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Biophysical and biochemical basis of resistance against thrips in table grape genotypes

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Abstract
An investigation was carried out for evaluating the table grape genotypes against incidence of thrips in Sector No. 70, UHS, Bagalkot, Karnataka after fore pruning (October) 2016. Results revealed that among 12 grape genotypes studied, significantly lowest thrips population was recorded in Red Globe (T12) during 29, 71 and 99 days after pruning (1.40, 4.08 and 3.28 thrips/shoot respectively). However, significantly highest population of thrips was recorded in Fantasy Seedless (T10) (4.08, 6.14 and 4.76 thrips/shoot) during 29, 71 and 99 DAP respectively. Correlation studies revealed that the incidence of thrips per shoot was significant and high positively correlated with sugar and amino acid. The incidence of thrips per shoot was significant and high negatively correlated with phenol and tannin. The incidence of thrips per shoot was positively correlated with leaf thickness.

Keywords: Table grape genotypes, Thrips, Sugar, Phenol, Amino acid, Tannin and Leaf thickness

1. Introduction

Grape (*Vitis vinifera* L.) belonging to the Vitaceae family, originated in Western Asia and Europe. It was introduced to India from Iran and Afghanistan by the Persian invaders in 1300 AD [7]. Grape is a non-climacteric fruit that grows on the perennial and deciduous woody climbing vine. Grape is a cross pollinated vine with simple, lobed, cut or toothed leaves (seldom compound) with racemes of greenish flowers, the fruit consisting of watery or fleshy pulp. The fresh grape berries are good source of sugars, carbohydrates, vitamins, proteins and minerals. Fruits are used for table purpose, wine, juice, raisins and canning. Fresh and dried fruits have various uses in Ayurveda and Umami medicine [12]. The fruits are considered to be laxative, stomachic, diuretic and cooling agents. The juice of unripe berries is used as an astringent in throat infections [12]. Tannins can also be extracted as a by-product from wine industry. It is an important fruit crop, earning foreign exchange. Grapes can be eaten as fresh or used for making jam, juice, jelly, vinegar, wine, grape seed extracts and grape seed oil. Approximately 71 per cent of world grape production is used for wine, 27 per cent as fresh fruit, and 2 per cent as dried fruit. However, in India, 90 per cent of the grape is used for table purpose, even though wine making has made strides [18]. The rest of the grapes are used mostly for raisin. It is widely grown in France, Italy, America, Africa, Australia, Algeria and India. The major grape growing states in India are Maharashtra (56.9%), Karnataka (21.8%), Andhra Pradesh (1.52%), Mizoram (3.05%) and Tamil Nadu (2.99%) accounting nearly 90 per cent of the total production [4]. In India, the current area and production under grapes is estimated as 121000 hectare with an annual production of 2597000 tonnes and productivity 27.9 tonnes per hectare. Maharashtra accounts for more than 80 per cent of the production and Karnataka stands second with area 21760 hectare and production of 420810 tonnes. Vijayapur is one of the major districts of Karnataka with area 8670 hectare and production 102790 tonnes in grape cultivation [4].

Extensive and intensive cultivation of grapes tend to attract various kinds of pests to the vineyards [2]. As many as 132 insects are known to attack grape vine in the world [8]. In India as many as 60 species of insects and a few mites have been found damaging vines [22]. Over 85 species of insects are known to occur on grapes in India [10]. As many as 26 pests infesting grapevine in Northern Karnataka [5]. Among various arthropod pests, thrips cause considerable damage to the grapes. Thrips, *Thrips hawaensis* (Morgan), *T. palmi* Karny, *Scirtothrips dorsalis* Hood and *Rhipiphorothrips cruentatus* Hood (Thysanoptera: Thripidae) are considered important pests of table grapes [3]. Thrips, adult and nymph cause damage by

rasping the lower surface of the leaf and sucking the oozing cell sap. They also attack blossoms and developing berries causing berry scarring. Three species of thrips namely, *T. hawaensis, T. palmi and S. dorsalis* were found infesting grapevine in Karnataka and Maharashtra [20]. Among the biochemical constituents sugar, phenol, amino acid, tannin and biophysical parameter like leaf thickness are responsible characters for incidence of sucking pests in different crops. However, information pertaining to varietal study, identification of possible biophysical and biochemical traits as sources of resistance against incidence of thrips on grapes is scanty. Keeping these points in view, the present investigation was undertaken to generate information on identification of thrips resistance sources in grapes.

2. Material and Methods

The experiment on biophysical and biochemical basis of resistance against thrips in grapes was conducted at Sector No. 70, UHS, Bagalkot during fore pruning 2016. Bagalkot is situated in northern dry zone of Karnataka state at 16.18°N latitude, 75.7°E longitude and at an altitude of 533 m above mean sea level; Bagalkot is considered to be a mild tropical region of Karnataka. The average rainfall of this area is about 683 mm, distributed over a period of 4 months from June to September with 25 rainy days. The average annual temperature of this area is 25.8 ºC.

The observations for thrips population in 12 grape genotypes were recorded at three phenological stages of crop (29, 71 and 99 DAP). Randomized Block Design was followed for recording the observations. Thrips population was recorded on five randomly selected shoots per vine by gently beating the canopy on to a stiff black paper board (30cm x 30cm). This procedure was repeated for five randomly selected and tagged vines for each genotype in whole orchard. All the 12 genotypes of grape which are harbouring different level of thrips infestation were studied separately for variations in leaf thickness. After fore pruning, the healthy leaf samples were collected simultaneously along with recording of thrips on 12 grape genotypes. Leaf thickness was recorded at three phenological stages of crop (29, 71 and 99 DAP). The leaves were sampled at the early morning hours *i.e.* before 09.00 AM from five selected vines of each genotype. From each vine, three leaves were sampled consisting one each from tagged shoots of 2nd (29 DAP), 6th (71 DAP) and 8th (99 DAP) nodes in respective stages of crop. In each leaf, six thin sections were used for recording of the leaf thickness by using a digital vernier calliper. Also healthy leaf samples were collected simultaneously along with recording of thrips in grapes and analyzed separately for different biochemical constituents like sugar [13], phenol [16], amino acid [17] and tannin [9] by following standard procedures. The leaves were sampled from the corresponding vines in the early morning hours *i.e.* before 09.00 AM and subjected to biochemical analysis. The biophysical and biochemical traits of tested genotypes of grape were analysed through one way ANOVA technique. An attempt was also made to correlate the biophysical and biochemical traits with incidence of thrips on different genotypes using statistiXL analysis tool. The treatment means were separated by using DMRT.

3. Results and Discussion

3.1 Incidence of thrips on shoots in different grape genotypes

Among 12 grape genotypes significantly lowest thrips population was recorded in Red Globe (T12) during 29, 71 and 99 DAP (1.40, 4.08 and 3.28 thrips/shoot respectively). However, significantly highest population of thrips was recorded in Fantasy Seedless (T10) (4.08, 6.14 and 4.76 thrips/shoot), followed by Kishmish Rozavis white (T4) (3.48, 6.06 and 4.60 thrips/shoot) during 29, 71 and 99 DAP respectively. In case of all the genotypes the peak population was recorded during 71 DAP, which coincided with flowering period (Table 1). The findings of the present study are also in partial agreement with the findings of Kulakarni *et al.* (2007) [15] who stated that thrips population was with an average peak of 8-10 thrips per shoot in November and December months which coincided with flowering period. Schwartz (1988) [21] also reported that the infestation of *Thrips tabaci* Lindeman were maximum in three table grape cultivars during the blossom stage (Fig. 1).

3.2 Biochemical constituents in different grape genotypes

For evaluating grape genotypes against incidence of thrips the biochemical study was carried out and discussed here under (Table 2).

3.2.1 Sugar

The concentration of sugar (mg/g) in leaf was found to vary significantly across the genotypes. Among the genotypes, significantly lowest sugar was recorded with genotype Red Globe (T12) during 29, 71 and 99 DAP (1.71, 2.16 and 2.09 mg/g of leaf respectively), which supported lowest thrips population. Whereas, significantly highest sugar was found with genotype, Fantasy Seedless (T10) during 29, 71 and 99 DAP (2.53, 5.73 and 3.53 mg/g of leaf respectively), which supported highest thrips population. Similar variation across the genotypes of groundnut with respect to sugar content was observed by Chakravarthy *et al*. (2013) [11]. He found that genotypes having high sugar content supported more number of thrips.

3.2.2 Phenol

The concentration of phenol (mg/g) in leaf was found to vary significantly across the genotypes. Among the genotypes, the significantly highest phenol was found with genotype, Red Globe (T12) during 29, 71 and 99 DAP (2.11, 3.78 and 4.65 mg/g of leaf respectively), which supported lowest thrips population. Significantly lowest phenol was recorded with genotype Fantasy Seedless (T10) during 29, 71 and 99 DAP (1.21, 1.36 and 3.08 mg/g of leaf respectively), which supported highest thrips population. These results are in conformity with the findings made by Nishanth *et al.* (2016) [19] on cotton. He reported phenol as resistance source in cotton germplasms by reducing thrips load on leaf.

3.2.3 Amino acid

The concentration of amino acid (µg/g) in leaf was found to vary significantly across the genotypes. Among the genotypes, significantly lowest amino acid was recorded in Red Globe (T12) (110.4, 191.4 and 109.6 µg/g of leaf during 29, 71 and 99 DAP respectively), which supported lowest thrips population. Whereas, the significantly highest amino acid in Fantasy Seedless (T10) (227.2, 435.4 and 348.6 µg/g of leaf during 29, 71 and 99 DAP respectively), which supported highest thrips population. Present results are in line with Kandakoor *et al.* (2014) [14] who observed variation across the genotypes with respect to amino acid in groundnut. He found amino acid to be positively correlated with incidence of thrips.

3.2.4 Tannin
The concentration of tannin (µg/g) in leaf was found to vary significantly across the genotypes. Among the genotypes significantly highest tannin was found with genotype Red Globe (T12) during 29, 71 and 99 DAP (157.2, 133.8 and 203.6 µg/g of leaf respectively), which supported lowest thrips population. Whereas, lowest tannin was recorded with genotype *viz.*, Fantasy Seedless (T10) during 29, 71 and 99 DAP (31.2, 60.4 and 51.2 µg/g of leaf respectively), which supported highest thrips population. Present results are in line with findings of Acharya and Singh (2008) [1] who reported lowest thrips population in cotton germplasms having high tannin content.

3.3 Biophysical parameters in different grape genotypes
The biophysical traits of leaf such as leaf thickness play a major role in arresting the movement in oviposition, feeding and development of insect pests. In this study, the possible biophysical trait such as leaf thickness was recorded for all the genotypes during the course of investigation. The leaf thickness varied significantly between the genotypes of grape studied. The present results were discussed here under (Table 3).

3.3.1 Leaf thickness
The leaf thickness varied significantly among the genotypes of grape. Significantly lowest leaf thickness was recorded with genotypes Crimson Seedless (T11) (110.4 µm), followed by Flame Seedless (T7) (116.2 µm) during 99 DAP. Significantly highest leaf thickness was recorded with the genotypes, Manik Chaman (T5) (141.4 µm), followed by Sharad Seedless (T8) (132.6 µm) during 99 DAP. The mean thrips population in Crimson Seedless was significantly lowest compared to Manik Chaman. From this finding it was revealed that thrips prefer leaves with more thickness. Similar kind of variation in leaf thickness was also observed by Bergh and Blanc (1997) [6] in miniature rose for egg laying and larval development of *Frankliniella occidentalis* (Pergande).

3.4 Correlation coefficients between biochemical, biophysical traits and incidence of thrips on grapes genotypes
The incidence of thrips on grape genotypes were correlated with the biochemical (sugar, phenol, amino acid and tannin), biophysical (leaf thickness) traits and are presented in Table 4 to 6.

3.4.1 Correlation after 29 days of pruning
The incidence of thrips per shoot was significant and high positively correlated with amino acid (r= 0.931), followed by sugar (r= 0.927). The incidence of thrips per shoot was significant and high negatively correlated with tannin (r= -0.967), followed by phenol (r= -0.854). The incidence of thrips per shoot was non-significant and positively correlated with leaf thickness (r= 0.225) (Table 4).

3.4.2 Correlation after 71 days of pruning
The incidence of thrips per shoot was significant and positively correlated with amino acid (r= 0.824), followed by sugar (r= 0.798). The incidence of thrips per shoot was significant and negatively correlated with phenol (r= -0.812), followed by tannin (r= -0.809). The incidence of thrips per shoot was significant and positively correlated with leaf thickness (r= 0.414) (Table 5).

3.4.3 Correlation after 99 days of pruning
The incidence of thrips per shoot was significant and positively correlated with amino acid (r= 0.927), followed by sugar (r= 0.837). The incidence of thrips per shoot was significant and negatively correlated tannin (r= -0.948), followed by phenol (r= -0.881). The incidence of thrips per shoot was non-significant and positively correlated with leaf thickness (r= 0.222) (Table 6).

Table 1: Incidence of thrips on different grape genotypes in different phenological stages (on shoots) during fore pruning.

Sl. No.	Genotypes	Number of thrips/shoot * Days after pruning (DAP)			Mean
		29 DAP	71 DAP	99 DAP	
T1	Thompson Seedless	2.80 (1.82)^{cde}	5.64 (2.48)^{bcde}	4.16 (2.16)^{bcd}	4.20
T2	Manjri Naveen	2.28 (1.67)^{b}	4.92 (2.33)^{ab}	3.52 (2.00)^{ab}	3.57
T3	2A Clone	2.88 (1.84)^{cdef}	5.46 (2.44)^{bcde}	4.20 (2.17)^{bcd}	4.18
T4	Kishmish Rozavis white	3.48 (1.99)^{g}	6.06 (2.56)^{cde}	4.60 (2.26)^{d}	4.71
T5	Manik Chaman	3.16 (1.91)^{efg}	5.34 (2.42)^{bcde}	4.36 (2.20)^{cd}	4.29
T6	Sonaka	3.04 (1.88)^{defg}	5.94 (2.54)^{bcde}	4.2 (2.17)^{bcd}	4.39
T7	Flame Seedless	3.28 (1.94)^{efg}	5.84 (2.52)^{bcde}	4.52 (2.24)^{d}	4.55
T8	Sharad Seedless	2.44 (1.71)^{bc}	5.02 (2.35)^{abc}	3.72 (2.05)^{abc}	3.73
T9	Krishna Sharad	2.56 (1.75)^{bcd}	5.12 (2.37)^{bcde}	3.98 (2.12)^{bcd}	3.89
T10	Fantasy Seedless	4.08 (2.14)^{h}	6.14 (2.58)^{e}	4.76 (2.29)^{d}	4.99
T11	Crimson Seedless	3.04 (1.88)^{defg}	5.08 (2.36)^{bcd}	4.28 (2.19)^{cd}	4.13
T12	Red Globe	1.40 (1.38)^{a}	4.08 (2.14)^{a}	3.28 (1.94)^{a}	2.92
	S.Em±	0.05	0.07	0.06	
	C.D. at 5%	0.14	0.21	0.17	
	CV (%)	6.40	6.90	6.32	

Each value is the mean of five replications
*Figures in parenthesis indicate square root (x+0.5) transformed values
Figures in each column followed by same alphabet (s) are not significantly different (P=0.05)

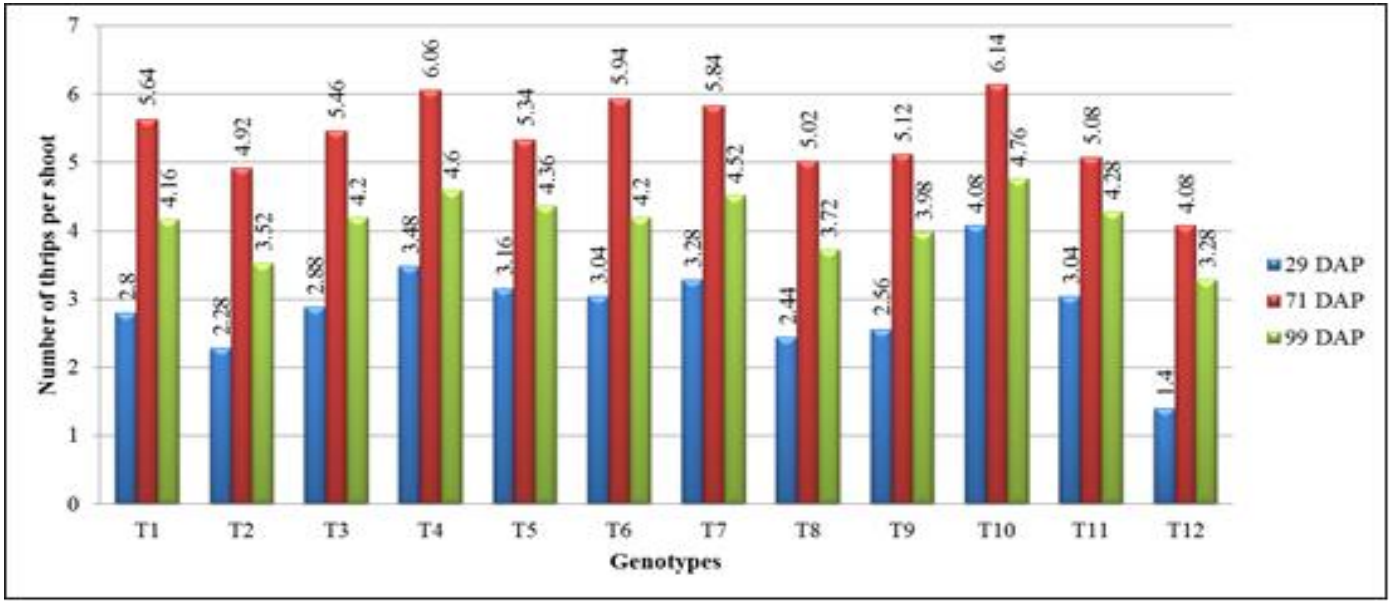

Fig 1: Incidence of thrips on different grape genotypes at different phenological stages (on shoots) during fore pruning. T1-Thompson Seedless, T2-Manjari Naveen, T3-2A Clone, T4-Kishmish Rozavis white, T5-Manik Chaman, T6-Sonaka, T7-Flame Seedless, T8-Sharad Seedless, T9-Krishna Sharad, T10-Fantasy Seedless, T11-Crimson Seedless, T12-Red Globe DAP: Days after pruning

Table 2: Biochemical constituents in leaves in grape genotypes in different phenological stages during fore pruning

Sl. No.	Genotypes	29 DAP					71 DAP					99 DAP				
		Number of thrips/shoot	Sugar (mg/g)	Phenol (mg/g)	Amino acid(µg/g)	Tannin (µg/g)	Number of thrips/shoot	Sugar (mg/g)	Phenol (mg/g)	Amino acid(µg/g)	Tannin (µg/g)	Number of thrips/shoot	Sugar (mg/g)	Phenol (mg/g)	Amino acid(µg/g)	Tannin (µg/g)
T1	Thompson Seedless	2.80 (1.82)^{cde}	2.13^{d}	1.96^{c}	160.4^{c}	80.2^{e}	5.64 (2.48)^{bcde}	2.86^{d}	2.89^{e}	301.8^{d}	110.2^{c}	4.16 (2.16)^{bcd}	2.16^{b}	4.51^{a}	194.6^{e}	138.4^{d}
T2	Manjri Naveen	2.28 (1.67)^{b}	1.71^{a}	2.05^{b}	119.2^{b}	105.6^{b}	4.92 (2.33)^{ab}	2.22^{a}	3.54^{b}	199.6^{a}	128.4^{a}	3.52 (2.00)^{ab}	2.12^{ab}	4.53^{a}	156.6^{b}	158.2^{b}
T3	2A Clone	2.88 (1.84)^{cdef}	2.13^{d}	1.72^{d}	179.2^{d}	79.6^{e}	5.46 (2.44)^{bcde}	3.05^{e}	2.63^{f}	304.2^{d}	88.2^{d}	4.20 (2.17)^{bcd}	2.25^{c}	4.14^{b}	213.2^{f}	135.6^{de}
T4	Kishmish Rozavis white	3.48 (1.99)^{g}	2.52^{g}	1.23^{hi}	213.2^{g}	35.4^{hi}	6.06 (2.56)^{cde}	4.90^{j}	1.53^{k}	433.2^{f}	64.2^{h}	4.60 (2.26)^{d}	3.10^{gh}	3.63^{d}	281.1^{i}	74.4^{h}
T5	Manik Chaman	3.16 (1.91)^{efg}	2.31^{c}	1.29^{g}	180.8^{de}	58.1^{g}	5.34 (2.42)^{bcde}	3.80^{h}	1.82^{i}	349.4^{e}	73.2^{fg}	4.36 (2.20)^{cd}	2.70^{f}	3.81^{cd}	223.4^{fg}	93.6^{f}
T6	Sonaka	3.04 (1.88)^{defg}	2.16^{d}	1.54^{e}	179.4^{d}	79.6^{e}	5.94 (2.54)^{bcde}	3.56^{f}	2.32^{g}	307.2^{d}	81.4^{e}	4.2 (2.17)^{bcd}	2.39^{d}	3.86^{c}	218.4^{fg}	132.2^{e}
T7	Flame Seedless	3.28 (1.94)^{efg}	2.38^{f}	1.27^{gh}	207.6^{f}	39.8^{h}	5.84 (2.52)^{bcde}	4.70^{i}	1.63^{j}	430.8^{f}	72.4^{g}	4.52 (2.24)^{d}	3.07^{g}	3.72^{cd}	231.4^{h}	84.2^{g}
T8	Sharad Seedless	2.44 (1.71)^{bc}	1.86^{b}	2.05^{b}	119.4^{b}	95.02^{c}	5.02 (2.35)^{abc}	2.53^{b}	3.42^{c}	245.8^{b}	118.2^{b}	3.72 (2.05)^{abc}	2.12^{ab}	4.52^{a}	160.8^{bc}	149.6^{c}
T9	Krishna Sharad	2.56 (1.75)^{bcd}	1.93^{c}	2.01^{bc}	160.02^{c}	89.2^{d}	5.12 (2.37)^{bcde}	2.61^{c}	3.12^{d}	270.1^{c}	116.8^{b}	3.98 (2.12)^{bcd}	2.15^{ab}	4.51^{a}	179.4^{d}	140.3^{d}
T10	Fantasy Seedless	4.08 (2.14)^{h}	2.53^{g}	1.21^{i}	227.2^{h}	31.2^{i}	6.14 (2.58)^{e}	5.37^{k}	1.36^{l}	435.4^{f}	60.4^{h}	4.76 (2.29)^{d}	3.53^{i}	3.08^{e}	348.6^{j}	51.2^{i}
T11	Crimson Seedless	3.04 (1.88)^{defg}	2.28^{e}	1.34^{f}	180.4^{de}	63.8^{f}	5.08 (2.36)^{bcd}	3.73^{g}	2.15^{h}	316.4^{d}	79.2^{ef}	4.28 (2.19)^{cd}	2.52^{e}	3.81^{cd}	220.6^{fg}	94.4^{f}
T12	Red Globe	1.40 (1.38)^{a}	1.71^{a}	2.11^{a}	110.4^{a}	157.2^{a}	4.08 (2.14)^{a}	2.16^{a}	3.78^{a}	191.4^{a}	133.8^{a}	3.28 (1.94)^{a}	2.09^{a}	4.65^{a}	109.6^{a}	203.6^{a}
	S.Em±	0.05	0.01	0.01	2.08	1.69	0.07	0.02	0.01	5.95	2.04	0.06	0.02	0.07	2.02	2.05
	C.D. at 5%	0.14	0.05	0.05	5.94	4.84	0.21	0.06	0.04	16.96	5.82	0.17	0.06	0.20	5.75	5.86
	CV (%)	6.40	5.86	5.53	7.74	5.98	6.90	6.09	5.31	7.11	6.86	6.32	5.36	6.93	6.13	7.79

Each value is the mean of five replications

Figures in each column followed by same alphabet (s) are not significantly different (p= 0.05)

Table 3: Biophysical parameters of grape genotypes in different phenological stages during fore pruning.

Sl. No.	Genotypes	29 DAP		71 DAP		99 DAP	
		Number of thrips/shoot	Leaf thickness(µm)*	Number of thrips/shoot	Leaf thickness(µm)**	Number of thrips/shoot	Leaf thickness(µm)***
T1	Thompson Seedless	2.80 (1.82)^{cde}	74.6 (8.67)^{a}	5.64 (2.48)^{bcde}	90.4 (9.53)^{bc}	4.16 (2.16)^{bcd}	125.8 (11.24)^{d}
T2	Manjri Naveen	2.28 (1.67)^{b}	80.2 (8.98)^{bc}	4.92 (2.33)^{ab}	104.2 (10.23)^{e}	3.52 (2.00)^{ab}	114.8 (10.74)^{ab}
T3	2A Clone	2.88 (1.84)^{cdef}	76.8 (8.79)^{ab}	5.46 (2.44)^{bcde}	95.6 (9.80)^{d}	4.20 (2.17)^{bcd}	112.8 (10.64)^{ab}
T4	Kishmish Rozavis white	3.48 (1.99)^{g}	89.8 (9.50)^{ef}	6.06 (2.56)^{cde}	105.8 (10.31)^{ef}	4.60 (2.26)^{d}	136.2 (11.69)^{ef}
T5	Manik Chaman	3.16 (1.91)^{efg}	93.2 (9.68)^{fg}	5.34 (2.42)^{bcde}	110.8 (10.55)^{f}	4.36 (2.20)^{cd}	141.4 (11.91)^{f}
T6	Sonaka	3.04 (1.88)^{defg}	83.8 (9.18)^{cd}	5.94 (2.54)^{bcde}	96.2 (9.83)^{d}	4.2 (2.17)^{bcd}	125.2 (11.21)^{d}
T7	Flame Seedless	3.28 (1.94)^{efg}	75.3 (8.70)^{a}	5.84 (2.52)^{bcde}	87.6 (9.39)^{ab}	4.52 (2.24)^{d}	116.2 (10.80)^{bc}
T8	Sharad Seedless	2.44 (1.71)^{bc}	95.2 (9.78)^{g}	5.02 (2.35)^{abc}	104.2 (10.23)^{e}	3.72 (2.05)^{abc}	132.6 (11.54)^{a}
T9	Krishna Sharad	2.56 (1.75)^{bcd}	85.2 (9.26)^{de}	5.12 (2.37)^{bcde}	94.5 (9.74)^{cd}	3.98 (2.12)^{bcd}	110.6 (10.54)^{e}
T10	Fantasy Seedless	4.08 (2.14)^{h}	85.6 (9.27)^{de}	6.14 (2.58)^{e}	104.4 (10.24)^{e}	4.76 (2.29)^{d}	124.6 (11.18)^{d}
T11	Crimson Seedless	3.04 (1.88)^{defg}	76.2 (8.76)^{ab}	5.08 (2.36)^{bcd}	85.6 (9.28)^{a}	4.28 (2.19)^{cd}	110.4 (10.53)^{a}
T12	Red Globe	1.40 (1.38)^{a}	88.2 (9.42)^{de}	4.08 (2.14)^{a}	109.6 (10.49)^{f}	3.28 (1.94)^{a}	121.3 (11.03)^{cd}
	S.Em±	0.05	0.08	0.07	0.08	0.06	0.08
	C.D. at 5%	0.14	0.25	0.21	0.24	0.17	0.24
	CV (%)	6.40	7.16	6.90	8.94	6.32	5.73

*Second node **Sixth node ***Eighth node

Each value is the mean of five replications Figures in parenthesis indicate square root (x+0.5) transformed values

Figures in each column followed by same alphabet (s) are not significantly different (P=0.05)

Table 4: Correlation for number of thrips per shoot with its components in grape genotypes after 29 days of fore pruning.

	Thrips incidence	Sugar	Phenol	Amino acid	Tannin	Leaf thickness
Thrips incidence	**1**					
Sugar	0.927**	**1**				
Phenol	-0.854**	-0.936**	**1**			
Amino acid	0.931**	0.966**	-0.90**	**1**		
Tannin	-0.967**	-0.928**	0.863**	-0.917**	**1**	
Leaf thickness	0.225^{NS}	0.314*	-0.254*	0.141^{NS}	-0.223^{NS}	**1**

Critical r @ 1% = 0.325 Critical r @ 5% = 0.250 *Significant at 5% ** Significant at 1%

Table 5: Correlation for number of thrips per shoot with its components in grape genotypes after 71 days of fore pruning.

	Thrips incidence	Sugar	Phenol	Amino acid	Tannin	Leaf thickness
Thrips incidence	**1**					
Sugar	0.798**	**1**				
Phenol	-0.812**	-0.966**	**1**			
Amino acid	0.824**	0.972**	-0.931**	**1**		
Tannin	-0.803**	-0.937**	0.983**	-0.891**	**1**	
Leaf thickness	0.414**	0.342**	-0.325**	0.344**	-0.306*	**1**

Critical r @ 1% = 0.325 Critical r @ 5% = 0.250 *Significant at 5% ** Significant at 1%

Table 6: Correlation for number of thrips per shoot with its components in grape genotypes after 99 days of fore pruning.

	Thrips incidence	Sugar	Phenol	Amino acid	Tannin	Leaf thickness
Thrips incidence	**1**					
Sugar	0.837**	**1**				
Phenol	-0.881**	-0.936**	**1**			
Amino acid	0.927**	0.905**	-0.935**	**1**		
Tannin	-0.948**	-0.902**	0.917**	-0.932**	**1**	
Leaf thickness	0.222^{NS}	0.278*	-0.229^{NS}	0.233^{NS}	-0.240^{NS}	**1**

Critical r @ 1% = 0.325 Critical r @ 5% = 0.250 *Significant at 5% ** Significant at 1%

4. Conclusions

The strong correlation was found between incidence of thrips and biochemical traits of leaves in grape genotypes. Among the biochemical traits, sugar and amino acid in leaves exhibited significant positive correlation with incidence of thrips, while phenol and tannin in leaves showed significant negative correlation. The leaf thickness varied significantly between the genotypes of grape. Though non-significant correlation was observed between the incidence of thrips and leaf thickness, it exhibited a positive correlation with the incidence of thrips.

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6. References

1. Acharya VS, Singh AP. Biochemical basis of resistance in cotton to the whitefly, *Bemisia tabaci* Genn. Journal of Cotton Research and Development. 2008; 22(2):195-199.
2. Alexandri AA. Efficacy of some insecticides in the control of moth, *Polychrosis botrana* Schieff Rouman. Annales Institute Cerc Penttu Plant Protection. 1973; 9:507-514.
3. Ananthakrishnan TN. Thrips (Thysanoptera) in agriculture and forestry-diagnosis, bionomics and control. Journal of Science and Indian Research. 1971; 30:113-146.
4. Anonymous. Area and production 2014-15. IG printers Pvt. Ltd., 105, DSIDC, Okhla, phase I, New Delhi, 2016, 21. http://www.NHBdatabase.com
5. Balikai RA, Kotikal YK. Pest status of grapevine in northern Karnataka. Agricultural Science Digest. 2003; 23(4):276-278.
6. Bergh JC, Blanc JPR. Performance of western flower thrips (Thysanoptera; Thripidae) on cultivars of miniature rose. Journal of Economic Entomology. 1997; 90(2):679-688.
7. Bose TK, Mitra SK, Farooqi AA, Sadhu MK. Grapes. Tropical Horticulture, Naya Prakash, Calcutta, India, 1999, 259-268.
8. Bournier A. Grape insects. Annual Review of Entomology. 1977; 22:355-376.
9. Burn RE. Method for estimation for tannin in grain sorghum. Agronomical Journal. 1971; 63:511-512.
10. Butani DK. Insects and fruits. Periodical Export Book Agency, New Delhi, 1979, 398.
11. Chakravarthy AK, Kandakoor BS, Khan KH, Kumar ACT, Venkataravana P. Biochemical constituents influencing thrips resistance in groundnut germplasm. Journal of Environment Biology. 2013; 35:675-681.
12. Dry PR, Hand PG, Ristic R. What is Vine Balance? Proceedings of 12th Australian Wine Industry Technical Conference, Melbourne, Victoria, Australia, 2004, 68-74.
13. Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F. Colorimetric method for determination of sugars and related substances. Analytical Chemistry. 1956; 28(3):350-356.
14. Kandakoor SB, Khan HK, Chakravarthy AK, Kumar CTA, Venkataravana P. Biochemical constituents influencing thrips resistance in groundnut germplasm. Journal of Environment Biology. 2014; 35:675-681.
15. Kulakarni NS, Sawant SD, Adsule PG. Seasonal incidence of insect pests on grapevine its correlation with the weather parameters. Acta Horticulture. 2007; 785:313-320.
16. Mallick CP, Singh MB. Plant enzymology and histoenzymology, Kalyani publishers, New Delhi, 1980, 286.
17. Moore S, Stein WH. A modified ninhydrin reagent for the photometric determination of amino acids and related compounds. Journal of Biological Chemistry. 1958; 211:907-913.
18. Nimbalkar SS, Bansode PS. Management of grapes export to UK and Netherland by Abhinav Drakasha Utpadak Sahakari Sanstha, Agar in Pune district. Agriculture Update. 2013; 8(3):371-377
19. Nishanth GK, Harijan Y, Katageri IS. Screening for sucking pests (thrips and jassids) resistance/tolerance in cotton germplasm lines (Gossypium hirsutum L.). International Quarterly Journal of Life Science. 2016; 11(1):85-91.
20. Ranganath HR, Krishna Kumar NK, Vikas Kumar. Thrips species composition on grapes in Karnataka and Maharashtra. Journal of Horticultural Science. 2008; 3(2):172-175.
21. Schwartz A. Population dynamics of *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) on table grapes. South Africa Journal of Enology and Viticulture. 1988; 9(1):19-21.
22. Wadhi SR, Batra HN. Pests of tropical and subtropical fruit trees. In Entomology in India, Ed. Pant NC, The Entomological Society of India, New Delhi, 1964, 227-260.