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Berry weight, quality and cane biochemistry changes in relation to cane thickness of own-rooted and grafted 'Tas-A-Ganesh' grape

R.G. Somkuwar, J. Satisha and S.D. Ramteke
National Research Centre for Grapes
P.O. Box 03, Manjri Farm Post, Pune - 412 307, India
E-mail : rgsgrapes@gmail.com

ABSTRACT

A field trial was conducted to determine the effect of cane thickness on berry quality and other biochemical parameters in 'Tas-A-Ganesh' grape at National Research Centre for Grapes, Pune, during the year 2008- 2009. Average bunch weight increased with increase in cane diameter. Own-rooted vines of cane thickness <6mm sprouted earlier than thicker canes. TSS of berries decreased with increase in berry size. Berries on grafted vines recorded lower TSS than on own-rooted vines. Biochemical parameters such as content of reducing sugars, carbohydrat and phenols were higher in grafted vines of cane thickness >10mm. Results indicate that thicker canes either on their own roots or on grafted vines are superior for yield and yield components, as also for physical properties of bunches and berries and total carbohydrate content of the canes.

Key words: Tas-A-Ganesh, sprouting, cane thickness, bunch weight, total soluble solids, reducing sugars, carbohydrates

INTRODUCTION

Grape (*Vitis vinifera* L.) is among the important fruit crops of our country, grown on an area of 1,11,000ha with annual production of 12,35,000t (Anon., 2012). In India, 74.5% of the grapes produced are used for table purpose, nearly 22.5% are dried for raisin making, 1.5% for wine making and 0.5% are used for juice making. It is known that the best grapes come from vineyards where vegetative growth and crop yield are balanced (Dry *et al*, 2004). Vine balance was defined by Gladstones (1992) stating, that "balance is achieved when vegetative vigour and fruit load are in equilibrium and consistent with high fruit quality."

In several studies on treatment-induced differences in grapevine productivity, yield components were analyzed to specify the developmental stages involved (May *et al*, 1976; Tafazoh, 1977; Cawthon and Morris, 1977; Scholefield *et al*, 1977a, 1977b; Shaulis, 1980; Pool, 1982). In these studies, effects of developmental stages on yield and its components were analyzed. Some of the practices like retention of specific number of canes per vine, and removal of leaves and bunches to achieve production of quality grapes from a unit area, need to be accorded priority. Information on source:sink alteration on berry development and quality, with respect to biochemical constituents in table grapes, is lacking. Therefore, the present study purports to focus on effects of cane thicknes of own-rooted and grafted vines in relation to yield and quality parameter in 'Tas-A-Ganesh' grape.

MATERIAL AND METHODS

The study was conducted at National Research Centre for Grapes, Pune, during the year 2008- 2009. Rootstock 'Dogridge' was planted during March 2000 along with own-rooted vines, and grafting of 'Tas-A-Ganesh' grape was effected in October, 2000. The experimental site is situated in Mid-West Maharashtra at an altitude of 559m above MSL at 18.32°N latitude and 73.51°E longitude. Pune has tropical wet and dry climate, with average temperatures ranging from 20 to 28°C. The vines were trained on four cordons on a horizontally divided canopy trellis with vertical shoot positioning. Height of the cordon from ground surface was 1.2m separated by 0.6m wide cross-arms. Distance from the fruiting wire to top of the foliage support wire was 0.6m. The vines were planted at a spacing of 3.0m between rows and 1.83m between vines, providing a density of 1815 vines per hectare.

Since the region falls under a tropical belt, double pruning and single cropping is practiced. The vines were, therefore pruned twice a year (back-pruning and forwardpruning). The experiment was laid out in Randomized Block Design, with four treatments of shoot diameter replicated five times. After back-pruning, approximately 80-100 shoots emerge with varying thickness on the four cordons of the vine. Shoot-thinning was performed at the 7-leaf stage. Retention of proportionate shoots of <6mm, 6-8mm, 8-10mm and >10mm diameter at shoot-thinning was done on both grafted and own-rooted vines. Each replication had five vines. Three vines with uniform shoots on each cordon and with fruitful canes were tagged and labelled for recording data in each replication. Standard recommended cultural practices were followed during the period of study. Observations on yield per vine were recorded after harvest.

Total phenolic content was determined using Folin-Ciocalteu method, using 4-methylcatechol as the standard. Concentration of phenolics was expressed as catechol equivalent (mg/g) of the lyophilized sample. Reducing sugars were estimated by dinitrosalicylic acid (DNSA) method, while total carbohydrates were estimated by Anthrone method, using D-glucose as the standard. Protein was estimated using the method of Lowry *et al* (1951). Total protein content was expressed as Bovine Serum Albumin Fraction-V equivalent (mg/g). Standard reference-chemicals like D-glucose, 4-methylcatechol, Bovine serum albumin, etc. used in the study were obtained from SD Fine Chemicals, Ltd., Mumbai (India). All other buffers and chemicals used were of AR grade from Merck Pvt. Ltd. Data were analyzed using the SAS model (version 9.3).

RESULTS AND DISCUSSION

Effect of cane thickness on vegetative growth and bunch weight

Observations recorded on vegetative traits are presented in Table 1. Significant differences were recorded for days to bud-sprout, bunch weight, berry weight, TSS and acidity. Own-rooted 'Tas-A-Ganesh' grapevines were earlier to sprout (9.33 days) than vines grafted on 'Dogridge' rootstock (10.58 days). Among own-rooted vines, thin canes (<6mm diameter) sprouted in 7.6 days, followed by 6-8mm (8.53), 8-10mm (10.13) and >10mm thick canes (11.06), respectively. The same trend was observed in grafted vines. These results are in conformity with those of Satisha *et al* (2010) who also reported early sprouting of own-rooted 'Thompson Seedless' grape compared to grafted vines. Interaction effect was also found to be significant. Prakash and Reddy (1990) compared the effect of different rootstocks for bud-sprout and reported that number of days required for bud-break was shorter when 'Gulabi' (Isabella)

Table 1. Effect of cane thickness on berry and bunch characters in 'Tas-A-Ganesh' grape

Parameter	Days to bud sprout	Av. bunch wt (g)	Av. berry wt (g)	Berry diameter (mm)	Berry length (mm)	TSS (^{0}Brix)	Acidity (%)
Factor-A							
Grafted	10.58	371.77	2.94	16.40	21.03	20.49	0.30
Own root	9.33	275.02	2.56	16.53	21.00	21.14	0.32
SEm±	0.0457	3.219	0.021	0.232	0.133	0.067	0.003
CD (*P=0.05*)	0.580	40.193	0.266	NS	NS	0.851	0.038
Factor-B							
<6 mm	8.66	258.05	2.43	14.89	19.68	21.62	0.32
6-8 mm	9.58	299.70	2.49	16.06	20.52	21.54	0.29
8-10mm	10.41	335.95	2.79	17.17	22.08	21.42	0.31
>10mm	11.16	399.88	3.28	17.76	21.78	18.70	0.30
SEm±	0.0646	4.553	0.030	0.328	0.189	0.094	0.004
CD (*P=0.05*)	0.205	14.48	0.09	1.043	0.601	0.299	0.0127
Interaction A x B							
Grafted							
Grafted <6mm	9.73	288.56	2.50	15.73	20.10	20.73	0.26
Grafted 6-8mm	10.64	320.14	2.63	16.60	21.43	20.40	0.30
Grafted 8-10mm	10.70	385.34	3.09	16.50	22.46	21.33	0.30
Grafted >10mm	11.27	493.04	3.54	16.80	20.13	19.53	0.33
Own root							
Own root <6mm	7.60	227.55	2.37	14.06	19.26	22.52	0.38
Own root 6-8mm	8.53	279.26	2.35	15.53	19.62	22.68	0.29
Own root 8-10mm	10.13	286.56	2.50	17.84	21.70	21.51	0.31
Own root >10mm	11.06	306.72	3.02	18.72	23.44	17.87	0.28
SEm±	0.0914	6.439	0.043	0.464	0.267	0.134	0.006
CD (*P=0.05*)	0.290	20.48	0.136	1.476	0.849	0.426	0.019

was used as the rootstock, and was longer in vines grafted on ‘Dogridge’. In grafted vines, higher bunch weight (371.77g) and berry weight (2.94g) were recorded compared to own-rooted vines (275.02g and 2.65g, respectively). Among grafted vines, higher cane thickness resulted in higher average bunch-weight and berry-weight compared to thinner canes. The same trend was observed in own-rooted vines, with varying cane thickness. This could be due to the influence of rootstock in increasing food reserves in the canes, thus increasing berry- and bunch-weight. Increase in bunch weight directly relates to total yield per vine. Though yield per vine in this case is not reported, there appears to be a direct impact on total yield per vine. Hedberg *et al* (1986) reported that ‘Shiraz’ vines grafted on ‘Ramsey’ and ‘Dogridge’ rootstocks outyielded ungrafted vines by 46 and 48%, respectively. They reported ability of ‘Dogridge’ rootstock to produce yields as high as those with ‘Ramsey’ highlighting the importance of adequate pruning level to enable full potential of the rootstocks to be realized. Ferree *et al* (1996) reported increased yield in grafted ‘Cabernet Franc’ and ‘White Riesling’ over own-rooted vines.

Differences for berry-diameter and berry-length among grafted and own-rooted vines were found to be non-significant. However, interaction effect among cane thickness, and grafted versus own-rooted vines, varied significantly. Among canes of varying thickness in grafted vines, higher berry diameter (16.80mm) was recorded in canes with thickness of >10mm diameter, whereas, minimum berry-diameter (15.73mm) was recorded in thin canes (<6mm). Among own-rooted vines, berry diameter increased significantly with increase in cane thickness. Differences in berry diameter with varying cane thickness may be due to higher amount of reserve food material in thicker canes. These findings are supported by Rizk-All *et al* (2011) who reported that grafting ensured best vegetative growth, improved efficiency of nutrient uptake and increased total chlorophyll content of leaves and total carbohydrates of canes, in comparison with ungrafted vines. Significant differences were recorded for total soluble solids in grape berries on own-rooted and grafted vines. Higher amount of total soluble solids was recorded in own-rooted vines (21.14^{0}Brix) over grafted vines (20.49^{0}Brix). Among variable cane thickness in own-rooted vines, TSS ranged from 17.87^{0}Brix in >10mm thick cane, to 22.68^{0}Brix in 6-8mm thick canes. However, in grafted vines, TSS ranged from 19.53^{0}Brix (>10mm thick canes) to 21.33^{0}Brix (8-10mm thick canes). In the present study, it was observed that TSS was lower in grafted vines than in own-rooted vines. TSS was also found to decrease with increase in cane thickness. Acidity varied significantly among different treatments and their interactions. This is perhaps be due to the fact that grafted vines impart more vigour to a crop than own-rooted vines. Increased vigour helps the vine protect its bunches from direct sunlight. Protected bunches under the canopy show lower TSS. Influence of rootstock on fruit composition has been reported by several workers, especially in relation to wine grapes, with a close link between fruit quality and wine made from those fruits. Fruit composition parameters that eventually affect wine quality include soluble solids, organic acids, pH, phenolics, anthocyanins, monoterpenes and other components (Jackson and Lombard, 1993). However, Reynolds and Wardle (2001) reported grafting to have no effect on vine size, or any of the yield components (yield/vine, clusters/vine, cluster weight, number of berries/cluster, berry weight and crop load). Berry size in relation to cane thickness in this experiment indicates that source:sink strength is greater when the canes are thick, either on own-rooted vines or on grafted vines.

Effect of cane thickness on biochemical parameters

Data on biochemical changes in relation to cane thickness in own-rooted or grafted grapevines is presented in Table 2. Among own-rooted and grafted grapevines, significant differences were recorded for amount of reducing sugars in canes of ‘Tas-A-Ganesh’ grape. Higher amount of reducing sugars was recorded in canes of grafted vines (7.26mg/g) compared to own-rooted vines (6.40mg/g). Among cane thickness treatments, higher content of reducing sugars (8.51mg/g) was recorded in thicker canes (>10mm) than in thin canes of <6mm diameter (5.56mg/g). With increase in cane diameter, content of reducing sugars also increased. However, interaction effect here was found to be non-significant. Increase observed in bunch-weight in thicker canes may be due to higher availability of reducing sugars. Higher sugar content in thick canes of grafted as well as own-rooted vines may have helped vines produce larger berries and bunches.

Significant differences were recorded for carbohydrate content in the canes of own-rooted vs. grafted vines. Higher concentration of carbohydrate was recorded in canes of grafted vines (9.36mg/g) compared to own-rooted vines (6.49mg/g). Among types of cane, higher amount of carbohydrates was noticed in thicker canes than in thinner ones. Canes of >10mm diameter recorded higher concentration 8.69mg/g than thinner canes (<6mm, 6.33mg/g). However, interaction effect here was found to be non-

Table 2. Effect of cane thickness on cane biochemical status in 'Tas-A-Ganesh' grape

Parameter	Reducing sugars (mg/g)	Carbohydrates (mg/g)	Starch (mg/g)	Proteins (mg/g)	Phenols (mg/g)
Factor-A					
Grafted	7.26	9.36	6.35	100.47	7.94
Own root	6.40	6.49	5.06	87.98	7.79
SEm ±	0.207	0.176	0.161	0.523	0.167
CD (*P=0.05*)	2.630	2.236	2.046	6.647	NS
Factor-B					
<6 mm	5.56	6.33	5.22	78.14	6.01
6-8 mm	6.15	8.20	5.56	84.23	7.63
8-10mm	7.10	8.48	5.71	100.70	8.13
>10mm	8.51	8.69	6.33	113.84	9.69
SEm ±	0.293	0.250	0.228	0.740	0.236
CD (*P=0.05*)	0.932	0.890	NS	2.354	0.750
Interaction A x B					
Grafted					
Grafted <6mm	6.09	7.49	5.96	81.23	6.44
Grafted 6-8mm	6.43	9.93	6.08	86.22	8.10
Grafted 8-10mm	7.56	9.97	6.21	110.92	8.40
Grafted >10mm	8.96	10.06	7.16	123.52	8.83
Own root					
Own root <6mm	5.04	5.17	4.47	75.05	5.59
Own root 6-8mm	5.87	6.47	5.05	82.24	7.17
Own root 8-10mm	6.65	7.06	5.21	90.49	7.86
Own root >10mm	8.06	7.33	5.51	104.16	10.56
SEm ±	0.415	0.353	0.322	1.047	0.334
CD (*P=0.05*)	NS	NS	NS	3.314	1.062

significant. Increase in carbohydrate content in grafted vines might be due to the fact that grafted vines are more efficient in nutrient uptake and storage of carbohydrates. This may have helped increase bunch-size. The above results are in conformity with those of Richards (1983) who observed that major functions of the grapevine root system are vine water-relations, uptake and translocation of nutrients, synthesis and metabolism of plant growth substances and storage of carbohydrates. Efficient assimilation and use of nutrients by plants is of prime importance for optimizing crop productivity. Grape berries, as typical "sink organs", rely on use of the available carbohydrate resources produced through the process of photosynthesis to support growth and development. Transport and allocation of sugars between photosynthetic "source tissues" and the heterotrophic "sink tissues" is known as 'assimilate partitioning' and is a major determinant of plant growth and productivity (Kingston-Smith, 2001). Rizk *et al* (2011), in their three-season study on Red Globe grafted on three different rootstocks, observed that percentage of total carbohydrates of the cane was much higher in vines grafted on 'Dogridge' rootstock than in own-rooted vines. They concluded that rootstocks were more efficient than own-rooted vines in respect of improving physical and chemical characteristics of the berries, vegetative growth parameters, increasing the content of total leaf chlorophylls and percentages of total nitrogen, phosphorus and potassium and content of total carbohydrates in the cane compared to non-grafted vines. Accumulation of starch in the canes of grafted vines was greater (6.35mg/g) than in own-rooted vines (5.06mg/g). However, differences among cane thickness and interaction were non-significant for most of the biochemical parameters, except proteins and phenols. Accumulation of starch in the permanent wood may be the most important carbohydrate reserve in a grapevine. Verma *et al* (2010), in their studies on 'Pusa Urvashi' grape variety grafted on different rootstocks, reported that the rootstocks induced a change in various biochemical parameters of grafted vines. Compared to 'Pusa Urvashi' grafted on itself (auto grafted), grafted rootstock-based plants exhibited improved physiological and nutrient status.

Variation in protein content of canes was observed in both grafted and own-rooted vines. Higher protein content was recorded in grafted vines (100.47mg/g) than in own-rooted vines (87.98mg/g). Among different cane thickness treatments, higher protein content was recorded in canes of higher thickness than in thinner canes. The same trend was observed in own-rooted vines. Interaction effect here was found to be highly significant. With increased cane thickness, protein content also increased. A positive correlation of berry and bunch weight was also established with higher content of proteins, carbohydrates and reducing sugars in the canes. Change in total phenols was observed for cane thickness alone. Total phenols were found to increase with increase in cane thickness. However, phenol content found in grafted vines was higher than in own-rooted vines. Phenolic compounds occur naturally in plant systems and are known for their anti-microbial properties. These inhibit fungal-spore germination, mycelial-fungal enzymes and toxin production by pathogens (Vidhyasekran, 1973). Higher levels of phenolic compounds in a plant system imply greater tolerance to biotic stresses (Gotez *et al*, 1999).

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