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Influence of Different Rootstocks on Vine Growth, Cane Storage, and Yield in Crimson Seedless Grapevine

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study investigated the influence of different rootstocks (Dogridge, 110R, 140Ru, and 1103P) on vine growth, cane storage, and yield in Crimson Seedless grapevines during 2021-22 and 2022-23 at ICAR-NRC Grapes, Pune. Growth parameters, including pruned biomass, leaf area, and

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stock: scion ratio, were significantly impacted by the rootstocks, with Dogridge rootstock recording the highest values. Dogridge also resulted in greater shoot length, shoot diameter, and minimum internodal length. Cane biochemical content, such as total phenol, tannin, proline, and carbohydrates, was highest in vines grafted on Dogridge, while 1103P rootstock showed the highest cane protein levels. Yield parameters, including average bunch weight and yield per vine, were superior in vines grafted on Dogridge. The study concluded that Dogridge rootstock significantly enhanced cane storage, biochemical composition, and yield, making it a suitable choice for Crimson Seedless grapevines in tropical conditions.

Keywords: Grapevine growth; vine storage; cane biochemical; rootstocks; crimson seedless.

1. INTRODUCTION

Grape cultivation in the sub-tropical and tropical regions of India is increasing due to favorable climatic conditions and high quality grape production. This fruit crop gaining important income source worldwide [1]. In India, grapes are cultivated on 1.62 lakh hectares yielding about 34.45 lakh metric tonnes annually, with an average productivity of 21.00 MT/ha [2]. Traditional grape cultivation involved growing commercial grape varieties on their own roots. However, due to declining soil and irrigation water quality the use of rootstock has become necessary. India is experiencing increased soil salinity, drought and reduced grape productivity, underscoring the importance of employing suitable rootstocks [3]. The rootstock absorbs water, nutrients and provides storage and resistance to various soil conditions and pests. Various modifications to the canes, such as adjusting the number, thickness and length have a significant influence on the quality of grape production. This is because the biochemical content within the vines affects fruitfulness, disease resistance and storage ultimately leading to increased yield and improved quality of grape production [4,5].

Crimson Seedless is attracting the consumers due to its affectionate red colour, oval, mild sweet, firm crisp flesh with natural flavor and the variety is gaining demand in Indian markets, growers are concentrating their efforts to obtain quality grape but several constraints are affecting its production under tropical conditions [6]. Satisha et al. [7] reported that *Vitis berlandierii* x *Vitis rupestris* group, including 110R, 1103P, 99R and B2-56 rootstocks recorded higher level of total phenols, flavon-3-ols, flavonoids, proline and total protein in the canes. Elaidy et al. [8] reveled that Red Globe grapevines on grafted rootstocks exhibited greater cane biochemical content and storage compared to the vines with their own roots. The aim of the study was to investigate the impact of Dogridge, 110R, 140Ru and 1103P rootstocks on the growth, biochemical composition of canes and yield of Crimson Seedless grapevines for the evaluation of suitable rootstock.

2. MATERIALS AND METHODS

The study was conducted at ICAR-National Research Centre for Grapes, Pune during the years 2021-22 and 2022-23. Four-year-old Crimson Seedless vines were grafted on different rootstocks (Dogridge, 110R, 140Ru and 1103P). The vines were trained using the 'extended Y' system of training, with four cordons (H shape – Height = 1.20m from ground, cross arm width = 0.60 m) developed horizontally with vertical shoot orientation on each cordon. The distance of 0.60m from the fruiting wire to the top of the foliage support wire was maintained. The soil was heavy black with pH 7.75 and EC 0.46 dSm^{-1}. This region falls within a tropical belt where double pruning and single cropping are the standard practices. Foundation pruning was done in April while fruit pruning was carried out in month of October. Randomly five matured canes from each vine were taken before fruit pruning and five vines were selected per replication. The harvested canes were oven dried, crushed and fine powder was prepared and it was stored at 4^0C to use for further analysis.

2.1 Cane Biochemical Analysis

Total phenol and tannin content in canes was estimated using Folin Ciocalteu reagent and measuring the absorbance at 630nm and 730nm the methods suggested by Singleton and Rossi [9]. The total phenol content (mg/g DW) was calculated from the standard curve using Gallic acid as standard and expressed as mg of Gallic Acid (GA) equivalent per gram of dry weight sample. Carbohydrate content in canes were determined using the Anthrone method Hedge and Hofreiter, [10] and was calculated by referencing a graph using glucose as a standard.

Protein content was estimated using the colorimetric method described by Lowry et al. [11] and was calculated from the standard curve using bovine serum albumin as standard. The proline content (µmoles/g DW) was estimated colorimetrically using the method suggested by Bates et al. [12]. It was calculated from a standard curve using proline as the standard and expressed as µmoles of proline equivalent per gram of dry weight sample.

2.2 Growth Parameters

Pruned biomass (kg/vine) was collected immediately after pruning using weighing balance. Leaf area (cm^2) was calculated using BIOVIS leaf area meter. To calculate stock: scion ratio, stock girth was measured one cm below the graft union and scion girth was measured one cm above the graft union with the help of Vernier caliper. The first sprouted bud with fully expanded leaf was taken as an indicator to measure the days to sprouting. Days to cane maturity was calculated from the date of pruning to the cane maturity. Five shoots per vine selected randomly were tagged for recording observations of shoot length (cm), shoot diameter (mm) and internodal length. The shoot length of each shoot was recorded using measuring tape, shoot diameter with Vernier Caliper and internodal length with scale at 120 DAP (Foundation pruning) from five vines.

2.3 Yield Parameters

Average bunch weight (g) was calculated by selecting five random healthy bunches per replication at the time of harvesting and their mean weight was recorded using weighing balance. Number of bunches/vine was counted on vine grafted on different rootstocks before harvest. To calculate yield (kg/vine), the total number of bunches of each vine were counted and multiplied by average bunch weight. The resultant was considered as average yield/vine and expressed as kg/vine.

2.4 Statistical Analysis

The experiment was conducted using a Randomized Block Design (RBD) with four rootstocks as treatments which were replicated five times. Data collected during the study was analyzed using the standard method of analysis of variance described by Panse and Sukhatme (1985).

3. RESULTS AND DISCUSSION

3.1 Vine Growth Parameters

Crimson Seedless grapevines grafted on different rootstocks had significant effect on growth parameters after foundation pruning. In pooled data of 2021-22 and 2022-23, Crimson Seedless vines grafted on Dogridge rootstock recorded higher pruned biomass (1.90 kg/vine), leaf area (147.87 cm^2), stock: scion ratio (1.09) while 140Ru rootstock recorded lowest pruned biomass (1.37 kg/vine) and stock: scion ratio (1.00). Lowest leaf area (136.96 cm^2) was recorded on 1103P rootstock.

The variation in pruned biomass among different rootstocks may be due to differences in vine vigor and assimilation of carbohydrates [13]. Grapevines accumulate more storage produce more canes, leaves, and overall growth, resulting in increased dry matter production [14]. Higher pruning weight on Dogridge rootstock was also reported by Satisha et al. [15] and Rizk-Alla et al. [16].

Crimson Seedless grapevines grafted on 140Ru rootstock were early to sprout (13.35) and days to cane maturity (120.63) which were at par with 1103P (121.85) while Dogridge rootstock recorded maximum days to sprouting (15.65) and days to cane maturity (126.73). The lower activity of polyphenol oxidase (PPO) in vines grafted on Dogridge rootstock may have led to uneven and delayed bud sprouting [17]. In grape cultivation, cane maturity plays a crucial role in ensuring maximum fruitfulness. Similarly, Somkuwar et al. [18] reported that Thompson Seedless own rooted vines had minimum days to sprouting and cane maturity than grafted vines.

Dogridge rootstock recorded maximum shoot length (77.03 cm) which was at par with vines grafted on 1103P (75.49 cm) and shoot diameter (8.24 mm) which was at par with 110R rootstock (8.08 mm) while 140Ru rootstock recorded minimum shoot length (70.85 cm) and shoot diameter (7.85 mm) at 120 days after pruning. Dogridge rootstock recorded minimum internodal length (3.77 cm) while 140Ru rootstock recorded maximum internodal length (4.29 cm).

This difference may be due to the rootstocks providing more vigour to the vine which directly affects to increase in shoot length. Similar results were reported by Satisha et al. [15] and

Somkuwar et al. [19] in shoot length, shoot diameter and internodal length, respectively.

3.2 Cane Biochemical Content

Crimson Seedless grapevines grafted on Dogridge rootstock showed higher cane total phenol (2.88 mg/g DW), total tannin (3.64 mg/g DW), cane proline (3.68 µmoles/g DW) and carbohydrates (431.71 mg/g DW) while lowest total phenol (2.32 mg/g DW), total tannin (2.53 mg/g DW), proline (2.36 µmoles/g DW) and carbohydrates (346.65 mg/g DW) in vine grafted on 140Ru rootstock. The vines grafted on 1103P rootstock (12.04 mg/g DW) recorded maximum cane protein, while vines grafted on 140Ru rootstocks (9.90 mg/g DW) recorded minimum cane protein. Ghule et al. [20] and Somkuwar et al. [19] reported highest cane protein in Dogridge rootstock grafted vines.

Phenolic compounds are naturally occurring in plants and have antimicrobial properties. Plants with higher levels of phenolic compounds are more tolerant to biotic stresses [21]. Proline serves as a crucial osmoprotectant during drought and salinity stress. Rootstocks had capacity to produce and store proline in the leaves [7]. Ghule et al. (2021) reported highest proline content in vines grafted on 110R rootstock. Grafted vines are more efficient in nutrient uptake and carbohydrate storage, leading to an increase in cane carbohydrate content Somkuwar et al., [22]; Ghule et al., [20] reported higher storage in vines grafted on Dogridge rootstock.

3.3 Yield Parameters

Crimson Seedless grapevines grafted on different rootstocks had significant effect on yield of vines. In pooled data of the year 2021-22 and 2022-23, highest average bunch weight (278.6 g), number of bunches/vine (43.22) and yield/vine (12.06 kg) was recorded in grapevines grafted on Dogridge rootstock which was significantly superior than other rootstock. Rootstock not only helps to withstand in vineyard in adverse climatic conditions but also help in improving yield and quality of grapes [18]. Similarly, Somkuwar et al. [23] recorded higher bunch weight and number of bunches in grapevines grafted on Dogridge rootstocks [24].

Table 1. Effect of different rootstocks on pruned biomass (kg), leaf area (cm²) and stock: Scion ratio in Crimson Seedless grapevines after foundation pruning

Parameter	**Pruned biomass (kg)**			**Leaf area (cm²)**			**Stock: Scion ratio**		
Rootstocks	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Dogridge	1.92	1.88	1.90	147.18	148.55	147.87	1.09	1.10	1.09
110R	1.40	1.41	1.40	143.66	145.26	144.46	1.01	1.05	1.03
140Ru	1.36	1.38	1.37	138.34	141.94	140.14	0.99	1.01	1.00
1103P	1.56	1.52	1.54	135.96	137.96	136.96	1.04	1.06	1.05
SE (m±)	0.09	0.07	0.057	2.53	2.85	1.90	0.013	0.008	0.008
CD @5%	0.27	0.23	0.168	7.78	NS	5.56	0.041	0.024	0.022

Table 2. Effect of different rootstocks on days to sprouting and days to cane maturity in Crimson Seedless grapevines after foundation pruning

Parameter	**Days to sprouting**			**Days to cane maturity**		
Rootstocks	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Dogridge	15.11	16.20	15.65	127.61	125.85	126.73
110R	14.20	14.31	14.25	124.44	123.74	124.09
140Ru	13.27	13.43	13.35	121.12	120.14	120.63
1103P	14.29	15.13	14.71	122.47	121.23	121.85
SE (m±)	0.35	0.38	0.26	1.51	1.37	1.02
CD @5%	1.09	1.19	0.76	4.64	NS	2.97

Table 3. Effect of different rootstocks on shoot length (cm), shoot diameter (mm) and internodal length (cm) in Crimson Seedless grapevines at 120 days after foundation pruning

Parameters	Shoot length (cm)			Shoot diameter (mm)			Internodal length (cm)		
Rootstocks	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Dogridge	75.42	78.65	77.03	8.26	8.21	8.24	3.76	3.78	3.77
110R	72.32	74.30	73.31	8.03	8.13	8.08	4.12	4.08	4.10
140Ru	70.66	71.04	70.85	7.85	7.85	7.85	4.32	4.26	4.29
1103P	74.54	76.44	75.49	7.94	8.08	8.01	4.23	4.15	4.19
SE (m±)	1.06	1.72	1.009	0.06	0.13	0.07	0.06	0.09	0.05
CD @5%	3.28	5.29	2.956	0.17	NS	0.21	0.20	0.27	0.16

Table 4. Effect of different rootstocks on cane total phenol (mg/g DW), tannin (mg/g DW) and protein (mg/g DW) content in Crimson Seedless grapevines

Parameters	Phenol (mg/g DW)			Tannin (mg/g DW)			Protein (mg/g DW)		
Rootstocks	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Dogridge	2.84	2.91	2.88	3.69	3.59	3.64	11.05	9.69	10.37
110R	2.57	2.40	2.49	2.57	3.01	2.79	11.36	10.83	11.09
140Ru	2.39	2.26	2.32	2.41	2.64	2.53	10.38	9.42	9.90
1103P	2.78	2.72	2.75	3.44	3.35	3.40	12.29	11.78	12.04
SE (m±)	0.15	0.16	0.10	0.26	0.17	0.15	0.07	0.07	0.05
CD @5%	NS	0.48	0.31	0.81	NS	0.46	0.23	0.22	0.15

Table 5. Effect of different rootstocks on proline and carbohydrate content of mature cane in Crimson Seedless grapevines

Parameters	Proline (µmoles/g DW)			Carbohydrates (mg/g DW)		
Rootstocks	**2021-22**	**2022-23**	**Pooled**	**2021-22**	**2022-23**	**Pooled**
Dogridge	3.29	4.08	3.68	428.00	435.41	431.71
110R	2.60	3.51	3.06	416.43	400.42	408.43
140Ru	2.05	2.67	2.36	350.49	342.82	346.65
1103P	2.11	2.82	2.47	390.69	364.74	377.72
SE (m±)	0.22	0.30	0.18	18.14	18.93	13.11
CD @5%	0.66	0.94	0.54	55.90	58.33	38.26

Table 6. Effect of different rootstocks on yield parameters inCrimson Seedless grapevine

Rootstocks	Average bunch weight (g)	Number of bunches/vine	Yield/vine (kg)
Dogridge	278.6	43.22	12.04
110R	265.36	39.39	10.45
140Ru	254.34	36.82	9.36
1103P	260.84	38.64	10.07
SE (m±)	3.42	1.11	0.17
CD @5%	10.56	3.44	0.51

4. CONCLUSION

The rootstocks had significant effect on cane storage such as total phenol, tannin, protein, proline and carbohydrates in Crimson Seedless grapevines. The higher storage in canes resulted into the better vine growth. For better grape yield, it is crucial to ensure optimal stock-scion compatibility, which enhances the vine vigour. Hence, considering all above parameters Crimson Seedless grapevine grafted on Dogridge rootstock followed by vines grafted on 110R rootstock proved better for accumulating more cane storage, cane biochemical content and yield of grapes.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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