RESISTANCE OF TOMATO STRAINS TO THE MOTH *Tuta absoluta* IMPARTED BY ALLELOCHEMICALS AND TRICHOME DENSITY

Resistência de linhagens de tomateiro à traça *Tuta absoluta*, relacionada a aleloquímicos e à densidade de tricomas

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ABSTRACT

We examined the resistance of improved tomato strains rich in 2-tridecanone (2-TD), zingiberene (ZGB) and acyl sugars (AA) to the tomato moth, *Tuta absoluta*. We also studied whether selection for strains with higher densities of glandular trichomes, and thus presumably strains with higher concentrations of 2-tridecanone, was effective in promoting greater resistance to the moth. The TOM-584 and TOM-679 strains were used as susceptible controls, which have normal concentrations of the three allelochemicals. The improved strain TOM-687, which has a high AA content, has a widely documented resistance and was used as a standard resistant strain. The wild strain PI134417, which is resistant by means of its high 2-TD content, was also used as a standard resistant strain. The experiment was installed in a greenhouse with a completely randomized design. The wild strain PI 134417 was confirmed as being highly resistant. TOM-622 (rich in 2-TD), ZGB-703 (rich in ZGB), and TOM-687 (rich in AA) showed significant reductions in the oviposition rate of the tomato moth, damage to the plants, injury to the leaflets, and the percentage of leaflets attacked in comparison with the control strains (TOM-584 and TOM-679). The levels of resistance to the moth for the TOM-622, ZGB-703, and TOM-687 strains were similar. In general, the genotypes with higher densities of glandular trichomes had greater resistance than the susceptible controls, with the strain BPX-367D-238-02 being particularly notable in its resistance.

Index terms: *Solanum lycopersicum*, genotypes, breeding, indirect selection.

RESUMO

Comparou-se a efetividade de linhagens melhoradas de tomateiro, ricas em 2-tridecanona (2-TD), zingibereno (ZGB) e acilaçúcares (AA), em relação aos níveis de resistência à traça-do-tomateiro *Tuta absoluta*. Verificaram-se, também, se linhagens selecionadas para maiores densidades de tricomas glandulares, presumivelmente com maiores níveis de 2-tridecanona, são efetivas em promover maior resistência à traça. Como testemunhas suscetíveis foram utilizadas as linhagens TOM-584 e TOM-679, com nível normal dos três aleloquímicos. A linhagem melhorada TOM-687 (com alto teor de AA) foi utilizada como linhagem resistente padrão, por ter sua resistência amplamente documentada, juntamente com o também resistente acesso selvagem PI134417 (com alto teor de 2-TD). O experimento foi instalado em casa de vegetação, em delineamento inteiramente casualizado. O acesso selvagem PI 134417 confirmou-se como altamente resistente. TOM-622 (rica em 2-TD), ZGB-703 (rica em ZGB) e TOM-687 apresentaram diminuições significativas na ovoposição da traça-do-tomateiro, bem como no dano geral na planta, lesão nos folíolos e porcentagem de folíolos atacados, comparadas às testemunhas TOM-584 e TOM-679. Os níveis de resistência à traça em TOM-622, ZGB-703 e TOM-687 foram similares entre si. Em geral, os genótipos selecionados com maiores densidades de tricomas glandulares apresentaram níveis de resistência também superiores aos das testemunhas suscetíveis, destacando entre eles o tratamento BPX-367D-238-02.

Termos para indexação: *Solanun lycopersicum*, genótipos, melhoramento, seleção indireta.

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INTRODUCTION

The tomato, *Solanum lycopersicum* L. (= sin. *Lycopersicon esculentum* Mill.), originated in the Andean zone of South America but was domesticated in Mexico and introduced to Europe in 1544. It later spread from Europe to South and East Asia, Africa, and the Middle East and was later returned to South America (NAIKA et al., 2006). Brazil cultivates approximately 60,000 hectares of tomatoes, yielding a total of 3.1 million tons and an average yield of 57.3 kg/hectare (EMBRAPA HORTALIÇAS, 2009)

The tomato is cultivated throughout the year in tropical and subtropical regions with good economic prospects, and the total cultivated area increases each year (EMBRAPA HORTALIÇAS, 2009). The tomato plays an important role in the Brazilian economy and is emerging as the most important crop produced in the country. Tomatoes

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have a relatively short growing cycle with high yields. However, tomato plants require constant attention from growers due to the large number of pests and diseases that occur during the crop cycle. Thus, this crop is demanding in terms of phytosanitary treatments (MOREIRA et al., 2005).

One of the principal insect pests affecting tomato production is the tomato moth, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) (MEDEIROS et al., 2005). This species is considered to be one of the leading pests in South America with regard to the economic losses it causes (CASTELO BRANCO et al., 2003, RESENDE et al., 2008). The damage from infestations of the species can be observed in the shoots of the plants. Additionally, the caterpillars produce holes in the leaves, stems, and fruits, which increase as the insect feeds. Under intense attack, the leaves turn yellow, wither, and senesce; the fruits are destroyed; and the plant may even die (MALUF et al., 1997). This insect pest represents a serious problem for tomato production due to both the intensity of the attack and its persistence throughout the entire tomato growing cycle. Chemical methods have been the most common control measures used by growers. However, the indiscriminate use of insecticides has led adverse effects, such as the selection of resistant biotypes, causing growers to use ever increasing dosages and resulting in less satisfactory results over time (SIQUEIRA et al., 2000).

During the domestication of the tomato, important alleles present in the gene pool of the genus were lost, resulting in a narrowing of its genetic base. The genes lost were principally related to pest and disease resistance. This may be one explanation for the susceptibility of current cultivars to countless pathogens and pests. One alternative approach to chemical pesticides for obtaining a better cost/benefit ratio is the development of resistant cultivars (PEREIRA et al., 2008; GONÇALVES NETO et al., 2010; MALUF et al., 2010).

Current programs for improving tomato plants in Brazil aim to obtain pest-resistant cultivars by incorporating the alleles for resistance present in wild plants into commercial cultivars so that they also produce the allelochemicals associated with resistance (ARAGÃO et al., 2000; MALUF et al., 2007; SILVA et al., 2009; GONÇALVES NETO et al., 2010; MALUF et al., 2010). At least three types of allelochemicals (acyl sugars, zingiberene, and 2-tridecanone) have been associated with resistance to *Tuta absoluta* (GONÇALVES et al., 2006; RESENDE et al., 2006; PEREIRA et al., 2008; SILVA et al., 2009; MALUF et al., 2010), but studies comparing levels of pest resistance among strains rich in different allelochemicals are few. In light of this situation, there is a clear need for additional research into this approach.

In this study, we examined the resistance of tomato strains rich in 2-tridecanone (2-TD), zingiberene (ZGB), or acyl sugars (AA) to the tomato moth, *Tuta absoluta*. We also studied whether strains with greater densities of glandular trichomes (derived from a wild species rich in 2-tridecanone) possessed satisfactory levels of resistance to the moth.

MATERIAL AND METHODS

The experiments were performed from 10 August to 30 November 2009, in greenhouses at the Experimental Station for Vegetables, HortiAgro Sementes Ltda, Fazenda Palmital, in the municipality of Ijaci, MG (21º14´16" south latitude, 45º08´00" west longitude, altitude 918 m), and at the Division of Vegetable Culture of the Federal University of Lavras (UFLA) in the municipality of Lavras, MG (21º14'43" south latitude, 45º59'59" west longitude, altitude 919 m).

We used a completely randomized experimental layout with one plant per pot (parcel) and six replicates in each of the 15 experimental groups for a total of 90 plants. We used the tomato (*S. lycopersicum*) strains TOM-584 (low concentrations of 2-TD, ZGB, and AA) and TOM-679 (low concentrations of 2-TD, ZGB, and AA) as nonresistant controls. The strain *S. habrochaites* var. *glabratum* PI 134417 (high concentration of 2-TD) was used as a resistant control. We also tested the following strains of tomato: TOM-622 (high concentration of 2-TD), TOM-687 (high concentration of AA), ZGB-703 (high concentration of ZGB), and nine genotypes obtained through the self-propagation of plants selected for higher densities of glandular trichomes within two advanced tomato populations prepared by Maluf et al. (2007), known as BPX-365E and BPX-367C. Seven of the genotypes selected for the density of their trichomes (BPX-365F-751-05-01-03, BPX-365F-751-05-02-02, BPX-365F-751-10-01-01, BPX-365F-751-10-01-02, BPX-365F-899-07-04-02, BPX-365F-899-14-02-03, and BPX-365F-899-14-02-04) correspond to the F7 strain, which was obtained by crossing TOM-679 and TOM-600 (a strain from which TOM-622 was selected for larger fruit size). The other two genotypes (BPX-367D-074-02 and BPX-367D-238-02) correspond to the F5 strain, which was obtained from crossing TOM-584 and TOM-600. TOM-600 is a strain rich in 2-TD, which was selected from an interspecies crossing of the tomato and *Solanum habrochaites* var. *glabratum* PI 134417. The strains BPX-365F and BPX-367D, which were selected for their higher densities of glandular trichomes, presumably also have elevated concentrations of 2-TD because 2-TD accumulates in glandular trichomes. TOM-687, a strain rich in AA, has commercial characteristics and a well-documented resistance to pests, including mites (*Tetranychus* spp.), the tomato moth (*Tuta absoluta*), and the white fly (*Bemisia argentifolii*) (MALUF et al., 2010). Thus, it was used as a standard resistant strain.

Seeds from all genotypes were planted on 10 Aug. 2009, except for PI 134417. Because it germinates more slowly, PI134417 was planted seven days earlier. On 16 Sept. 2009, we potted the plants in 500 mL polyethylene pots. Twenty-four days after transplantation (10 Oct. 2009), the different genotypes to be tested were placed into a screened greenhouse that had been previously infested with a population of *Tuta absoluta*. Infestation with *Tuta absoluta* was performed under commercial tomato production conditions, using a cultivar of the Santa Cruz group from a greenhouse located in the municipality of Ijaci, MG, that had a severe infestation of the pest. The replicates of the various treatments were randomized during the treatment with *Tuta absoluta*. To ensure a high level of infestation with the tomato moth across the 15 genotypes to be tested, additional tomato plants of the Santa Clara cultivar, which has low concentrations of 2-TD, ZGB, and AA, and which are known to be susceptible to the moth, were placed inside the greenhouse where the experiment was carried out as a substrate for oviposition and as food for the resulting caterpillars.

The first evaluation of oviposition was performed on Oct. 20 2009, 10 days after exposure to the moth, by counting the number of eggs present using a binocular stereoscopic microscope with 20 to 80x magnification. The evaluation was repeated every two days, until the number of eggs counted on the susceptible control, TOM-584, reached a maximum, which occurred on the sixteenth day after exposure.

For this observation of eggs, we only used leaflets from the upper third of the plant, which had been previously marked with white adhesive tape for later evaluations of damage. We recorded the number of eggs per 2 cm^2 of leaf area. After 20 days of exposure to the moth, on 30 Nov. 2009, we evaluated the damage to the plants caused by the insect, the type of injuries to the leaflets, and the percentage of the leaflets attacked using the scoring method proposed by Maluf et al. (1997). In this system, scores vary from 0 to 5, and lower scores indicate less damage (higher levels of resistance). Six evaluations of the damage caused by the insect were performed at two-day intervals. The scores given for damage to the plants, type of injury to the leaflets, and percentage of leaflets attacked were tracked over time and used to create a curve. A smaller area under the damage versus time curve is indicative of higher resistance to the moth.

The data obtained were processed with the SAS (STATISTICAL ANALYSIS SYSTEM INSTITUTE, 1990) software using the average values from each experimental group. The significance of the differences observed between groups was determined with Duncan's test. Non-orthogonal comparisons were used to make comparisons of interest between the treatment groups.

RESULTS AND DISCUSSION

Significant differences were found using the F test regarding the characteristics evaluated, indicating that the oviposition rate, severity of damage to the plants, injuries to the leaflets, and the percentage of leaflets attacked were reduced by the presence of the allelochemicals 2-TD, ZGB, and AA in the tomato strains evaluated (Tables 1 and 2).

The control strains, TOM-584 and TOM 679, which have low concentrations of allelochemicals, showed significantly higher rates of oviposition than the TOM-622, ZGB-703, and TOM 687 strains, which possess high concentrations of the allelochemicals 2-TD, ZGB, and AA, respectively (Table 1, comparisons C2, C3, and C4). With regard to oviposition, the aversion of the pest to strains rich in the various allelochemicals is evident, indicating a satisfactory effect of these strains (2-TD, ZGB, and AA rich) in reducing oviposition by the moth. The associations between lower rates of oviposition and higher concentrations of 2-TD, ZGB, and AA have been reported recently by Aragão et al. (2000), Silva et al. (2009), Gonçalves Neto et al. (2010) and Maluf et al. (2010).

The TOM-622, ZGB-703, and TOM-687 strains did not differ significantly from one another, indicating that the three allelochemicals (2-TD, ZGB, and AA) had equivalent effects on oviposition, which was consistently lower on these strains than on the susceptible controls, TOM-679 and TOM-584 (Table 1, comparisons C6, C7, and C8). However, TOM-622 was not as repellent to oviposition as the wild strain from which its resistance was obtained, *Solanum habrochaites* var. *glabratum* PI 134417. This wild strain has a high concentration of 2-TD and a high density of glandular trichomes. Thus, it was used as a resistant control (Table 1, comparison C5). The reduction in oviposition on PI 134417 relative to the susceptible controls, TOM-584 and TOM-679, was greater than the reduction between any other strains tested (Table 1).

Table 1 – Total number of *Tuta absoluta* eggs per 2 cm^2 of leaf area measured on leaves from the upper third of tomato plants (eggs counted 14 days after infestation with *Tuta absoluta)* and estimates of several comparisons of interest. UFLA, Lavras, MG, 2009.

Treatments	Total no. of eggs	Comparisons of interest	Estimates
T1=TOM-584	12.16 G [/Z]	C1=(TOM-584+TOM679)/2 vs. PI 134417	11.17**
T2=TOM-679	11.53 GH	C2=(TOM-584+TOM679)/2 vs. TOM-622	6.12**
T3=PI134417	0.68A	C3=(TOM-584+TOM679)/2 vs. TOM-687	6.58**
T4=TOM-622	5.73BCDE	C4=(TOM-584+TOM679)/2 vs. ZGB-703	6.93**
T5=TOM-687	5.26BCD	C5=PI134417 vs. TOM-622	-5.05*
T6=ZGB-703	4.92BCD	C6=TOM-687 vs. TOM-622	-0.47ns
T7= BPX-36F-751-05-01-03	4.52BC	C7=TOM-687 vs. ZGB-703	0.35ns
T8=BPX-365F-751-05-02-02	7.02BCDE	C8=TOM-622 vs. ZGB-703	0.82ns
T9= BPX-365F-751-10-01-01	6.45BCDE	C9=TOM-687 vs. BPX-36F-751-05-01-03	0.75ns
T10= BPX-365F-751-10-01-02	7.15BCDE	C10=TOM-687 vs. BPX-365F-751-05-02-02	-1.75ns
T11= BPX-365F-899-07-04-02	7.02BCDE	C11=TOM-687 vs. BPX-365F-751-10-01-01	-1.18ns
T12= BPX-365F-899-14-02-03	8.4DEF	C12=TOM-687 vs. BPX-365F-751-10-01-02	-1.88ns
T13= BPX-365F-899-14-02-04	7.85CDE	C13=TOM-687 vs. BPX-365F-899-07-04-02	-1.75ns
T14= BPX-367D-074-02	8.97EFG	C14=TOM-687 vs. BPX-365F-899-14-02-03	-3.13*
T15= BPX-367D-238-02	3.85B	C15=TOM-687 vs. BPX-365F-899-14-02-04	-2.58ns
		C16=TOM-687 vs. BPX-367D-074-02	-3.70*
		C17=TOM-687 vs. F5 BPX-367D-238-02	1.42ns

[Z] Averages followed by the same letter in the same column do not differ significantly from each other according to the Duncan test (P<0.05%). ns: not significant, *: significant at P d"0.05, **: significant at P $\leq$0.01.

The strains BPX-365F-899-14-02-03 and BPX-367D-074-02 also showed slightly higher rates of oviposition than the TOM-687 strain, differences detected as significant by the comparisons C14 and C16 (Table 1). In contrast, BPX-365F and BPX-367D had equal or fewer numbers of eggs than the susceptible controls, TOM-584 and TOM-679. These two strains were bred to have high 2-TD concentrations by means of having more glandular trichomes. However, this phenotype is controlled by more than one gene locus; thus variation is expected in the levels of resistance to pests among strains selected based on the concentration of 2-TD or the densities of trichomes (a correlated trait). In a study of the distribution of 2-TD concentrations in the F2 generation derived from crossing PI 134417 and TSWV-547 (a strain with a low concentration of 2-TD), Barbosa and Maluf (1996) observed a predominance of plants with a low concentration of 2-TD, which suggests that the low concentration phenotype is dominant. Various other factors may also contribute to these differences, including the possible presence of other allelochemicals, which could be either antagonistic and mask the effects of 2-TD, or could exhibit synergistic effects with 2-TD and increase its effects.

The susceptible control strains, TOM-679 and TOM-584, did not differ from each other in injury to leaflets (LF), percentage of leaflets attacked (%FA), or damage to plants (DP) (Table 2), but both strains showed significantly greater damage than the TOM-622, TOM-687, and ZGB-703 strains, which have high concentrations of the allelochemicals 2-TD, AA, and ZGB, respectively (Table 2, comparisons C2, C3, and C4). Similar differences were also observed when comparing the wild strain, PI 134417 (the source of the high 2-TD concentration and the high density glandular trichomes traits present in the TOM-622, BPX-365F, and BPX-367D strains), with the strain selected for its high concentration of 2-TD, TOM-622 (Table 2, comparison C5).

Table 2 – Average damage to tomato plants in response to infestation by the tomato moth, *Tuta absoluta*. The area under the curve of damage versus time was calculated up to 34 days after infestation using the scores for injury to leaflets (LF), percentage of leaflets attacked (%FA), and total damage to plants (DP). UFLA: Lavras-MG, 2009.

	Calculated area		
Treatments	LF	%FA	DP
T1=TOM-584	43.17F	41.67E	39.33E[/Z]
T2=TOM-679	39.33EF	37.83E	44.33E
T3=PI134417	12.17A	7.67A	8.83A
T4=TOM-622	21.50BC	21.17BC	23.00BC
T5=TOM-687	23.0BC	20BC	21.83BC
T6=ZGB-703	22.33BC	21.68BC	25.00CD
T7= BPX-36F-751-05-01-03	22.33BC	22.83C	22.33BC
T8= BPX-365F-751-05-02-02	23.33BC	21.83BC	26.17CD
T9= BPX-365F-751-10-01-01	26.67BCD	26.67C	26.83CD
T10= BPX-365F-751-10-01-02	25.67BCD	25.17C	28.00CD
T11= BPX-365F-899-07-04-02	22.17BC	21.50BC	22.50BC
T12= BPX-365F-899-14-02-03	38.83EF	36.17E	39.50E
T13= BPX-365F-899-14-02-04	29.17CD	27.67CD	28.67CD
T14=BPX-367D-074-02	33.50DE	35.0DE	30.66D
T15= BPX-367D-238-02	18.0AB	13.67AB	17.83B
Identification of comparisons of interest		Estimates	
C1=(TOM-584+TOM679)/2 vs., PI 134417	29.08**	32.08**	33.00**
C2=(TOM-584+TOM679)/2 vs., TOM-622	19.75**	18.58**	18.83**
C3=(TOM-584+TOM679)/2 vs., TOM-687	18.25**	19.75**	20.00**
C4=(TOM-584+TOM679)/2 vs., ZGB-703	18.92**	18.08**	16.83**
C5=PI134417 vs. TOM-622	-9.33*	-13.50**	-14.16**
C6=TOM-687 vs. TOM-622	1.50ns	-1.17ns	-1.17ns
C7=TOM-687 vs. ZGB-703	0.67ns	-1.67ns	-3.17ns
C8=TOM-622 vs. ZGB-703	-0.83ns	-0.50ns	-2.00ns
C9=TOM-687 vs. BPX-36F-751-05-01-03	0.66ns	-2.83ns	-0.50ns
C10=TOM-687 vs. BPX-365F-751-05-02-02	-0.33ns	-1.83ns	-4.33ns
C11=TOM-687 vs. BPX-365F-751-10-01-01	-3.67ns	-6.67ns	-5.00ns
C12=TOM-687 vs. BPX-365F-751-10-01-02	-2.67ns	-5.17ns	-6.17ns
C13=TOM-687 vs. BPX-365F-899-07-04-02	0.83ns	-1.50ns	-0.67ns
C14=TOM-687 vs. BPX-365F-899-14-02-03	-15.83**	-16.17**	-17.67**
C15=TOM-687 vs. BPX-365F-899-14-02-04	-6.17ns	-7.67ns	-6.83*
C16=TOM-687 vs. BPX-367D-074-02	-10.50**	-15.00**	-8.83*
C17=TOM-687 vs. BPX-367D-238-02	5.00ns	6.33ns	4.00ns

[Z] Averages followed by the same letter in the same column do not differ significantly from each other according to the Duncan test (P<0.05%). ns: not significant, *: significant at P d"0.05, **: significant at P $\leq$ 0.01.

The wild strain, PI 134417, generally exhibited significantly less damage in terms of LF, %FA, and DP, even when compared with the TOM-622 strain, which was rich in 2-TD and was derived from the wild strain (Table 2, comparison C5); this reinforces the hypothesis that other factors are also influencing this resistance in the wild strain. Of the nine genotypes selected in the preceding generation based on their higher density of trichomes, seven were as resistant to the moth as the TOM-622, TOM-687, and ZGB-703 strains (Table 2, comparisons C9, C10, C11, C12, C13, C15, and C17). Only two genotypes (BPX-365F-899-14-02-03 and BPX-367D-074-02) had levels of damage equivalent to those observed in the susceptible controls (TOM-679 and TOM-584). These results confirm the influence of the different allelochemicals on resistance to the moth. The genotype BPX-367D-238-02, which was observed to have fewer ovipositions (Table 1), also had noticeably lower levels of damage. Specifically, the damage, as measured by LF and %FA, did not differ from that seen in the resistant wild strain, PI 134417 (Table 2). Maluf et al. (2007) found similar results for mites of the genus *Tetranychus*. Specifically, strains BPX-365F-751-05-02-02 and BPX-367D-238-02, which was also used in this study, were found to be among the most resistant strains (Table 2).

The correlation between the higher density of glandular trichomes measured in the previous generation (MALUF et al., 2007) and resistance to the moth was imperfect because the genotypes BPX-365F-899-14-02-03 and BPX-367D-074-02, which were susceptible to the moth (Table 2), came from plants (Table 3) with densities of glandular trichomes substantially higher than those of their recurrent parental strains, TOM-679 and TOM-584, respectively. However, the other seven BPX-365F and BPX-367D strains, which were selected based on the same criteria, were resistant to the tomato moth. This discrepancy can be partially explained by the possibility that there is segregation in the trichome density between one generation and another.

According to Maluf et al. (2007), the density of type IV and VI glandular trichomes in populations of BPX-365E and BPX-367C, which correspond to the densities in the precursor generations BPX-365F and BPX-367D, is related to the level of aversion that mites (*Tetranychus urticae*) have. Although not perfect, a selection criterion based on higher densities of glandular trichomes generally led to greater moth resistance. This indicates that a selection for higher trichome densities, even if done in a previous generation, can provide for an indirect selection of plants resistant to the tomato moth because this resistance is related to the concentration of 2-TD and the density of glandular trichomes, which are positively correlated traits (Aragão et al., 2000).

Table 3 – Average density (number/cm^2) of glandular trichomes on the abaxial and adaxial faces and the glandular totals for both faces of the plants used in the bioassay with mites, *Tetranychus* spp., from Maluf et al. (2007).

	Trichomes						
	Abaxial			Adaxial			
Treatments	IV	VI	Total	IV	VI	Total	Average
TOM-584	0.00	0.00	0.00	0.00	246.70	246.70	123.30
TOM-679	0.00	1480.00	1480.00	0.00	986.70	986.70	1233.30
BPX-367B-074-02	0.00	1480.00	1480.00	0.00	986.70	1480.00	1480.00
BPX-367B-238-02	0.00	493.30	986.70	0.00	986.70	986.70	986.70
BPX-365D-751-05-01-03	0.00	986.70	986.70	0.00	1480.00	1480.00	1233.30
BPX-365D-751-05-02-02	0.00	2466.70	2466.70	0.00	1480.00	1480.00	1973.30
BPX-365D-751-10-01-01	0.00	1973.30	1973.30	0.00	986.70	986.70	1480.00
BPX-365D-751-10-01-02	0.00	986.70	986.70	0.00	1480.00	1480.00	1233.30
BPX-365D-899-07-04-02	0.00	1480.00	1480.00	0.00	1973.30	2466.70	1973.30
BPX-365D-899-14-02-03	0.00	1480.00	1480.00	0.00	1480.00	1480.00	1480.00
BPX-365D-899-14-02-04	0.00	1480.00	1480.00	0.00	1973.30	2466.70	1973.30

The associations found in this study between elevated levels of allelochemicals and resistance to the tomato moth, *Tuta absoluta*, in genotypes with already improved characteristics (e.g., the TOM-622, ZGB-703, and TOM-687 strains, which are rich in 2-TD, ZGB, and AA, respectively) have been known for some time now. AA has been associated with resistance to the moth since the initial segregated generations of the original interspecies crossing of L. esculentum X L. *pennelli* LA-716 (RESENDE et al., 2006) to more advanced strains with characteristics agronomically similar to commercial genotypes (SILVA et al., 2009; GONÇALVES NETO et al., 2010; MALUF et al., 2010). Similar correlations have been described for ZGB and 2-TD (and the corresponding density of glandular trichomes). Freitas et al. (2000) showed the effectiveness of ZGB in conferring resistance to the white fly *Bemisia* spp. with observations of fewer nymphs and live adults in F2 plants selected for a high level of ZGB. Silva et al. (2009) found a high resistance to the tomato moth in genotypes homozygous for higher concentrations of ZGB. Barbosa and Maluf (1996) demonstrated that plants with high concentrations of 2-TD exhibited mechanisms of resistance to the moth that were mediated by the aversion of the insect toward oviposition or feeding on the plants.

CONCLUSION

In this study, the advanced strains TOM-687, ZGB-703, and TOM-622, which are rich in the allelochemicals AA, ZGB, and 2-TD, respectively, had similar levels of resistance to the tomato moth as plants with homozygous genotypes rich in these allelochemicals. These advanced strains had similar rates of insect oviposition (Table 1) and had similar scores for LF, %FA, and DP (Table 2). These data indicate that a strain rich in any one of these allelochemicals (2-TD, ZGB, or AA) will be a tomato genotype with resistance to the moth. We also demonstrated that selecting for higher densities of glandular trichomes in genotypes derived from the wild strain PI 134417 is an indirect method to select genotypes with resistance to the tomato moth, although it is not without drawbacks.

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