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Short Communication

Trichome and biochemical basis of resistance against *Tuta absoluta* in tomato genotypes

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Abstract

South American tomato moth, *Tuta absoluta*, a serious pest of tomato (*Solanum lycopersicum*) in tropics and subtropics, is rapidly spreading world over. Twenty one wild/cultivated/advanced breeding lines of tomato were screened for resistance to *T. absoluta* under greenhouse conditions (choice bioassay) and promising genotypes were evaluated further for their antibiosis activity through no choice bioassay under *in-vitro* conditions. From 21 genotypes screened, six wild accessions viz., *S. pennellii* (LA 1940); *S. chilense* (LA 1963); *S. arcanum* (LA 2157); *S. lycopersicum* (LA1257) and *S. corneliomulleri* (LA 1292, LA1274) were relatively resistant to *T. absoluta* based on mean percent damage and were further studied under *in-vitro* conditions. These genotypes recorded relatively more larval mortality, prolonged larval and pupal duration with reduced adult emergence of *T. absoluta*. Among these six genotypes, *S. pennellii* (LA-1940) showed resistance both under choice and no choice bioassays with higher number of type IV trichomes, highest total flavonoids and phenols. In general, glandular trichomes (GTs) (type I, IV, VII) showed negative correlation in different genotypes of tomato with reference to larval number/plant, percent damage and adult activity, whereas type V (non-GTs) showed negative correlation with number of larvae/plant.

Keywords: breeding, choice bioassay, glandular trichomes, larval mortality

Introduction

Tuta absoluta (Lepidoptera: Gelechiidae) is an emerging pest on tomato in different countries causing up to 100% crop loss (Desneux *et al.*, 2010; Sridhar *et al.*, 2014). Total reliance on insecticides for its management results in resistance development apart from residues (Rakha *et al.*, 2017). Wild relatives of tomato are known for insect resistance source (Oliveira *et al.*, 2009) and generally associated with the presence of different trichome types and densities (Tissier, 2012). Glandular trichomes (GT) synthesize and store secondary metabolites (Schilmiller *et al.*, 2010; McDowell *et al.*, 2011). The diversity of trichome types and chemical composition among tomato species respond differently against herbivore attack in conferring resistance (Rakha *et al.*, 2017) to *T. absoluta*. The objective of this study is to assess cultivated and wild tomato genotypes for resistance to *T. absoluta* and identification of mechanism involved.

Experimental

Tomato genotypes and choice bioassay

Twenty-one tomato genotypes (11 wild and 10 cultivated) were screened against *T. absoluta* (Table 1) in a greenhouse

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Table 1. Trichomes, biochemical parameters and incidence of *T. absoluta* on different tomato genotypes (choice bioassay)

Tomato genotypes	Accession no.	Number of trichomes/0.5 mm²				*Tuta absoluta* incidence/damage			Total phenols (mg/100 g DW)	Total flavonoids (mg/100 g DW)
		Abaxial surface		Adaxial surface		Mean no. of larvae[a]	Mean adult activity[a]	Mean % leaf damage[b]		
		NG	G	NG	G					
S. pennellii	LA-1940	0.00	33.67	0.00	27.67	0.00 (0.71)	0.20 (0.81)	0.00 (4.05)	2200	1437.9
S. chilense	LA-1960	134.33	0.00	113.33	4.67	4.13 (2.14)	1.40 (1.29)	67.00 (55.26)	1300	887.2
	LA-1963	227.00	0.33	60.33	2.67	2.73 (1.77)	0.40 (0.88)	17.30 (24.90)	1450	1235.4
	LA-1967	131.67	0.00	103.67	1.67	4.13 (2.13)	1.80 (1.44)	99.50 (88.37)	1500	1226.8
S. corneliomulleri	LA-1274	8.33	38.67	8.00	28.33	3. 80 (2.06)	1.40 (1.28)	35.00 (36.55)	1325	1154.3
	LA-1609	36.33	0.67	35.33	5.00	4.73 (2.26)	1.40 (1.29)	52.70 (46.84)	1075	832.7
	LA-1292	65.00	3.33	14.33	11.67	1.47 (1.34)	1.20 (1.17)	3.70 (11.73)	1025	884.4
S. lycopersicum	LA-1257	231.00	10.33	113.33	19.00	1.86 (1.47)	0.60 (0.99)	28.40 (32.49)	1725	1294.6
S. pimpinellifolium	LA-0397	136.33	1.33	76.33	11.33	7.00 (2.70)	3.40 (1.88)	99.80 (89.19)	1600	1036.5
S. arcanum	LA-2157	7.33	4.67	2.33	6.67	3.27 (1.94)	1.00 (1.16)	18.50 (25.68)	1400	1131.0
S. peruvianum	LA-0455	141.67	3.33	65.00	4.67	5.00 (2.32)	1.60 (1.35)	100.0 (90.00)	1704	1194.0
H-506	–	103.67	2.00	35.67	17.00	6.87 (2.69)	2.40 (1.62)	48.50 (44.36)	1350	821.5
H-501	–	121.33	2.33	70.33	27.67	4.40 (2.14)	1.40 (1.27)	41.40 (40.33)	1450	1002.4
H-410	–	106.00	4.00	39.33	43.67	5.20 (2.35)	2.60 (1.65)	42.90 (41.20)	1525	1008.2
H-418	–	99.33	6.00	58.67	14.00	3.73 (2.02)	1.20 (1.20)	46.00 (42.98)	1500	1010.0
H-407	–	80.33	1.33	30.33	12.67	3.80 (2.06)	1.60 (1.34)	45.00 (42.41)	1450	953.3
H 38–10	–	94.33	6.67	62.67	6.67	2.93 (1.80)	1.60 (1.35)	42.90 (41.19)	1775	1156.1
AVTO-1366	–	90.67	3.67	51.33	0.67	7.87 (2.79)	2.20 (1.58)	52.70 (46.84)	1450	896.6
Arka Samrat	–	119.00	20.00	11.33	82.33	7.67 (2.72)	2.40 (1.61)	59.00 (50.48)	1300	805.0
Arka Rakshak	–	111.00	14.33	31.67	42.67	9.40 (3.10)	3.80 (2.06)	63.00 (52.88)	1650	1020.4
Shivam		34.00	0.67	2.33	4.33	4.47 (2.21)	1.00 (1.11)	52.70 (46.84)	1175	885.4
SEM ±						0.10	0.11	0.48	–	–
CD ($P = 0.05$)						0.20	0.23	0.99		

G, glandular; NG, non-glandular.
[a]Values in parenthesis are square root (x + 0.5) transformed.
[b]Values in parenthesis are arcsine (x + 0.5) transformed.

at the Indian Institute of Horticultural Research, Bengaluru, India, during 2017–18. The methodology followed was as given by Maluf *et al*. (1997) and Rakha *et al*. (2017). Five plants each from 20 plants raised per genotype were screened against *T. absoluta* and were correlated with trichome types.

No-choice bioassay

The genotypes with mean damage of <40% under choice bioassay were further evaluated under controlled conditions in growth chambers (26 °C temperature and 70% relative humidity). Life stage duration of *T. absoluta* was assessed based on Rakha *et al*. (2017). Ten first instar larvae of *T. absoluta* were released on tomato leaves in petri plates in triplicate. Statistical analysis was done using analysis of variance and means were compared by duncan's multiple range test (DMRT).

Trichome and biochemical assays

Different trichomes, GT and NGT, were assessed per 0.5 mm^2 on abaxial and adaxial leaf surfaces in tomato genotypes using a scanning electron microscope (model: TM 3030 Plus, Hitachi Co., Japan). Trichome types were classified according to Luckwill (1943).

Estimation of total phenolic content in the samples was determined according to Folin–Ciocalteu's method (Singleton and Rossi, 1965) with minor modifications using gallic acid (GA) as standard. Total flavonoid content was determined according to Bao *et al*. (2005).

Principal component analysis was used to know the extent of variation among the tested tomato genotypes. Data was processed using the StatistiXL software (ver. 1.8).

Results

Choice assay

Mean *T. absoluta* larval incidence ranged 0–9.40/plant among tested genotypes. Wild genotype LA-1940 (*Solanum pennellii*) was completely free from *T. absoluta* damage. Among the cultivated genotypes, 'Arka Rakshak' had highest larval incidence (9.40/plant) and adult activity (3.80/plant). Minimum adult activity (0.20 adults/plant) was observed in LA-1940 (Table 1).

Trichome types and density

S. lycopersicum (LA-1257) showed highest NGT on both abaxial and adaxial surfaces (231.00 and 113.33 trichomes, respectively). *S. corneliomulleri* (LA-1274) had highest abaxial (38.67) and adaxial (28.33) GTs. However, in cultivated genotypes, highest GTs were on adaxial leaf surface of 'Arka Samrat' (82.33), H-410 (43.67) and 'Arka Rakshak' (42.67 trichomes) (Table 1).

NGT also varied among the genotypes studied. Type III was dominant in LA-1257 with 193.33 on abaxial surface and LA-1963 with 147.67 trichomes, whereas type V was dominant in LA-1963 with 79.33 and 40 trichomes on abaxial and adaxial surfaces, respectively. Similarly, more type V trichomes were in LA-1292 and LA-1257. Among GTs, types I and IV were dominant in LA-1274 and LA-1940, whereas type VI was dominant in LA-1292 and LA-1257.

The number of GT (type I, IV, VII) showed negative correlation in different genotypes of tomato with reference to larval number/plant ($r = -0.47$, -0.47 and -0.09), percent damage ($r = -0.32$, -0.34 and -0.23) and adult activity ($r = -0.29$, -0.31 and -0.15) and type IV showed significant role in conferring resistance.

Principal component analysis (PCA) analysis

PCA biplot parameters indicated percent larval mortality, larval duration, pupal duration and decrease in adult emergence are directly correlated. Trichomes, except for abaxial glandular, to certain extent, were negatively correlated with these characters. Genotypes LA-1274 and LA-1940 were closely associated with high content of total phenols, flavonoids and abaxial GTs. It appears that total phenols and flavonoid contents alone in leaf are not significantly related to percent decrease in adult emergence. The presence of specific compounds like tomatine *etc*. may be responsible for the observed values, which needs further confirmation.

No-choice feeding assay

Significant larval mortality of *T. absoluta* was observed in wild genotypes compared to cultivated lines and ranged from 93.33% (LA-2157) to 76.67% (LA-1257) in wild accessions and 6.67% in control. Highest larval and pupal duration were recorded in LA-1292 and LA-1940 in comparison with 'Arka Rakshak' (control). Least adult emergence (3.33%) was observed in LA-1940 (Table 2).

Discussion

Glandular and non-GTs play important role in host plant resistance by affecting the performance of herbivores (Bitew, 2018). In the current study some of the genotypes with less NGT (LA-1940, LA-1274 and LA-2157) and GT (LA-1963 and LA-1292) were more resistant to *T. absoluta*. However, some of the genotypes showed susceptibility to *T. absoluta* even with more GT/NGT indicating governance of resistance was through factors other than trichome type, density and their combination, which is in line with observations of Bitew (2018). Higher Zingiberene

Table 2. *T. absoluta* life stage parameters on tomato wild genotypes and cultivated check under no choice bioassay

Wild tomato accessions	Accession number	Mean % larval mortality*	Larval duration (d)#	Pupal duration (d)#	Decrease in adult emergence (%)*
S. pennellii	LA 1940	90.00 (78.03)[ab]	14.67 (3.89)[ab]	10.00 (3.24)[ab]	96.66 ± 3.33 (84.02)[a]
S. chilense	LA1963	80.00 (66.55)[bc]	12.50 (3.60)[bc]	9.33 (3.13)[bc]	86.66 ± 3.33 (69.30)[abc]
S. arcanum	LA2157	93.33 (84.02)[a]	13.67 (3.76)[ab]	9.33 (3.13)[bc]	93.33 ± 6.67 (81.26)[ab]
S. corneliomulleri	LA1292	90.00 (78.03)[ab]	16.33 (4.10)[a]	12.00 (3.53)[a]	93.33 ± 3.33 (78.02)[abc]
S. lycopersicum	LA1257	76.67 (63.79)[c]	13.33 (3.71)[ab]	6.33 (2.61)[d]	76.66 ± 6.67 (62.08)[c]
S. corneliomulleri	LA1274	81.67 (69.30)[bc]	14.33 (3.85)[ab]	7.67 (2.85)[cd]	83.33 ± 3.33 (66.55)[bc]
Control (cv. Arka Rakshak)	–	6.67 (13.96)[d]	9.67 (3.19)[c]	6.33 (2.61)[d]	6.66 ± 3.33 (13.96)[d]
SEM ±		4.58	0.14	0.12	5.51
CD ($P = 0.05$)		13.90	0.42	0.36	16.71

Means ± SE ($n = 3$).
In a column, figures with same alphabets are statistically at par with each other.
*Figures in parentheses are arcsine transformed values.
#Figures in parentheses are square root transformed values.

(Azevedo *et al.*, 2003), 2-tridecanone (Maluf *et al.*, 1997) were identified as major factors responsible for *T. absoluta* resistance in tomato.

The genotypes LA-1940, LA-1963, LA-2157 and LA-1292 are useful for resistance breeding against *T. absoluta*. LA-1940 showed tolerance both in choice and no choice bioassays with higher total flavonoids, phenols, type IV trichomes and resulted in minimum *T. absoluta* adult emergence (Table 1). LA-1963, though have higher NGT, have higher phenols and flavonoids. Environmental factors affect the development of GTs and compounds associated with insect resistance (Wilkens *et al.*, 1996; Kang *et al.*, 2010; Rakha *et al.*, 2017).

The results suggest that LA-1940 (*S. pennellii*) can be a potential source of resistance to *T. absoluta* in future tomato breeding programmes. There is a need to study the genetic basis of resistance and compatibility/closeness of wild tomato genotypes with cultivated lines.

Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/S147926211800062X

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