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Biophysical parameters of different tomato genotypes responsible for resistance/susceptibility to South American tomato leaf miner, *Tuta absoluta* (Meyrick)

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Abstract
Biophysical parameters of different tomato genotypes were estimated during *Rabi* 2016-17 and 2017-18 to identify the resistance/susceptibility to *Tuta absoluta* (Meyrick). The leaflet length and width were significantly lower in moderately resistant genotypes EC-620410, EC-620343 and EC-620401 with 2.68 cm and 1.31 cm, 2.74 cm and 1.44 cm and 3.06 cm and 1.63 cm, respectively whereas significantly higher in highly susceptible genotypes EC-160885 and EC-620433 with 7.08 cm and 3.13 cm and 6.35 cm and 3.01 cm, respectively. The leaflet thickness and trichome density were significantly higher in moderately resistant genotypes EC-620410, EC-620401 and EC-620343 with 0.35 mm, 0.34 mm and 0.33 mm and 466.50, 408.66 and 431.67 per 0.25 cm^2, respectively, whereas leaflet thickness and trichome density were significantly lower in highly susceptible genotype EC-160885 (0.18 mm and 128.17 per 0.25 cm^2, respectively).The moderately resistant genotypes EC-620410, EC-620401, EC-538153 and EC-164577 with highest SCMR values of 44.40, 42.25, 42.18, and 41.78, respectively, with lowest *T. absoluta* infestation whereas highly susceptible genotypes EC-620433 and EC-160885 recorded lowest SCMR values 31.99 and 31.91, respectively. The significant positive correlation was observed between leaflet length, width and with the infestation of *T. absoluta* on leaflets, fruits and larvae per compound leaf whereas leaflet thickness, trichome density and SPAD chlorophyll meter reading (SCMR values) were found to be significant negative correlation.

Keywords: Biophysical parameters, *Tuta absoluta*, tomato genotypes, correlation

1. Introduction
Tomato production has been fluctuating due to many biotic and abiotic constraints. Prominent among the biotic constraints are pests and diseases which reduce yields and the quality of marketable fruits. The major insect pest complex of tomato includes fruit borer, *Helicoverpa armigera* (Hubner), tobacco caterpillar, *Spodoptera litura* (Fabricius), serpentine leaf miner, *Liriomyza trifolii* (Burgess), whitefly, *Bemisia tabaci* (Gennadius), aphids, *Aphis gossypii* (Glover), mealybugs, *Phenacoccus solenopsis* (Tinsley) and mites, *Tetranychus urticae* (Koch). Recently, South American tomato leaf miner or pinworm, *Tuta absoluta* (Meyrick) (Lepidoptera : Gelechiidae), is emerging as major pest and causing extensive damage up to cent per cent yield loss in India particularly under South Indian field conditions. It has been reported from different parts of India throughout the year though the incidence level varies (Sridhar *et al.*, 2014) [20].

T. absoluta is an invasive species commonly known as South American tomato leaf miner, South American tomato pinworm, and South American tomato moth and tomato borer. It is considered as one of the most devastating pests of tomato in the countries it has invaded so far. The pest is native to Peru in South America; it has spread to Argentina, Bolivia, Brazil, Chile, Columbia, Ecuador, Paraguay, Uruguay and Venezuela. Since the first detection in Spain in 2006, this pest is spreading rapidly across Southern Europe and North Africa to whole of the Mediterranean countries and in Asia, it is distributed in Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen (Desneux *et al.*, 2010) [5], India (Shasank *et al.*, 2015) [18], Bangladesh (Hossain *et al.*, 2016) [19] and Nepal (Bajracharya *et al.*, 2016) [13].

In India, *T. absoluta* was first reported during October, 2014 infesting tomato fields in Pune, Ahmednagar, Dhule, Jalgaon, Nashik and Satara districts of Maharashtra (Shashank *et al.*, 2015). Subsequently pest was recorded from Karnataka (Sridhar *et al.*, 2014, Kalleshwaraswamy *et al.*, 2015 and Ballal *et al.*, 2016) [20, 10, 4], Tamil Nadu

(Shanmugam *et al.*, 2016 and Ballal *et al.*, 2016) [16, 4], Andhra Pradesh and Telangana (Anitha *et al.*, 2015) [2], New Delhi (Shashank *et al.*, 2016) [3], Gujarat (Ballal *et al.*, 2016) [4], Madhya Pradesh (Swathi *et al.*, 2017) [21], Punjab (Sandeep *et al.*, 2017) [14], Meghalaya (Sankarganesh *et al.*, 2017) [15] and Himachal Pradesh (Sharma and Gavkare, 2017) [17] causing severe damage to tomato in invaded areas in India.

T. absoluta attacks the tomato crop from seedling to harvesting stage. Tomato plants are damaged by feeding on leaves, stems, flower buds and both green and ripe fruits by the invasion of secondary pathogens which enters through the wounds caused by the pest (Shasank *et al.*, 2015) [18]. In early infestation, newly emerged neonates penetrate the leaf into the mesophyll layer and feed between the lower and upper surfaces of the leaf to form small and transparent mines. As a result of continuous feeding by the larvae, the irregular mines combine together and eventually form galleries. The mines were filled with black coloured fecal pellets and over time the mined areas turns brown and dryup. In fruits, the larvae tunnel inside and leave only a pinhead size hole visible from outside and make mines just below the surface. More than one hole are seen near to the calyx on fruit. It causes reduction in yield and fruit quality, known to cause 50 to 100 per cent loss under greenhouse and open field conditions. When plants from heavily infested are shaken, adult moths found flying near to ground surface (EPPO, 2005) [5].

Several chemical pesticides are used to control the pest, but none is suitably adapted for management of the tomato leaf miner because of the endophytic habit of larvae, which are protected in the leaf mesophyll or inside fruit, further foliar spray easily wash out by wind and rain (Abbes and Chermiti, 2011 and Guedes and Picanco, 2012) [1, 8]. The endophytic behavior of larvae leads to indiscriminate use of insecticides in the infested fields which results in development of insecticide resistance, pest resurgence, environmental pollution, pesticide residues in fruits, destruction of natural enemy populations and health hazards. To avoid problems caused due to indiscriminate use of insecticides, utilization of Host Plant Resistance (HPR) is an ecologically viable, alternate insect pest management strategy. The use of resistant varieties would be an alternative to chemical control. The study of the mechanisms and causes of resistance to *T. absoluta* is fundamental for the determination of the resistance factors necessary to incorporate into plant breeding programmes for insect resistance and to provide objective parameters for the crosses. It is always agreed that, pest control using resistant tomato varieties is the best and sustainable option (Oliveira *et al.*, 2009) [13]. To our knowledge, there is no longer cultivated variety resistant to *T. absoluta*. The development and cultivation of *T. absoluta* resistant tomato cultivars is very limited in India. Therefore, there is a need to identify the resistant tomato variety to *T. absoluta* and biophysical parameters responsible for resistance.

2. Materials and Methods

Data on certain bio-physical parameters *viz.*, leaflet length, width and thickness, trichome density and SPAD-Chlorophyll Meter Readings of tomato genotypes were estimated for the variations in incidence of tomato leaf miner.

2.1 Biophysical Parameters

2.1.1 Length of leaflets

Fifteen tomato plants were selected from three replications (five plants from each replication). On each plant, three single compound leaves (top, middle and bottom) were selected. From each single compound leaf, one leaflet was collected then the length of leaflets (end to end) in respect of 45 leaflets per genotype were measured with the help of measuring scale and expressed in centimeters.

2.1.2 Width of leaflets

Fifteen tomato plants were selected from three replications (five plants from each replication). On each plant, three single compound leaves (top, middle and bottom) were selected. From each single compound leaf one leaflet was collected then the width of leaflets (end to end) in respect of 45 leaflets per genotype were measured with the help of measuring scale and expressed in centimeters.

2.1.3 Trichome density

The tomato leaflet was cut into bits of 0.25 cm^2 and number of trichomes present on leaves was counted under a stereo zoom trinocular microscope and expressed as number of trichomes per 0.25 cm^2.

2.1.4 Thickness of leaflets

Thickness of tomato leaflets related to each genotype was measured by using the digital vernier calipers and expressed in millimeters.

2.1.5 SPAD Chlorophyll Meter Reading (SCMR)

SPAD Chlorophyll Meter Readings (SCMR) which denote relative chlorophyll content of fully expanded leaf (second from top) which were measured by using SPAD (Soil Plant Analytical Development) meter of Minolta Company, NJ, USA (SPAD 502). This meter enables obtaining instant readings without destroying the plant tissue. Before measurement, the instrument was calibrated and transmission was measured with no leaflet inside. Then the leaflet was clamped by the meter which absorbs certain portion of red light. The mean of SCMR reading was taken out in the end and presented as average SPAD value and it was expressed as SPAD chlorophyll meter reading (SCMR).

The above biophysical parameters of tomato genotypes were correlated with the incidence of *T. absoluta* on leaves and fruits to arrive at the relatively resistant and susceptible genotypes of tomato.

3. Results and Discussion

The data obtained regarding various biophysical parameters *viz.*, leaflet length, width and thickness, trichome density and SPAD-Chlorophyll meter reading (SCMR values) of the tomato genotypes during *Rabi* 2016-17 and 2017-18 are presented in Tables 1 to 8.

3.1 Biophysical parameters of tomato genotypes during *Rabi* 2016-17

The results of biophysical parameters in different tomato genotypes during *Rabi* 2016-17 are presented in Table 1.

3.1.1 Leaflet length (cm)

Significantly minimum leaflet length was recorded in genotype EC-620410 (2.77 cm) and found to be on par with EC-620343 (2.79 cm). The maximum leaflet length was observed in genotype EC-160885 (7.19 cm) which was followed by EC-620372 (6.50 cm), EC-620376 (6.40 cm), EC-620433 (6.39 cm) and EC-249514 (6.27) (Table 1).

3.1.2 Leaflet width (cm)
Leaflet width of different tomato genotypes varied from 1.34 to 3.18 cm. significantly lowest leaflet width was observed in EC-620410 (1.34 cm) followed by EC-620343 (1.46 cm), EC-620401(1.57 cm), EC-631369 (1.57 cm) and EC-620422 (1.76 cm). The highest leaflet width was recorded in EC-160885 (3.18 cm) and found on par with EC-620372 (3.13 cm). The leaflet width of other genotypes ranged from 1.78 to 3.01 cm (Table 1).

3.1.3 Leaflet thickness (mm)
The leaflet thickness in genotypes was ranged from 0.18 mm (EC-160885) to 0.34 mm (EC-620410). The genotype EC-620372 recorded lowest leaflet thickness of 0.19 mm which was on par with EC-620433 (0.20 mm) and EC-620376 (0.20 mm) whereas highest leaflet thickness was recorded in genotype EC-620410 (0.34 mm) followed by EC-620401 (0.31 mm), EC-620343 (0.31 mm) and EC-164577 (0.29 mm) (Table 1).

3.1.4 Trichome density
The number of trichomes on leaves per 0.25 cm^2 in genotypes ranged from 124.33 to 460.67. The highest trichome density per 0.25 cm^2 was recorded in EC-620410 (460.67) followed by EC-620343 (425.67), EC-620401 (395.00) and EC-538153 (383.00) whereas the lowest number of trichomes was recorded in EC-160885 (124.33) followed by EC-620372 (145.67) and EC-620433 (164.33) (Table 1).

3.1.5 SPAD Chlorophyll Meter Reading (SCMR)
The data on leaf colour (SCMR values) revealed that the SCMR value ranged from 30.91 to 43.16. Among all the genotypes EC-620410 recorded the highest (43.16) SCMR value followed by EC-538153 (42.97) EC-620401 (42.56) and EC-164577 (42.43). The lowest SCMR value was recorded in EC-620372 (30.91) followed by EC-160885 (31.25), EC-620433 (31.49) and EC-249-514 (31.49) (Table 1).

Table 1: Biophysical parameters of different tomato genotypes screened against South American tomato leaf miner, *T. absoluta* during *Rabi* 2016-17

Genotype	Leaflet length (cm)	Leaflet width (cm)	Leaflet thickness (mm)	Trichome density (number/ 0.25 cm^2)	SCMR value
EC-620410	2.77	1.34	0.34	460.67	43.16
EC-538156	6.18	2.91	0.21	210.00	32.47
EC-620395	5.84	2.71	0.21	224.33	33.70
EC-620372	6.50	3.13	0.19	145.67	30.91
EC-165700	6.16	2.89	0.24	202.00	33.31
EC-620147	5.76	2.59	0.22	215.00	33.09
EC-567305	5.13	2.50	0.23	244.00	37.13
EC-620433	6.39	3.05	0.20	164.33	31.49
EC-160885	7.19	3.18	0.18	124.33	31.25
EC-620397	5.76	2.63	0.26	222.00	34.24
EC-620406	4.93	2.25	0.26	230.00	37.30
EC-249514	6.27	2.95	0.21	190.67	31.49
EC-620394	4.39	2.27	0.24	297.00	38.25
EC-165690	4.74	2.33	0.27	273.00	35.69
EC-620376	6.40	3.01	0.20	174.00	34.14
EC-631379	4.31	2.33	0.28	298.33	38.72
EC-620401	2.99	1.57	0.31	395.00	42.56
EC-620392	4.90	2.44	0.24	260.33	38.41
EC-249508	4.61	2.20	0.24	258.67	34.25
EC-164563	5.22	2.50	0.22	246.67	34.51
EC-521067-B	5.86	2.62	0.23	223.00	36.24
EC-164577	4.15	2.14	0.29	326.00	42.43
EC-620343	2.79	1.46	0.31	425.67	39.43
EC-620382	4.97	2.52	0.26	254.33	38.17
EC-620370	4.14	2.11	0.27	316.67	37.38
EC-620396	4.06	2.01	0.25	302.33	37.02
EC-538153	3.83	1.78	0.28	383.00	42.97
EC-620422	3.64	1.76	0.28	349.67	38.97
EC-620427	4.32	2.14	0.24	278.00	37.85
EC-631369	3.36	1.57	0.27	380.33	38.54
SE(m)	0.265	0.165	0.014	6.699	0.970
CD (p=0.05)	0.753	0.469	0.040	19.014	2.752

Each value of three replications

3.2 Biophysical Parameters of Tomato Genotypes during *Rabi* 2017-18
The results of biophysical parameters in different tomato genotypes during *Rabi* 2017-18 are presented in Table 2.

3.2.1 Leaflet length (cm)
The differences in length of leaflets among the genotypes were significant and among all the genotypes, leaflets of EC-160885 were significantly longer (6.97 cm) followed by EC-620372 (6.44 cm), EC-620433 (6.30 cm), EC-620376 (6.24 cm) and EC-249514 (6.11 cm) while the genotype EC-620410 had the short leaflet length (2.60 cm). The other genotypes with short leaflet length were EC-620343 (2.70 cm), EC-620401 (3.14 cm) and EC-631369 (3.64 cm) (Table 2).

3.2.2 Leaflet width (cm)
The leaflet width of EC-160885 was significantly high (3.08 cm) as compared to other genotypes followed by EC-620372 (3.00 cm), EC-620433 (2.96 cm), EC-620376 (2.93 cm), EC-249514 (2.86 cm) and EC-165700 (2.86 cm), whereas width

was lowest in the genotype EC-620410 (1.29 cm) followed by EC-620343 (1.41 cm), EC-620401 (1.69 cm), EC-631369 (1.86 cm) and EC-538153 (1.90 cm) (Table 2).

3.2.3 Leaflet thickness (mm)

In genotypes, the leaflet thickness was ranged from 0.19 mm (EC-160885) to 0.38 mm (EC-620410). The genotype EC-620372 recorded the leaflet thickness of 0.22 mm which was on par with EC-620433 (0.22 mm) and EC-620376 (0.22 mm) (Table 2).

3.2.4 Trichome density

The number of trichomes on leaves per 0.25 cm^2 showed significant variation among the genotypes. The highest trichome density per 0.25 cm^2 was recorded in EC-620410 (472.33) followed by EC-620343 (437.67), EC-620401 (422.33) and EC-631369 (399.33), while the lowest number of trichomes was recorded in EC-160885 (132.00) followed by EC-620372 (154.00) and EC-620433 (173.00) (Table 2).

3.2.5 SPAD Chlorophyll Meter Reading (SCMR)

Among all the genotypes, EC-620410 recorded the highest (45.64) SCMR value followed by EC-620343 (42.64), EC-620401 (41.94). The lowest SCMR value was recorded on EC-620372 (32.24) which was followed by EC-620433 (32.49), EC-160885 (32.58) and EC-620376 (32.58) (Table 2).

Table 2: Biophysical parameters of different tomato genotypes screened against South American tomato leaf miner, *T. absoluta* during *Rabi* 2017-18

Genotype	Leaflet length (cm)	Leaflet width (cm)	Leaflet thickness (mm)	Trichome density (number/ 0.25 cm^2)	SCMR value
EC-620410	2.60	1.29	0.38	472.33	45.64
EC-538156	6.06	2.81	0.23	217.67	34.81
EC-620395	5.77	2.63	0.23	230.33	35.27
EC-620372	6.44	3.00	0.22	154.00	32.24
EC-165700	6.09	2.84	0.23	208.67	34.64
EC-620147	5.91	2.72	0.23	223.67	35.09
EC-567305	4.97	2.41	0.25	257.33	36.35
EC-620433	6.30	2.96	0.22	173.00	32.49
EC-160885	6.97	3.08	0.19	132.00	32.58
EC-620397	5.58	2.56	0.24	232.33	35.33
EC-620406	5.27	2.43	0.24	236.33	35.77
EC-249514	6.11	2.86	0.23	195.33	32.94
EC-620394	4.30	2.20	0.26	311.67	39.92
EC-165690	4.61	2.25	0.26	286.33	37.31
EC-620376	6.24	2.93	0.22	183.00	32.58
EC-631379	4.17	2.10	0.27	317.33	40.81
EC-620401	3.14	1.69	0.34	422.33	41.94
EC-620392	4.82	2.30	0.26	274.33	37.05
EC-249508	4.82	2.38	0.26	266.00	36.41
EC-164563	5.07	2.42	0.24	255.33	35.89
EC-521067-B	5.49	2.49	0.24	234.33	34.81
EC-164577	4.02	2.01	0.28	339.00	41.12
EC-620343	2.70	1.41	0.36	437.67	42.64
EC-620382	4.89	2.40	0.25	265.00	36.35
EC-620370	4.05	2.02	0.28	328.67	40.90
EC-620396	4.26	2.18	0.27	314.00	40.27
EC-538153	3.76	1.90	0.30	378.33	41.39
EC-620422	3.78	1.91	0.30	358.67	41.25
EC-620427	4.49	2.21	0.26	294.67	39.13
EC-631369	3.64	1.86	0.30	399.33	41.75
SE(m)	0.307	0.162	0.019	8.361	0.375
CD (p=0.05)	0.872	0.459	0.053	23.73	1.064

Each value of three replications

3.3 Biophysical parameters of Tomato Genotypes during *Rabi* 2016-17 and 2017-18 (Pooled Data)

The pooled data on biophysical parameters of different tomato genotypes for two consecutive years of *Rabi* 2016-17 and 2017-18 are presented in Table 3.

3.3.1 Leaflet length (cm)

The pooled data on leaflet length presented Table 3 indicated that all tested tomato genotypes were significantly differed from each other in respect of leaflet length. The leaflet length in different genotypes was significantly varied from 2.68 to 7.08 cm. However, the genotype EC-620410 was recorded with lowest leaflet length (2.68 cm) and found on par with EC-620343 (2.74 cm). The maximum leaflet length was observed in genotype EC160885 (7.08 cm) followed by E C 620372 (6.47 cm), EC-620433 (6.35 cm) and EC-620376 (6.32 cm).

3.3.2 Leaflet width (cm)

The pooled data on leaflet width from both the years revealed that the leaflet width in different genotypes ranged from 1.31 to 3.13 cm. The genotype EC-160885 was significantly highest leaflet width (3.13 cm) as compared to other genotypes followed by EC-620372 (3.06 cm), EC-620433 (3.01 cm), EC-620376 (2.97 cm), EC-249514 (2.90 cm) and EC-165700 (2.87 cm), whereas lowest leaflet width was recorded in genotype EC-620410 (1.31 cm) followed by EC-620343 (1.44 cm), EC-620401 (1.63 cm) and EC-631369 (1.71 cm) (Table 3).

3.3.3 Leaflet thickness (mm)
It can be seen from pooled data on leaflet thickness of both the years revealed that the genotype EC-160885 recorded the lowest leaflet thickness of 0.18 mm which was on par with EC-620372 (0.19 mm) and EC-620433 (0.20 mm) whereas highest leaflet thickness was observed in EC-620410 (0.35 mm) followed by EC-620401 (0.34 mm), EC-620343 (0.33 mm) and EC-631369 (0.30 mm) (Table 3).

3.3.4 Trichome density
The number of trichomes on leaves per 0.25 cm^2 showed significant variation among the genotypes. The maximum trichome density per 0.25 cm^2 was recorded in EC-620410 (466.50) followed by EC-620343 (431.67), EC-620401 (408.66) and EC-631369 (389.83) while the lowest number of trichomes was recorded in EC-160885 (128.17) followed by EC-620372 (149.83) and EC-620433 (168.67) (Table 3).

3.3.5 SPAD Chlorophyll Meter Reading (SCMR)
Among all the genotypes EC-620410 recorded the highest SCMR value (44.40) followed by EC-620401 (42.25), EC-538153 (42.18) and EC-164577 (41.78). The lowest SCMR value was recorded in EC-620372 (31.57) which was followed by EC-160885 (31.91) and EC-620433 (31.99) (Table 3).

Table 3: Biophysical parameters of different tomato genotypes screened against South American tomato leaf miner, *T. absoluta* during *Rabi* 2016-17 and 2017-18 (Pooled Data)

Genotype	Leaflet length (cm)	Leaflet width (cm)	Leaflet thickness (mm)	Trichome density (number/ 0.25 cm^2)	SCMR value
EC-620410	2.68	1.31	0.35	466.50	44.40
EC-538156	6.12	2.86	0.22	213.83	33.64
EC-620395	5.80	2.67	0.21	227.33	34.48
EC-620372	6.47	3.06	0.19	149.83	31.57
EC-165700	6.12	2.87	0.23	205.33	33.97
EC-620147	5.84	2.66	0.22	219.33	34.09
EC-567305	5.05	2.46	0.24	250.67	36.74
EC-620433	6.35	3.01	0.20	168.67	31.99
EC-160885	7.08	3.13	0.18	128.17	31.91
EC-620397	5.67	2.60	0.26	227.17	34.79
EC-620406	5.10	2.34	0.26	233.17	36.53
EC-249514	6.19	2.90	0.24	193.00	32.21
EC-620394	4.34	2.23	0.25	304.33	39.09
EC-165690	4.68	2.29	0.24	279.67	36.50
EC-620376	6.32	2.97	0.21	178.50	33.36
EC-631379	4.24	2.21	0.28	307.83	39.76
EC-620401	3.06	1.63	0.34	408.66	42.25
EC-620392	4.86	2.37	0.25	267.33	37.73
EC-249508	4.72	2.29	0.24	262.33	35.33
EC-164563	5.14	2.46	0.22	251.00	35.20
EC-521067-B	5.68	2.56	0.22	228.67	35.53
EC-164577	4.09	2.08	0.29	332.50	41.78
EC-620343	2.74	1.44	0.33	431.67	41.03
EC-620382	4.93	2.46	0.26	259.67	37.26
EC-620370	4.10	2.06	0.27	322.67	39.14
EC-620396	4.16	2.09	0.27	308.17	38.65
EC-538153	3.79	1.84	0.29	380.67	42.18
EC-620422	3.71	1.84	0.28	354.17	40.11
EC-620427	4.41	2.18	0.24	286.33	38.49
EC-631369	3.50	1.71	0.30	389.83	40.15
SE(m)	0.279	0.157	0.012	6.509	0.552
CD (p=0.05)	0.792	0.445	0.033	18.473	1.567

Each value of three replications

3.4 Correlation of biophysical parameters of different tomato genotypes against infestation of *T. absoluta* during *Rabi* 2016-17 and 2017-18
Results from various correlation studies of biophysical parameters in different genotypes were presented hereunder (Tables 4 to 8).

The significant positive correlation was observed between leaflet length, width and with the per cent infestation on leaflets, fruits and larvae per compound leaf whereas leaflet thickness, trichome density and SPAD Chlorophyll Meter Reading (SCMR) were found significant negative correlation.

The leaflet length and width were significantly lower in moderately resistant genotypes EC-620410, EC-620343 and EC-620401 with 2.68 cm and 1.31 cm, 2.74 cm and 1.44 cm and 3.06 cm and 1.63 cm, respectively whereas significantly higher in highly susceptible genotypes EC-160885 and EC-620433 with 7.08 cm and 3.13 cm and 6.35 cm and 3.01 cm, respectively.

The leaflet thickness and trichome density were significantly higher in moderately resistant genotypes EC-620410, EC-620401 and EC-620343 with 0.35 mm, 0.34 mm and 0.33 mm and 466.50, 408.66 and 431.67 per 0.25 cm^2, respectively, whereas significantly lower in highly susceptible genotype EC-160885 (0.18 mm and 128.17 per 0.25 cm^2, respectively).

The correlation studies of SPAD Chlorophyll Meter Reading (SCMR) with infestation of *T. absoluta* showed that there was a negative significant correlation between SCMR values and per cent infestation on leaflets, fruits and larvae per compound leaf. The moderately resistant genotypes EC-620410, EC-620401, EC-538153, EC-164577 with highest SCMR values of 44.40, 42.25, 42.18 and 41.78 respectively, with lowest *T. absoluta* infestation whereas highly susceptible

genotype EC-160885 recorded lowest SCMR values 31.91. We can hypothesise that presence of darker leaves (more SCMR values) probably have some negative effect on growth and metabolism of the larval population leading to lower infestation of *T. absoluta*.
The present results are close in agreement with the findings of Oliveira *et al.* (2012) [12] who found the genotypes with higher densities of glandular trichomes had greater resistance than the susceptible control. Similarly, Guedes and Picanco (2011) who reported as the source of *T. absoluta* resistance was the density of glandular trichomes on the leaves. Ecole *et al.* (2001) [6] found that the leaf density of glandular trichomes produce insecticidal compounds active towards larvae of *T. absoluta* leading to their effective control. Khederi *et al.* (2014) [11] reported that the most infested tomato genotypes (Mobil and Cal J N3) showed the lowest IV and VI trichome style ranks of leaf blade, vein and glandular trichomes. Significant negative relations were found between egg and larvae density with leaf I style trichome and also larvae and adult density with IV and V style trichomes.

Table 4: Correlation studies of leaflet length with per cent infestation of South American tomato leaf miner, *T. absoluta* on leaflets, number of larvae per compound leaf and per cent damage on fruits of different genotypes during *Rabi* 2016-17 and 2017-18

S. No.	Variable	Correlation Coefficient	Regression equation	R^2 Value
a.	Leaflet length (x) Vs per cent infestation on leaflets (y)	0.84**	Y= -1.86 + 4.41 x	0.71
b.	Leaflet length (x) Vs number of larvae/ compound leaf (y)	0.92**	Y= -0.67 + 0.49 x	0.85
c.	Leaflet length (x) Vs per cent damage on fruits (y)	0.97**	Y= -0.88 + 6.40 x	0.94

** Significant at 0.01 level

Table 5: Correlation studies of leaflet width with per cent infestation of South American tomato leaf miner, *T. absoluta* on leaflets, number of larvae per compound leaf and per cent damage on fruits of different genotypes during *Rabi* 2016-17 and 2017-18

S. No.	Variable	Correlation Coefficient	Regression equation	R^2 Value
a.	Leaflet width (x) Vs per cent infestation on leaflets (y)	0.84**	Y= -5.16+10.59 x	0.70
b.	Leaflet width (x) Vs number of larvae/compound leaf (y)	0.90**	Y= -1.02+1.17 x	0.81
c.	Leaflet width (x) Vs per cent damage on fruits (y)	0.96**	Y= -5.59+15.33 x	0.92

** Significant at the 0.01 level

Table 6: Correlation studies of leaflet thickness with per cent infestation of South American tomato leaf miner, *T. absoluta* on leaflets, number of larvae per compound leaf and per cent damage on fruits of different genotypes during *Rabi* 2016-17 and 2017-18

S. No.	Variable	Correlation Coefficient	Regression equation	R^2 Value
a.	Leaflet thickness (x) Vs per cent infestation on leaflets(y)	-0.80**	Y=48.99-115.76 x	0.64
b.	Leaflet thickness (x) Vs number of larvae/compound leaf (y)	-0.85**	Y= 4.95-12.68 x	0.72
c.	Leaflet thickness (x) Vs per cent damage on fruits(y)	-0.92**	Y= 73.31-169.48 x	0.86

** Significant at the 0.01 level

Table 7: Correlation studies of trichome density with per cent infestation of South American tomato leaf miner, *T. absoluta* on leaflets, number of larvae/compound leaf and per cent damage on fruits of different genotypes during *Rabi* 2016-17 and 2017-18

S. No.	Variable	Correlation Coefficient	Regression equation	R^2 Value
a.	Trichome density (x) Vs per cent infestation on leaflets (y)	-0.83**	Y= 36.71-0.06 x	0.68
b.	Trichome density (x) Vs number of larvae/compound leaf (y)	-0.89**	Y= 3.63-0.00 x	0.80
c.	Trichome density (x) Vs per cent damage on fruits (y)	-0.96**	Y=55.45-0.09 x	0.93

** Significant at the 0.01 level

Table 8: Correlation studies of SCMR with per cent infestation of South American tomato leaf miner, *T. absoluta* on leaflets, number of larvae per compound leaf and per cent damage on fruits of different genotypes during *Rabi* 2016-17 and 2017-18

S. No.	Variable	Correlation Coefficient	Regression equation	R^2 Value
a.	SCMR (x) Vs per cent infestation on leaflets (y)	-0.81*	Y= 72.20-1.41 x	0.66
b.	SCMR (x) Vs number of larvae/compound leaf (y)	-0.88**	Y= 7.62-0.15 x	0.78
c.	SCMR (x) Vs per cent damage on fruits (y)	-0.96**	Y= 108.51-2.10 x	0.92

* Significant at the 0.05 level
** Significant at the 0.01 level

4. Conclusions

The leaflet length and width were significantly lower in moderately resistant genotypes EC-620410, EC-620343 and EC-620401 with 2.68 cm and 1.31 cm, 2.74 cm and 1.44 cm and 3.06 cm and 1.63 cm, respectively whereas significantly higher in highly susceptible genotypes EC-160885 and EC-620433 with 7.08 cm and 3.13 cm and 6.35 cm and 3.01 cm, respectively. The leaflet thickness and trichome density were significantly higher in moderately resistant genotypes EC-620410, EC-620401 and EC-620343 with 0.35 mm, 0.34 mm and 0.33 mm and 466.50, 408.66 and 431.67 per 0.25 cm^2, respectively, whereas leaflet thickness and trichome density were significantly lower in highly susceptible genotype EC-160885 (0.18 mm and 128.17 per 0.25 cm^2, respectively).The moderately resistant genotypes EC-620410, EC-620401, EC-538153 and EC-164577 with highest SCMR values of 44.40, 42.25, 42.18, and 41.78, respectively, with lowest *T. absoluta* infestation whereas highly susceptible genotypes EC-620433 and EC-160885 recorded lowest SCMR values 31.99 and 31.91, respectively.
The significant positive correlation was observed between leaflet length, width and with the infestation of *T. absoluta* on leaflets, fruits and larvae per compound leaf whereas leaflet thickness, trichome density and SPAD chlorophyll meter reading (SCMR values) were found to be significant negative correlation.

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