and phloem was positively correlated with resistance to mustard aphids.

The trichome density at upper surface indicated that there was a wide range of variation (Table 2). The maximum trichome density on upper surface was recorded in IIHR 2486 and *Solanum pimpinellifolium* while, the genotypes WIR 13708 and Sun Cherry had minimum trichome density than other genotypes. However, maximum trichome density at lower surface was recorded with the genotypes BRDT 3 and IIHR 2486 whilst the genotypes, WIR 13708 had minimum trichome density as compared to other genotypes (Table 2). Correlation study depicted that trichome density at upper and lower surface had non-significant positive correlation with aphid population ($r = 0.042^{NS}$ and 0.210^{NS}), whereas, in whitefly, it showed non-significant negative correlation ($r = -0.245^{NS}$ and -0.245^{NS}) (Table 3). The present findings are in agreement with those of Leite *et al.* (2006), who reported that the non-glandular or low density trichomes were not important for reducing aphid population. Taggar and Gill (2012) found negative correlation of trichome density with the eggs, nymphs and adults of whitefly. Bindu and Pramanik (2017) found trichome density was negatively correlated with the population of whitefly.

Table 1. Population of aphid and whitefly against different tomato genotypes.

Genotype	Mean aphid population (per 3 leaves per plant)	Mean whitefly population (per 3 leaves per plant)
Arka Vikas	0.74^{abcd}	0.70^{cdefgh}
Sel 18	0.74^{abcd}	0.64^{hi}
Superbug SPS	0.77^{abc}	0.71^{cdef}
VRT-101A	0.79^{a}	0.70^{cdefg}
WIR 13708	0.73^{cd}	0.74^{bcd}
WIR 3956	0.76^{abc}	0.64^{ghi}
Sun Cherry	0.78^{ab}	0.73^{bcd}
Arka Meghali	0.73^{bcd}	0.76^{bc}
EC 538380	0.75^{abcd}	0.75^{bc}
IIHR 2486	0.74^{abcd}	0.73^{bcd}
EC 620421	0.60^{f}	0.51^{k}
BRDT-1	0.60^{f}	0.62^{ij}
CLN 1621L	0.75^{abc}	0.78^{ab}
Pusa Rohini	0.70^{de}	0.73^{bcde}
Solanum peruvianum	0.59^{f}	0.58^{j}
S. chilenseyellow	0.73^{bcd}	0.74^{bc}
S. cheesmaniae	0.67^{e}	0.65^{fghi}
S. pimpinellifolium	0.77^{abc}	0.68^{defghi}
EC 538455	0.65^{e}	0.67^{efghi}
BRDT 3	0.78^{ab}	0.82^{a}
SEm±	0.01	0.01
CD (p=0.05)	0.03	0.04
CV (%)	3.11	3.74

Means in a column sharing same letter are not significantly different by DMR Test at $p < 0.05$.

Leaf chlorophyll was found to be highest in EC 620421 and BRDT-1, while Arka Meghali and CLN 1621L had the least content of leaf chlorophyll (Table 2). The correlation study showed that both aphid and whitefly population had significant negative correlation with total chlorophyll content (r = –0.553**, –0.569**) (Table 3). The present findings are more or less similar to the earlier findings of Helmi and Rashwann (2015), who reported that Photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) showed negative relationship with sap sucking insects.

Table 2. Morphological traits of different tomato genotypes for their relative resistance against sucking insect pests.

Genotype	Stem diameter (mm) Mean ± S.E	Trichome density (number per cm^2)		Total leaf chlorophyll (mg/g) Mean ± S.E
		Upper surface Mean ± S.E	Lower surface Mean ± S.E	
Arka Vikas	1.71 ± 0.03^{a}	111.33 ± 4.67^{f}	136.67 ± 5.77^{i}	4.22 ± 0.12^{e}
Sel. 18	1.39 ± 0.03^{cdef}	71.56 ± 2.70^{g}	88.22 ± 4.08^{jk}	2.52 ± 0.13^{gh}
Superbug SPS	1.51 ± 0.02^{bcd}	64.56 ± 2.50^{g}	80.44 ± 1.94^{k}	3.57 ± 0.10^{f}
VRT-101A	1.68 ± 0.04^{a}	66.44 ± 1.35^{g}	88.11 ± 5.25^{jk}	4.29 ± 0.04^{e}
WIR 13708	1.49 ± 0.07^{cd}	62.78 ± 1.64^{g}	74.44 ± 0.95^{k}	2.69 ± 0.04^{g}
WIR 3956	1.26 ± 0.01^{f}	97.78 ± 1.35^{f}	112.78 ± 2.44^{ij}	4.38 ± 0.08^{e}
Sun Cherry	1.41 ± 0.04^{cde}	63.22 ± 5.99^{g}	78.78 ± 5.24^{k}	2.10 ± 0.09^{h}
Arka Meghali	1.71 ± 0.03^{a}	168.89 ± 8.17^{cd}	262.89 ± 18.85^{cde}	0.87 ± 0.13^{i}
EC 538380	1.37 ± 0.07^{def}	155.89 ± 3.60^{de}	276.33 ± 9.51^{bcd}	3.91 ± 0.13^{ef}
IIHR 2486	1.33 ± 0.04^{ef}	204.00 ± 6.45^{a}	295.67 ± 7.73^{b}	5.23 ± 0.05^{cd}
EC 620421	1.46 ± 0.03^{cde}	169.11 ± 6.30^{cd}	233.11 ± 20.98^{efg}	6.68 ± 0.09^{a}
BRDT-1	1.38 ± 0.05^{def}	110.00 ± 3.40^{f}	129.44 ± 3.26^{i}	5.87 ± 0.08^{b}
CLN 1621L	1.63 ± 0.02^{ab}	155.67 ± 3.79^{de}	242.33 ± 21.63^{efg}	1.06 ± 0.09^{i}
Pusa Rohini	1.44 ± 0.11^{cde}	157.00 ± 3.67^{de}	238.78 ± 5.90^{efg}	2.73 ± 0.06^{g}
Solanum peruvianum	1.51 ± 0.06^{bcd}	146.11 ± 3.89^{e}	250.22 ± 7.90^{def}	5.69 ± 0.07^{bc}
S. chilenseyellow	1.43 ± 0.02^{cde}	141.33 ± 7.23^{e}	193.11 ± 6.83^{h}	2.82 ± 0.59^{g}
S. cheesmaniae	1.42 ± 0.04^{cde}	163.89 ± 2.35^{cd}	228.56 ± 8.09^{fg}	5.40 ± 0.16^{bcd}
S. pimpinellifolium	1.53 ± 0.02^{bc}	187.44 ± 3.19^{b}	280.78 ± 10.52^{bc}	2.73 ± 0.11^{g}
EC 538455	1.40 ± 0.03^{cde}	166.11 ± 11.08^{cd}	218.44 ± 4.15^{gh}	5.67 ± 0.19^{bc}
BRDT 3	1.77 ± 0.04^{a}	176.67 ± 5.20^{bc}	371.00 ± 5.77^{a}	5.02 ± 0.19^{d}
CD ($p = 0.05$)	0.12	14.27	25.94	0.49
CV (%)	4.83	6.58	8.07	7.77

Means in a column sharing same letter are not significantly different by DMR Test at $p < 0.05$.

Table 3. Correlation between morphological traits of tomato genotypes and sucking insect pests.

Morphological traits	Aphid	Whitefly
Stem diameter (mm)	0.368**	0.267*
Trichome density (number per cm^2) Upper surface	0.042^{NS}	-0.245^{NS}
Trichome density (number per cm^2) Lower surface	0.210^{NS}	-0.113^{NS}
Total leaf chlorophyll (mg/g)	–0.553**	–0.569**

*,** Indicate significance of values at p=0.01 and 0.05, respectively.

Total phenol content presented in Table 4 pointed out that the genotypes *Solanum peruvianum* and EC 620421 had maximum amount of leaf phenol content and the genotypes WIR 13708 and EC 528380 had minimum amount of leaf phenol content. However, correlation study revealed that the total phenol content was highly significant and negatively correlated with aphid and whitefly population (r = –0.882**, –0.748**) (Table 5). This finding is in accordance with Helmi and Rashwann (2015), who reported that the total phenol content had a negative relationship with the findings of the sucking insect infestation. Samota *et al.* (2018) reported that the total phenol content had a significant and negative correlation with the whitefly population. Yadav and Rana (2018) observed a negative and significant correlation between phenol content and mustard aphid infestation.

Table 4. Biochemical traits of different tomato genotypes for their relative resistance against sucking insect pests.

Genotype	Phenol content (mg CE/100 g fw) Mean ± S.E	Total sugar content (%) Mean ± S.E	Tannins (mg CE/100 g dm) Mean ± S.E
Arka Vikas	5.31 ± 0.12^{defgh}	4.54 ± 1.00^{bcde}	7.08 ± 0.10^{fgh}
Sel 18	3.14 ± 0.26^{hi}	6.28 ± 0.15^{ab}	6.66 ± 0.26^{h}
Superbug SPS	3.26 ± 0.53^{ghi}	6.73 ± 1.17^{a}	7.63 ± 0.13^{cde}
VRT-101A	6.19 ± 0.22^{de}	6.56 ± 0.52^{a}	7.46 ± 0.07^{def}
WIR 13708	2.41 ± 0.14^{i}	3.04 ± 0.15^{de}	7.67 ± 0.09^{cde}
WIR 3956	5.38 ± 0.16^{defgh}	6.62 ± 0.58^{a}	7.15 ± 0.14^{fg}
Sun Cherry	4.36 ± 0.93^{efghi}	3.18 ± 0.08^{de}	7.40 ± 0.05^{ef}
Arka Meghali	3.66 ± 0.13^{efghi}	5.73 ± 0.60^{ab}	6.16 ± 0.08^{i}
EC 538380	2.67 ± 0.10^{i}	3.00 ± 0.21^{e}	6.72 ± 0.10^{gh}
IIHR 2486	6.01 ± 0.17^{de}	4.66 ± 1.13^{bcde}	7.64 ± 0.06^{cde}
EC 620421	21.33 ± 0.21^{a}	2.94 ± 0.07^{e}	8.33 ± 0.08^{ab}
BRDT-1	13.54 ± 1.97^{c}	5.72 ± 0.10^{ab}	7.94 ± 0.10^{bc}
CLN 1621L	7.17 ± 0.18^{d}	5.27 ± 0.40^{abc}	6.82 ± 0.09^{gh}
Pusa Rohini	5.86 ± 0.20^{def}	5.34 ± 0.59^{abc}	7.10 ± 0.43^{fgh}
Solanum peruvianum	22.87 ± 0.67^{a}	4.89 ± 0.07^{abcd}	7.67 ± 0.08^{cde}
S. chilenseyellow	3.38 ± 0.60^{fghi}	6.27 ± 0.87^{ab}	7.62 ± 0.06^{cde}
S. cheesmaniae	14.36 ± 2.25^{c}	4.56 ± 0.14^{bcde}	7.88 ± 0.04^{cd}
S. pimpinellifolium	4.48 ± 0.24^{efghi}	3.55 ± 0.50^{cde}	7.46 ± 0.13^{def}
EC 538455	18.92 ± 0.59^{b}	3.52 ± 0.13^{cde}	8.69 ± 0.09^{a}
BRDT 3	5.71 ± 0.28^{defg}	3.19 ± 0.07^{de}	7.53 ± 0.10^{cdef}
CD (p = 0.05)	2.19	1.45	0.40
CV(%)	16.66	18.48	3.26

Means in a column sharing same letter are not significantly different by DMR Test at $p < 0.05$.

Superbug SPS and WIR 3956 were the genotypes that contained highest amount of total sugar. However, the genotypes namely EC 620421 and EC 528380 had lesser total sugar content in fruit (Table 4). Correlation study showed that the total sugar content had non-significant positive correlation with aphid population (r = 0.169^{NS}) , whereas, in whitefly, it showed non-significant negative correlation (r = -0.033^{NS}) (Table 5). The present findings are in accordance with the earlier findings of Srujana (2014), who reported that total sugars at reproductive stage had no significant influence on incidence of sucking insect pests in selected urdbean genotypes.

Table 5. Correlation between biochemical traits of tomato genotypes and sucking insect pests.

Biochemical traits	Aphid	Whitefly
Total phenol content	–0.882**	–0.748**
Total sugar	0.169^{NS}	$–0.033^{NS}$
Tannin content	–0.544**	–0.480**

*,** Indicate significance of values at p = 0.01 and 0.05, respectively.

Leaf tannin was observed to be the highest in EC 538455 and EC 620421 whereas, Arka Meghali and Sel 18 conatined the least (Table 4). Correlation study revealed that the tannin content exhibited significant negative correlation with both aphid and whitefly population whitefly (r= –0.544**, –0.480**) (Table 5). The present results are in agreement with the earlier results of Mwila *et al*. (2017), who reported that the tannin activity was significantly ($p < 0.05$) negatively correlated with leaf damage (r = –0.569), nymph count (r = –0.774) and with whitefly count (r = –0.442). Zhang *et al.* (2003) found that the aphid population was negatively correlated with the tannin content present in the leaf. Taggar *et al.* (2014) found that the tannin contents in leaves showed significant negative correlation with whitefly population (nymphs and adults). High concentration of tannins have also been reported to impart resistance to *B. tabaci* in cotton (Raghuraman *et al.* 2004).

It may be concluded that among the twenty genotypes, five genotypes namely *Solanum peruvianum*, EC 620421, BRDT-1, EC 538455 and *S. cheesmaniae* are found to be tolerant to aphid and whitefly population due to high phenol and tannin content as well as stem diameter which has significant association with aphid and whitefly population. It is evident that tolerance is conferred by combination of morphological and biochemical attributes and can be used as effective and reliable selection criteria for tolerance.

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