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Influence of Different Rootstocks on Vine Growth, Bunch Yield, Quality, Chlorophyll Content and Photosynthetic Activity in Crimson Seedless Grapevine

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ABSTRACT

A field experiment was carried out from 2021 to 2024 at the ICAR-National Research Centre for Grapes, Pune, to assess the impact of four different rootstocks (110R, 140Ru, 1103P and Dogridge) on vine growth, bunch yield, quality, chlorophyll content and photosynthetic activity in Crimson Seedless grapevines. Growth parameters, including pruned biomass (0.87 kg) were significantly impacted by the rootstocks, with Dogridge rootstock recording the highest values. Additionally, 1103P resulted in longer shoot length (106.26 cm), number of canes (35.87), stock: scion ratio (0.96) and minimum days to achieve uniform colour (107.33 days) in Dogridge also led to the earliest harvest (139.80 days). Yield and quality parameters, including number of bunches vine^{-1} (31.80), 50 berry weight (159.78 g), yield vine^{-1} (8.52 kg), berry length (21.33 mm) and berry diameter (16.17 mm) were superior in vines grafted onto 1103P and Dogridge. Among quality attributes varied significantly, with 110R producing berries with the highest TSS (19.89 °Brix), while acidity was lowest in 140Ru (0.57%). This rootstock also recorded superior total chlorophyll content (19.10 mg ml^{-1}) at 90 days after fruit pruning. For photosynthetic activity, 110R had the highest assimilation rate (7.67 µmol H_2O m^{-2} s^{-1}), while Dogridge showed superior stomatal conductance (0.18 µmol H_2O m^{-2} s^{-1}), intercellular CO_2 (331.86 µmol CO_2 mol^{-1}), and transpiration rate (2.72 mmol H_2O m^{-2} s^{-1}). Overall, the findings suggest that both Dogridge and 1103P rootstocks significantly enhanced growth and yield, making it a suitable choice for Crimson Seedless grapevines in tropical conditions.

KEYWORDS: Rootstock, growth, yield, quality, photosynthetic activity, chlorophyll content

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1. INTRODUCTION

Grape cultivation in the sub-tropical and tropical regions of India is increasing due to favourable climatic conditions and high-quality grape production. In India, grapes are cultivated on 1.76 lakh ha yielding about 38.96 lakh mt annually, with an average productivity of 22.15 mt ha^{-1}. (Anonymous, 2024a). During the fiscal year 2023-24, the country exported 343,982.34 metric tons, valued at 417.07 million USD (Anonymous, 2024b). The primary grape growing regions in India are Maharashtra (70.67%), Karnataka (24.49%), Tamil Nadu (1.43%), Andhra Pradesh (1.34%), Madhya Pradesh (1.02%) and Mizoram (0.50%). These regions account for 99% of the nation's grape production. Commercial grape cultivation in the country faces challenges related to soil salinity and chlorides in irrigation water. Various rootstocks are used to grow grapes to overcome these issues. Grafting is the primary method used to sustain grape production, and it involves using suitable rootstocks. Grape rootstocks such as Dogridge, 110R and 1103P are being used in Maharashtra and Karnataka to combat issues such as salinity, drought, nematodes, and poor fruitfulness. Rootstock is becoming increasingly popular in Indian Viticulture due to its ability to thrive in abiotic conditions such as drought and salinity, as well as its potential to enhance scion physiology and morphology (Satisha et al., 2010).

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. 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 (Leao and Oliveira, 2023; Oliveira et al., 2024).

Photosynthesis is adversely affected by drought and salt accumulation mainly due to the stomatal closure. The resulting reduction in carbohydrate production may be an important constraint for growth and yield. In addition, nutrient availability and source/sink relations have been reported to affect water relations and gas exchange. Rootstocks were also found to modify leaf gas exchange of the scion under non irrigated conditions, even though vine water status was not altered (Padgett-Johnson et al., 2000).

The Crimson Seedless (*Vitis vinifera* L.) grape is a late-season, attractive, red seedless grape cultivar, introduced in 1989 as a Seedless alternative to Emperor. The popularity of 'Crimson Seedless' can be ascribed to the following: it has elongated, late maturing, a red seedless grape which is not susceptible to berry crack, thus allowing for a more extended ripening period (Ramteke et al., 2021). The grape quality required for export is largely depends on canopy management practices such as orchard orientation, training, pruning, thinning of berries, bunches and leaf removal practices for quality production (Al-Saif et al., 2023). Crimson Seedless is attracting the consumers due to its affectionate red colour, oval, mild sweet, firm crisp flesh with natural flavour 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 (Somkuwar et al., 2021). The aim of the study was to investigate the impact of different grape rootstocks (110R, 140Ru, 1103P and Dogridge) on growth, yield and quality, and photosynthetic activity of Crimson Seedless grapevines for recommendations as a suitable rootstock.

2. MATERIALS AND METHODS

The study was conducted at ICAR-National Research Centre for Grapes, Pune during three years (October, 2021–March, 2024). Four-year-old Crimson Seedless vines were grafted on different rootstocks (110R, 140Ru, 1103P and Dogridge). The vines were trained to 'extended Y' trellis, with four cordons (H shape–Height=1.20 m from ground, cross arm width=0.60 m) developed horizontally with vertical shoot orientation on each cordon. The distance of 0.60 m from the fruiting wire to the top of the foliage support wire was maintained. The soil in the region is heavy black with pH 7.75 and EC 0.46 dSm^{-1}. This region falled within a tropical belt where double pruning and single cropping were the standard practices. Foundation pruning was done in April while fruit pruning was carried out in month of October.

2.1. *Growth parameters*

Pruned biomass were measured after forward pruning for selected vines and average was calculated. The number of canes $vine^{-1}$ was counted at 90 days after foundation pruning and mean was recorded. Five shoots $vine^{-1}$ were selected randomly and tagged for recording observations of shoot length (cm) and shoot diameter (mm). The shoot length of each shoot was recorded using measuring tape, shoot diameter with Vernier Calliper. To calculate stock: scion ratio, stock girth was measured 1 cm below the graft union and scion girth was measured one cm above the graft union with the help of Vernier calliper. Leaf area (cm^2) was calculated using BIOVIS leaf area meter. Days taken for flowering was calculated from the date of fruit pruning to opening of 50% flowers in the inflorescence for individual vine and mean was recorded. Days taken to achieve uniform colour was calculated from the date of fruit pruning to uniform berry colour development for individual vine and mean was recorded. Days taken for berry setting was calculated from the date of fruit pruning to berry set in the inflorescence for individual vine and mean was recorded and days to harvest was calculated from the date of fruit pruning for individual vines.

2.2. Yield and quality parameters

Average bunch weight (g) was derived from the mean weight of five randomly selected healthy bunches per replication while, the average weight of 50 berries was calculated and expressed in grams. Number of bunches vine^{-1} was counted on vine grafted on different rootstocks after the berry set. To calculate yield (kg vine^{-1}), the total number of bunches of each vine were counted and multiplied by average bunch weight. The resultant was considered as average yield vine^{-1} and expressed as kg vine^{-1}. Berry length and diameter were measured using the vernier calliper. Total soluble solids (TSS) were measured with a portable handheld refractometer (Erma Refractometer, Japan) at room temperature, while titratable acidity was measured by titrating a known volume of juice with 0.1 NaOH using phenolphthalein as indicator.

2.3. Photosynthetic activity

Assimilation rate, stomatal conductance, intercellular CO_2 and transpiration rate were measured using an Infra-Red Gas Analyzer (IRGA model Li 6400, LI-COR Biosciences, NE, USA) on fifth to sixth matured leaves from the shoot tip, between 11 am and 12:30 pm.

2.4. Chlorophyll content

Chlorophyll estimation was carried out by using the dimethylsulfoxide (DMSO) method (Hiscox and Israclstam, 1979).

2.5. 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 analysed using the standard method of analysis of variance described by Panse and Sukhatme (1985).

3. RESULTS AND DISCUSSION

3.1. Growth parameters

Crimson Seedless grapevines grafted on different rootstocks had significant effect on growth parameters (Table 1). In pooled data of three years, vines grafted on Dogridge rootstock recorded higher pruned biomass (0.87 kg) followed by 140Ru (84.00 kg), while 110R and 1103P rootstocks recorded lowest pruned biomass (0.81 kg). The variation in pruned biomass among different rootstocks might be due to differences in vine vigor and assimilation of carbohydrates. Grapevines accumulated more storage produced more canes, leaves, and overall growth, resulting in increased dry matter production. Higher pruning weight on Dogridge rootstock was also reported by Satisha et al. (2010) and Rizk-Alla et al. (2011). The rootstock 110R exhibited the highest fruitfulness (87.75%), while 140Ru rootstock had the lowest fruitfulness (82.27%). The maximum number of canes, shoot length and stock: scion ratio was recorded on 1103P (35.87, 106.26 cm and 0.96, respectively), while 140Ru rootstock recorded lowest number of canes and shoot length (32.93 and 80.97 cm, respectively) and stock: scion ratio in 110R (0.92). The production of higher number of canes vine^{-1} might be due to the vigour imparted by rootstock that was converted into number of canes vine^{-1}. Tambe and Gawade (2004) reported greater number of canes in Tas-A-Ganesh grafted on rootstocks as compared with own rooted vines. 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. (2010) and Somkuwar et al. (2014) in shoot length and shoot diameter. The variation in stock:

Table 1: Effect of different rootstocks on vegetative growth parameters of Crimson seedless (pooled mean for three years)

Rootstocks	Pruning weight (kg vine^{-1})	Number of canes vines^{-1}	Fruitfulness (%)	Shoot length (cm)	Shoot diameter (mm)	Stock: scion ratio	Leaf area (cm^2)
110R	0.81	33.80	87.75	90.45	7.13	0.92	147.28
140Ru	0.84	32.93	82.27	80.97	6.70	0.94	155.12
1103P	0.81	35.87	87.70	106.26	6.40	0.96	151.36
Dogridge	0.87	34.47	87.38	102.16	7.07	0.94	152.83
SEm±	0.01	0.28	0.67	0.74	0.03	0.01	0.67
CD at 5%	0.03	0.88	2.06	2.27	0.08	0.02	2.07
Sig	**	**	**	**	**	**	NS

*: Significant at $p<0.05$; **: Significant at $p<0.01$; NS: Non-significant

scion ratio of same cultivar grafted on different rootstocks might be due to differences in genetic constituent of the rootstock. The maximum leaf area was recorded on 140Ru (155.12 cm^2), while 110R rootstock grafted vines recorded minimum leaf area (147.28). The variation in leaf area obtained in different varieties might be due to the changes in root anatomy and physiology of scion which results in vigorous growth leads to more photosynthesis which attributed to the large sized leaves. De Souza et al. (2015) reported that leaf area of Cabernet Sauvignon was affected by the different rootstocks.

The results presented in Figure 1 showed that vines grafted on 110R rootstock had minimum days for flowering (37.83) and days to berry setting (48.30). On the other hand, vines grafted on Dogridge was late to flower (40.70), while those grafted onto 1103P took the maximum days for berry setting (50.40). Menora et al. (2014) who reported minimum days for flowering in own rooted Flame Seedless vines. In pooled data, the earliest uniform colour development was observed

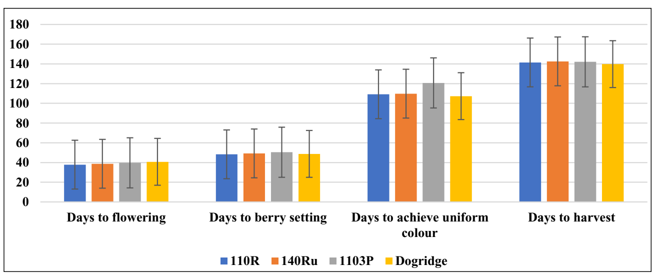

Figure 1: Rootstocks effects on days to flowering, days to berry setting, days to achieve uniform colour and days to harvest

in vines grafted onto Dogridge (107.33), while longest days to uniform colour development 1103P (120.73) rootstock. Crimson Seedless vines grafted on Dogridge were early to harvest (139.80), while 140Ru took the longest time (142.57). The findings of the present investigation were in agreement with the research results of Somkuwar et al. (2020) for Manjari Naveen grapevines that were grafted on Dogridge rootstock.

3.2. *Yield and quality parameters*

The data on effect of different rootstocks on yield and quality parameters of Crimson Seedless grapevines are presented in Table 2. In pooled data of three years (2021–24), the vines grafted on Dogridge rootstock exhibited highest bunch weight (269.64 g) and 50 berry weight (159.78) 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. Similarly, Somkuwar et al. (2024) reported higher bunch weight in grapevines grafted on Dogridge rootstocks. The number of bunches vine^{-1} and yield vine^{-1} in Crimson Seedless grapevines varied significantly with different rootstocks with highest number of bunches vine^{-1} and yield vine^{-1} in 1103P (31.80 and 8.52 kg, respectively) while lowest bunches vine^{-1} and yield vine^{-1} was in vine grafted on Dogridge rootstocks (30.27) and 110R (7.61 kg). According to Tambe and Gawade (2004), Tas-A-Ganesh grafted on Dogridge (4.18 kg vine^{-1}), followed by Thompson Seedless grafted on Dogridge (3.89 kg vine^{-1}) had the highest yield. Rizk-Alla et al. (2011) discovered that Red Globe vines grafted on Dogridge, followed by Salt Creek rootstock, had a higher yield vine^{-1}.

The berry length and berry diameter also significantly influenced by rootstocks. In pooled mean, higher berry length and berry diameter was recorded in Crimson Seedless grapevines grafted on Dogridge rootstock (21.33 and 16.17 mm, respectively) while lower berry length and berry diameter was recorded in 140Ru grafted vines (20.13 and 15.27 mm) respectively. The berry diameter was an important parameter for quality grape production (Matthews and Nuzzo, 2006). The higher photosynthetic rate, cane carbohydrate and protein storage which leads to higher accumulation of food material towards developing berries and results into higher berry diameter. The highest TSS level was observed in 110R (19.89°Brix), while the lowest was in 140Ru (19.41°Brix). In terms of acidity,

Table 2: Effect of different rootstocks on bunch and quality parameters of Crimson seedless (pooled mean for three years)

Rootstocks	Bunches vine^{-1}	Average bunch weight (g)	50 berry weight (g)	Yield (kg vine^{-1})	Berry length (mm)	Berry diameter (mm)	TSS (°Brix)	Acidity (%)
110R	30.30	252.03	142.13	7.61	20.77	15.67	19.89	0.60
140Ru	31.67	244.79	144.93	7.76	20.13	15.27	19.41	0.57
1103P	31.80	267.28	156.46	8.52	20.80	15.73	19.42	0.63
Dogridge	30.27	269.64	159.78	8.17	21.33	16.17	19.59	0.59
SEm±	0.25	2.06	1.21	0.09	0.10	0.08	0.10	0.004
CD at 5%	0.78	6.35	3.74	0.28	0.31	0.24	0.29	0.011
Sig	**	**	**	**	**	**	*	**

*: Significant at $p<0.05$; **: Significant at $p<0.01$; NS: Non-significant

140Ru grafted vines had lowest values (0.57), whereas the highest acidity was recorded in 1103P (0.63). TSS levels in berries were affected by various factors, including the duration between pruning and harvest, as well as the yield vine^{-1} (Menora, 2014).

3.3. *Chlorophyll content*

Significant differences in chlorophyll a and b content were recorded among the different rootstocks (Table 3). The vines grafted on 1103P rootstock recorded significantly higher chlorophyll a and total chlorophyll at 90 days after fruit pruning (14.82 and 19.10 mg ml^{-1}, respectively), while the lowest content was found in vines grafted on 140Ru (9.49 and 12.45 mg ml^{-1}, respectively). Chlorophyll b content was highest in Dogridge (5.35 mg ml^{-1}) and lowest in 140Ru grafted vines (2.96 mg ml^{-1}). Similar results were recorded in our earlier study (Somkuwar et al., 2011). Rafaat and El-Gendy (2013), while evaluating Flame Seedless on some rootstocks, reported higher leaf chlorophyll content in Salt Creek and Freedom than their own rooted vines.

Table 3: Effect of different rootstocks on chlorophyll content parameters of Crimson seedless (pooled mean for three years)

Rootstocks	90 days after fruit pruning		
	Chlo. A (mg ml^{-1})	Chlo. B (mg ml^{-1})	Total chlo. (mg ml^{-1})
110R	9.69	3.26	12.95
140Ru	9.49	2.96	12.45
1103P	14.82	4.28	19.10
Dogridge	13.51	5.35	18.86
SEm±	0.15	0.06	0.17
CD at 5%	0.45	0.19	0.53
Sig	**	**	**

*: Significant at p<0.05; **: Significant at p<0.01; NS: Non-significant

3.4. *Photosynthetic activity parameters*

The impact of different rootstocks on the photosynthetic activity during the flowering stage of Crimson Seedless grapevines is presented in Table 4. From pooled analysis, it was evident that the choice of rootstock had a significant impact on the assimilation rate. The Crimson Seedless grape grafted onto 110R had the highest assimilation rate (7.67 µmol H_2O m^{-2} s^{-1}), which was statistically on par with 1103P (7.49 µmol H_2O m^{-2} s^{-1}), while 140Ru rootstock had the lowest assimilation rate (6.57 µmol H_2O m^{-2} s^{-1}). The highest recorded stomatal conductance (0.18 µmol H_2O m^{-2} S^{-1}), intercellular CO_2 (331.86 µmol CO_2 mol^{-1}) and transpiration rate (2.72 mmol H_2O m^{-2} S^{-1}) was consistent with the performance of Dogridge rootstock which was

Table 4: Effect of different rootstocks on photosynthetic activity of Crimson seedless

Rootstocks	Assimilation rate (µmol H_2O m^{-2} s^{-1})	Stomatal conductance (µmol H_2O m^{-2}) S^{-1}	Intercellular CO_2 (Ci) (µmol CO_2 mol^{-1})	Transpiration rate (mmol H_2O m^{-2} S^{-1})
110R	7.67	0.10	277.83	2.21
140Ru	6.57	0.11	276.71	2.06
1103P	7.49	0.14	299.83	2.69
Dogridge	7.12	0.18	331.86	2.72
SEm±	0.06	0.001	2.36	0.02
CD at 5%	0.18	0.003	7.26	0.07
Sig	**	**	**	**

*: Significant at p<0.05; **: Significant at p<0.01; NS: Non-significant

followed by 1103P rootstock (0.14 µmol H_2O m^{-2} S^{-1}, 299.83 µmol CO_2 mol^{-1}, 2.69 mmol H_2O m^{-2} S^{-1}). On the other hand, lowest Intercellular CO2 and transpiration rate was observed in grapevines grafted on 110R rootstock (276.71 µmol CO_2 mol^{-1} and 2.06 mmol H_2O m^{-2} S^{-1}), while the lowest stomatal conductance was recorded on 110R rootstock. The rootstocks have deep root system which imparts more water and nutrient absorption than own rooted vines, which might be the major reason for higher stomatal conductance vines on rootstock (Lamoureux et al., 2017). The water stress and drought tolerance mechanism significantly affects the leaf stomatal conductance (Faralli et al., 2021). The rate of assimilation rate, stomatal conductance, intercellular CO_2, and transpiration rate might be influenced by rootstock genotype, root system, vine vigour and scion characteristics (Somkuwar et al., 2015). Bica et al. (2000) reported that scion foliar biomass and leaf area might be responsible for alteration in the gas exchange parameters. They found significant effect of rootstock on assimilation rate, stomatal conductance, intercellular CO_2, and transpiration rate.

4. CONCLUSION

Different rootstocks greatly influenced the growth, yield, quality, chlorophyll content, and photosynthetic activity of Crimson Seedless grapevines. Dogridge and 1103P rootstocks proved to be the most beneficial, with Dogridge enhanced pruned biomass, berry weight, and photosynthetic activity, while 1103P resulted in higher yield and chlorophyll content. Additionally, both rootstocks enhanced vine vigor, fruitfulness, and adaptability to tropical conditions. Therefore, Dogridge and 1103P were recommended for improving the growth, yield, and overall quality of Crimson Seedless grapes in tropical climates.

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6. REFERENCES

Al-Saif, A.M., Fahmy, M.A., Baghdady, G.A., El-Razik, A.M.A., Kabsha, E.A., Farouk, M.H., Hamdy, A.E., 2023. The impact of bud load on berry quality, yield, and cluster compactness in H4 strain grapevines. Agronomy 13, 2431.

Anonymous, 2024a. India stat: state wise area, production and productivity of grapes in India (2023–2024–3rd advanced estimates). Accessed on 5th April, 2024. Available at https://www.indiastat.com/data/agriculture/grapes-viticulture/data-year/2024.

Anonymous, 2024b. Analytical trade profile of fresh grape. Assessed on 5th April, 2024. Available at https://agriexchange.apeda.gov.in/indexp/Product_32headChart.aspx?gcode=0205.

Bica, D., Gay, G., Morando, A., Soave, E., Bravdo, B.A., 2000. Effects of rootstock and Vitis vinifera genotype on photosynthetic parameters. Acta Horticulturae 526, 373379.

De Souza, C.R., Da Mota, R.V., Franca, D.V.C., Pimentel, R.M.D., Regina, M.D.A., 2015. Cabernet sauvignon grapevine grafted onto rootstocks during the autumn-winter season in south eastern Brazilian. Scientia Agricola 72(2), 138–146.

Faralli, M., Bianchedi, P.L., Bertamini, M., Varotto, C., 2021. Rootstock genotypes shape the response of cv. Pinot Gris to Water Deficit. Agronomy 11(1), 75.

Hiscox, H.D., Israclstam, G.F., 1979. A method for extraction of chlorophyll from leaf tissues without maceration. Canadian Journal of Botany 57(12), 1332–1334.

Lamoureux, L.A., Sacco, D., Risse, P.A., Lovisolo, C., 2017. Factors influencing stomatal conductance in response to water availability in grapevine: a meta-analysis. Physiologia Plantarum 159(4), 468–482.

Leao, P.C., Oliveira, C.R., 2023. Agronomic performance of table grape cultivars affected by rootstocks in semi-arid conditions. Bragantia 82, e20220176.

Matthews, M.A., Nuzzo, V., 2006. Berry size and yield paradigms on grapes and wines quality. Acta Horticulture 754, 423–435.

Menora, N.B., 2014. Studies on the effect of different rootstocks on growth, yield, raisin recovery and quality of commercial grape varieties. M.Sc. Thesis, Dr. Y.S.R. Horticultural University, Rajendranagar, Hyderabad.

Oliveira, C.R., Mendonca Junior, A.F., Leao, P.C., 2024. Rootstock effects on fruit yield and quality of 'BRS Taina' seedless table grape in semi-arid tropical conditions. Plants 13(16), 2314.

Padgett-Johnson, M., Williams L.E., Walker, M.A., 2000. The influence of *Vitis riparia* rootstock on water relations and gas exchange of *Vitis vinifera* cv. Carignane scion under non-irrigated conditions. American Journal of Enology and Viticulture 51(2), 137–143.

Panse, V.G., Sukhatme, P.V., 1985. Statistical methods for Agricultural workers. Indian Council of Agricultural Research, New Delhi.

Rafaat, S.S., El-Gendy, 2013. Evaluation of flame seedless grapevines grafted on some rootstocks. Journal of Horticultural Science and Ornamental Plants 5(1), 1–11.

Rizk-Alla, M.S., Sabry, G.H., Abd-El-Wahab, M.A., 2011. Influence of some rootstocks on the performance of red globe grape cultivar. The Journal of American Science 7(4), 71–81.

Ramteke, S.D., Bhagwat, S.R., Gavali, A.H., Langote, A., Khalate, S.M., Kalbhor, J.N., 2021. Pre-harvest application of ethrel and potassium schoenite on yield, quality, biochemical changes, and shelf-life in Crimson Seedless grapes. International Journal of Agriculture Environment and Biotechnology 14(4), 489–494.

Satisha, S.J., Somkuwar, R.G., Sharma, J., Upadhyay, A. K., Adsule, P.G., 2010. Influence of rootstocks on growth yield and fruit composition of Thompson seedless grapes grown in the Pune region of India. South African Journal of Enology and Viticulture 31(1), 1–8.

Somkuwar, R.G., Bondage, D.D., Surange, M.S., Ramteke, S.D., 2011. Rooting behaviour, polyphenol oxidase activity and biochemical changes in grape rootstocks at different growth stages. Turkish Journal of Agriculture and Forestry 35(3), 281–287.

Somkuwar, R.G., Jogaiah S., Sawant, S.D., Taware, P.B., Bondage, D.D., Itroutwar, P., 2014 Rootstocks influence the growth, biochemical contents and disease incidence in Thompson Seedless grapevines. British Journal of Applied Science and Technology 4(6), 1030–1041.

Somkuwar, RG., Taware, P.B., Bhange, A.M., Sharma. J., Khan, I., 2015. Influence of different rootstocks on growth, photosynthesis, biochemical composition, and nutrient contents in Fantasy Seedless grapes. International Journal of Fruit Science 15(3), 251–266.

Somkuwar, R.G., Samarth, R., Ghule, V.S., Sharma, A.K., 2020. Crop load regulation to improve yield and quality of Manjari Naveen grape. Indian Journal of

Horticulture 77(2), 381–383.
Somkuwar, R.G., Bhor, V.A., Ghule, V.S., Hakale, D., Shabeer, A., Sharma, A.K., 2021. Rootstock affects stress relieving enzymatic activity during bud break in 'Red Globe' grapevine under semi-arid condition. Vitis 60(2), 93–99.
Somkuwar, R.G., Thutte, A.S., Upadhyay, A.K., Deshmukh, N.A., Sharma, A.K., 2024. Rootstock influences photosynthetic activity, yield and berry quality in Manjari Naveen grape. Indian Journal of Horticulture 81(01), 43–47.
Tambe, T.B., Gawade, M.H., 2004. Influence of rootstocks on vine vigour, yield and quality of grapes. Acta Horticulturae 662, 259–263.