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ROOTSTOCKS INFLUENCES, GROWTH, BUNCH YIELD, QUALITY, AND RAISIN RECOVERY IN MANJARI KISHMISH GRAPES

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ABSTRACT

The experiment was conducted at ICAR-National Research Centre for Grapes in Pune between 2021-2024 to investigate the influence of different rootstocks on growth, yield, quality, and raisin recovery of Manjari Kishmish grapes. Manjari Kishmish grapes grafted onto Dogridge rootstock exhibited higher fruitfulness and highest shoot diameter and leaf area. The Dogridge rootstock also resulted in early flowering and berry setting, while the 110R rootstock led to an early harvest. Dogridge rootstocks produced highest yield and grape quality with notable higher chlorophyll content at 45 and 90 days after fruit pruning. However, consistent nutrient pattern was not observed across the different rootstocks. Additionally, Dogridge rootstock exhibited superior stomatal conductance and higher intercellular CO_2 compared to the other rootstocks.
Keywords **:** Manjari Kishmish, growth, yield, quality, chlorophyll content and petiole nutrient.

Introduction

The grape (*Vitis vinifera* L.) is an important fruit crop grown in India. Basically, it is a temperate fruit crop that has been successfully adapted to the sub-tropical as well as tropical climate and is well known for its various health benefits. Although, India is predominant in grape cultivation, approximately 78% of the total production is used for table purpose, almost 17-20 percent is dried for raisin production, while and the remaining 2% is utilized in the production of juice and wine (Somkuwar *et al.*, 2024a). About 90% production is used for raisin making using Thompson Seedless or its clones (Somkuwar *et al.*, 2019). Manjari Kishmish (clonal selection from Kishmish Rozavis) is becoming popular due to its high raisin recovery (Somkuwar *et al.*, 2024b). To produce quality raisins with internationally and nationally acceptable, careful balance of source: sink ratio is required (Somkuwar and Ramteke, 2006a). Furthermore, cultural practices as nutrition, irrigation, and canopy management play an important role in producing good quality raisin (Somkuwar *et al.* 2020b). Among the various canopy management practices, leaf removal practice is being followed as it not only maintains and increase productivity but also has pronounced effect on the distribution of photo assimilates and the source-sink relationship between leaves and fruits of vineyard which adjust balanced between development and yield (Kliewer *et al.*, 2005).

Grape rootstocks like Dogridge, 110R and 1103P are commonly used in Maharashtra and Karnataka to combat issues such as salinity, drought, and low 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). The rootstock is an important tool for controlling vine growth and productivity in addition to addressing soil issues. The growth of the vine is more dependent on the interaction between the stock and scion than on either one alone. Therefore, a rootstock that is beneficial for one cultivar in a specific environment may not be helpful for others in the same way (Hartmann *et al.*, 1993).

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 (Zhu, 2001). 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). Keeping in view, the present investigation was carried out to study the influence of four different rootstocks on growth, bunch yield, quality, raisin recovery, photosynthesis activity and nutrient status on 'Manjari Kishmish' grapevine.

Materials and Methods

The experiment was carried out over three consecutive years (2021-2024) at ICAR-NRC for Grapes, Pune (18.32°N and 73.51°E). Four-year-old Manjari Kishmish, a raisin grape variety was grafted on four different rootstocks (110R, 140Ru, 1103P and Dogridge). The vines were trained to Y-Trellis system, with a spacing of 9 ft × 5 ft., thereby accommodating 968 vines per acre. The vines were pruned twice in a year: once in the summer (known as back pruning) to develop canes for fruit bud differentiation and second pruning on the mature canes after five to six months later (called forward pruning) to encourage bunch development. Five vines were selected and tagged under each replication. The means of five vines was calculated for each parameter, which includes growth parameters like pruning weight, fruitfulness, shoot length, shoot diameter, stock: scion ratio, leaf area, days to flowering, days to berry setting and days to harvest, yield and quality parameters like numbers of bunches/vine, average bunch weight, 50 berry weight and yield (kg/vine), berry length, berry diameter, TSS, acidity and raisin recovery, and nutrient content parameters, and photosynthetic activity. The experiment was laid out in Randomized Block Design (RBD) with five replications. Data were subjected to statistical analysis as per the method given by Panse and Sukhatme (1985).

Results and Discussion

The data recorded on various growth parameters of Manjari Kishmish grafted on different rootstocks is presented in Table 1. The rootstock Dogridge exhibited highest pruning weight (1.16 kg), while 140Ru had the lowest values (0.99 kg). The variation in pruned biomass among different rootstocks may be due to differences in vine vigor and assimilation of carbohydrates. Grapevines accumulate more storage produce more canes, leaves, and overall growth, resulting in increased dry matter production (Menora *et al.* 2018). The rootstock 110R showed the highest fruitfulness (95.91 %) followed by 140Ru (93.64 %), while the 1103P had the lowest fruitfulness (90.00 %). A variation of 25 per cent in fruitfulness among the rootstocks was reported by Larry *et al.*, (1994). Since the yearly variation in fruitfulness was independent of rootstock (fruitfulness for all rootstock were high one year and low during the next year), climatic factors can be considered as probable causes for variation. The maximum shoot length was observed on 110R rootstock (106.83 cm) which was at par with Dogridge (104.84 cm), while the minimum in 1103P (100.32 cm). It might be due to rootstock imparts more vigour in vine which directly results maximum growth of vine indicated through the maximum shoot length. The differences in vigour suggest a stionic influence caused by rootstock genotypes (Verma *et al.*, 2010). The highest shoot diameter was recorded in Manjari Kishmish grafted on Dogridge (7.20 mm), while the lowest was observed in 140Ru (6.17 mm). The production of canes depends upon vigour of the vine and their dimensions, which in turn depends upon the extent of stored food material in the vine (Fawzi *et al.*, 1984). These results are in close conformity with the results of Somkuwar *et al.*, (2014) who reported highest shoot diameter in Thompson Seedless vines grafted on Dogridge rootstock. The maximum stock: scion ratio was found in vines grafted on 110R (0.94), while the minimum was recorded in 1103P (0.89). The stock scion ratio nearing 1.00 will have uniform girth of both stock and scion (Somkuwar *et al.*, 2015). The variation in stock: scion ratio of same cultivar grafted on different rootstocks might be due to differences in genetic constituent of the rootstock. Somkuwar *et al.*, (2006b) reported higher stock: scion ratio in Flame Seedless grafted on different rootstocks while Satisha *et al.*, (2010) found that there was no adverse effects of different rootstocks on stock: scion ratio in Thompson Seedless grapes in initial years of vineyard and also long duration evaluations. The largest leaf area was recorded on Dogridge (168.52 cm^2) followed by 110R (163.34 cm^2) and the smallest was observed in 140Ru (159.05 cm^2). The leaf area is a main element in source-sink relationship. The vigorous rootstock imparts more growth to vines which enhanced higher shoot length and shoot diameter which results in accumulation of more carbohydrate and other food material in vines which gives maximum leaf area. The higher pruned biomass converted more stored food material for leaf area development (Ghule *et al.*, 2019).

The results presented in Fig. 1 indicated that vines grafted on Dogridge rootstock was early to flower (36.77) and days to berry setting (46.03). On the other hand, vines grafted onto 110R took maximum days for flowering (38.40) and days taken for berry setting (47.63). Menora *et al.* (2018) who reported minimum days taken for flowering in own rooted Flame Seedless vines. Somkuwar *et al.* (2014) also reported that Thompson Seedless own rooted vines recorded less days for bud sprout and growth than vines grafted on rootstocks. Manjari Kishmish vines grafted on 110R took the minimum time to harvest (135.37), while 1103P took the longest time (137.73). The findings of the present investigation are similar to the research results of Somkuwar *et al.* (2020a) for Manjari Naveen grapevines that were grafted onto Dogridge rootstock showing minimum days to harvest.

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

Rootstocks	Pruning weight (Kg/vine)	Fruitfulness (%)	Shoot length (cm)	Shoot diameter (mm)	Stock: scion ratio	Leaf area (cm^2)
110R	1.03	95.91	106.83	6.82	0.94	163.34
140Ru	0.99	93.64	101.64	6.17	0.90	159.05
1103P	1.03	90.00	100.32	6.43	0.89	159.81
Dogridge	1.16	92.33	104.84	7.20	0.93	168.52
SEm±	0.01	0.68	0.73	0.08	0.01	1.17
CD (P=0.05)	0.02	2.11	2.25	0.25	0.02	3.61
Sig	**	**	**	**	**	**

*: Significant at P < 0.05, **: Significant at P < 0.01, NS: Non significant

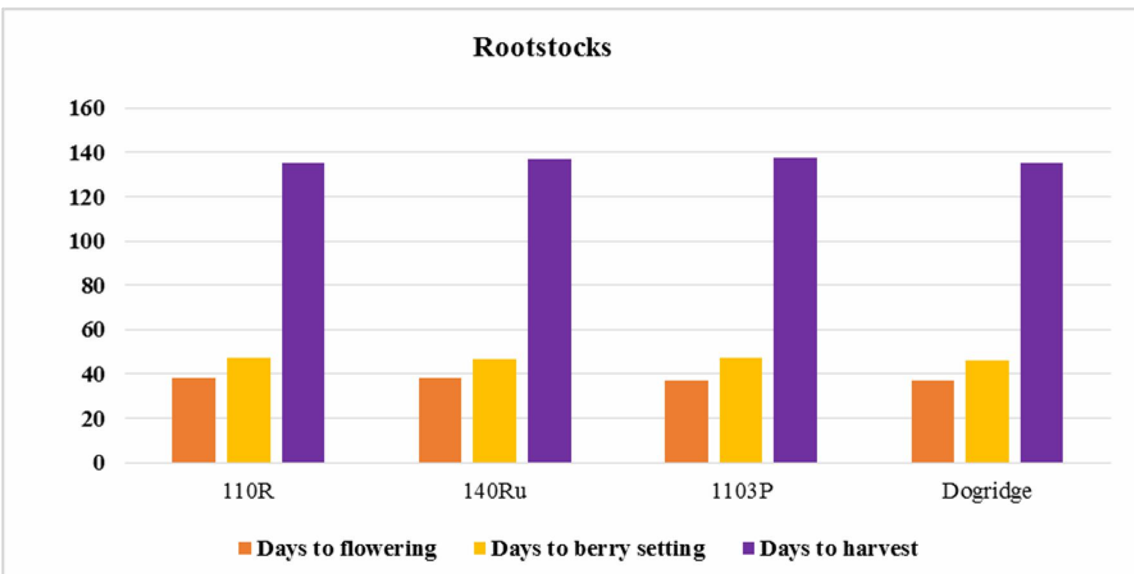

Fig. 1: Rootstocks effects on days to flowering, days to berry setting, and days to harvest.

The data on the impact of various rootstocks on the yield and quality parameters of Manjari Kishmish grapevines were evaluated over three consecutive season (2021-22, 2022-23 and 2023-24) are shown in Table 2. The highest bunch weight was recorded on 1103P (275.54 g) which was at par with Dogridge (273.40 g), while the lowest in vines grafted on140Ru (245.38 g). The highest 50-berry weight and yield per vine was recorded on Dogridge (143.21 g and 11.12 kg, respectively) which was at par with 1103P (138.20 g and 10.98 kg, respectively), while the lowest value was seen in 114Ru (126.46 g) and 110R (9.66 kg). Similarly, Somkuwar *et al.* (2024c) recorded higher bunch weight in grapevines grafted on Dogridge rootstocks. The number of bunches per vine and yield per vine in Manjari Kishmish grapevines varied significantly with different rootstocks with highest number of bunches in vines grafted on 1103P (31.80) and the lowest in Dogridge (30.27). According to Tambe and Gawade (2004), Tas-A-Ganesh grafted on Dogridge (4.18 kg/vine), followed by Thompson Seedless grafted on Dogridge (3.89 kg/vine) 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 per vine.

Berry diameter was also significantly influenced using different rootstock. The highest berry diameter was recorded in Manjari Kishmish (15.43 mm) grapevines grafted on Dogridge rootstock, while the smallest berry diameter was observed in 140Ru grafted vines (14.57 mm). The berry diameter is 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 was recorded in Dogridge (22.41 ^{o}B), while the lowest in 1103P (21.19 ^{o}B). TSS levels in grape berries were affected by various factors, including the duration between pruning and harvest, as well as the yield per vine (Menora, 2014). When the yield of grapes on a vine increase, the total soluble solids decreased due to nutrient competition. Somkuwar *et al.* (2020a, 2013) also found similar results in Manjari Naveen and Sharad Seedless grapevine grafted on Dogridge rootstock. The highest acidity was found on 1103P (0.56 %) which was at par with Dogridge and 110R (0.55 %) rootstocks, while 140Ru had the lowest acidity (0.54 %). According to Somkuwar *et al.* (2020b), higher temperature under tropical condition can result in a rise in sugar levels and a decrease in acidity. Increasing TSS and decreasing total acidity in raisins can improve their colour, taste, and texture (Arzani *et al.*, 2009). The highest raisin recovery was found on Dogridge rootstock (26.50 %) which was at par with 110R (26.39 %), while the lowest raisin recovery was recorded on 140Ru (25.54). The higher raisin recovery in Manjari Kishmish might be attributed to the higher TSS content in fresh grape berries. Somkuwar *et al*. (2020c) also found that fresh grapes with the highest sugar levels resulted in high raisin recovery.

Table 2: Effect of different rootstocks on bunch and quality of Manjari Kishmish (pooled mean for three year)

Rootstocks	Bunches /Vine	Average bunch weight (g)	50 berry weights (g)	Yield (kg/ vine)	Berry length (mm)	Berry diameter (mm)	TSS (^{o}Brix)	Acidity (%)	Raisin recovery (%)
110R	30.30	248.13	132.21	9.66	19.52	14.95	22.19	0.55	26.39
140Ru	31.67	245.38	126.46	10.29	18.79	14.57	22.23	0.54	25.54
1103P	31.80	275.54	138.20	10.98	19.04	15.03	21.19	0.56	25.68
Dogridge	30.27	273.40	143.21	11.12	19.32	15.43	22.41	0.55	26.50
S Em±	0.25	4.44	1.90	0.18	0.17	0.08	0.18	0.004	0.19
CD (P=0.05)	0.78	13.68	5.86	0.55	0.53	0.26	0.55	0.014	0.59
Sig	**	**	**	**	NS	**	**	*	**

*: Significant at $P < 0.05$, **: Significant at $P < 0.01$, NS: Non significant

Chlorophyll content parameters

Significant differences in chlorophyll a, b and total chlorophyll content were recorded among the rootstocks (Table 3). The Dogridge rootstock recorded significantly higher chlorophyll a, b, and total chlorophyll content (22.04, 7.15 and 29.19 mg/ml, respectively), while the lowest content was noticed in vines grafted on 110R (19.90, 5.62 and 25.52 mg/ml, respectively) at 45 days after fruit pruning. At 90 days after fruit pruning, the highest chlorophyll a, b, total chlorophyll content was recorded in Dogridge (10.35, 3.21 and 13.55 mg/ml, respectively) and the lowest in vines grafted on 140Ru (6.38, 2.50 and 8.88 mg/ml respectively). Similar results were also 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 in Salt Creek and Freedom grafted vines than their own rooted vines. These results are also supported by Bica *et al*. (2000) and Keller *et al.* (2001) who found that the effect of rootstock was significantly higher on chlorophyll content. The low chlorophyll a/b ratio is an expression of large photosynthetic unit thereby increasing the light collecting capacity by a high content of light harvesting chlorophyll a/b protein complex. Reduced chlorophyll a/b in 1613-C and Dogridge rootstocks have influenced photosynthetic efficiency in Pusa Urvashi, which was reported by Verma *et al.* (2010).

Table 3: Effect on different rootstocks on chlorophyll content in Manjari Kishmish (pooled mean for three year)

Rootstocks	45 days after fruit pruning			90 days after fruit pruning		
	Chlo. A (mg/ml)	Chlo. B (mg/ml)	Total chlo. (mg/ml)	Chlo. A (mg/ml)	Chlo. B (mg/ml)	Total chlo. (mg/ml)
110R	19.90	5.62	25.52	8.29	2.93	11.23
140Ru	20.07	5.77	25.84	6.38	2.50	8.88
1103P	21.50	6.20	27.70	8.38	3.18	11.57
Dogridge	22.04	7.15	29.19	10.35	3.21	13.55
SEm±	0.16	0.05	0.21	0.06	0.03	0.09
CD (P=0.05)	0.50	0.14	0.64	0.19	0.08	0.26
Sig	**	**	**	**	**	**

*: Significant at P < 0.05, **: Significant at P < 0.01, NS: Non significant

Photosynthetic activity parameters

The data on gas exchange parameters for 'Manjari Kishmish' vines grafted onto different rootstocks are presented in Table 4. The highest rate of assimilation was observed in vines grafted on 140Ru (16.46 µmol H_2O m^{-2} s^{-1}), while the lowest was recorded in those grafted on 110R rootstock (7.85 µmol H_2O m^{-2} s^{-1}). The stomatal conductance rate was highest in vines grafted onto 1103P and Dogridge rootstocks (0.16 µmol H_2O m^{-2} s^{-1}) followed by 110R rootstock (0.12 µmol H_2O m^{-2} s^{-1}). 140Ru rootstock showed lowest stomatal conductance (0.10 µmol H_2O m^{-2} s^{-}1) suggesting the rootstock for its better efficiency in reserving the food material required for bunch development. The rate of stomatal conductance might also be influenced by genotype, root system, and vine vigour. Koblet *et al*. (1996) noted that rootstock had a marked effect on net assimilates and suggested the selection of rootstock based on soil fertility to avoid excess fertilizers.

The highest recorded intercellular CO_2 (311.00 µmol CO_2 mol^{-1}) and transpiration rate (2.80 mmol H_2O m^{-2} S^{-1}) were observed in vines grafted on Dogridge followed by 1103P and 140Ru rootstocks (290.00 µmol CO_2 mol^{-1} and 2.13 mmol H_2O m^{-2} S^{-1} respectively). In contrast, the lowest intercellular CO_2 was recorded in vines grafted on 140Ru rootstock (123.72 µmol CO_2 mol^{-1}), while the lowest transpiration rate was observed in 110R rootstock (2.09 H_2O m^{-2} s^{-1}) grafted vines. The 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.

Table 4: Effect on different rootstocks on chlorophyll content in Manjari Kishmish

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	7.85	0.12	287.00	2.09
140Ru	16.46	0.10	123.72	2.13
1103P	9.67	0.16	290.00	2.12
Dogridge	8.51	0.16	311.00	2.80
SEm±	0.12	0.001	2.74	0.01
CD (P=0.05)	0.38	0.004	8.43	0.04
Sig	**	**	**	**

*: Significant at P < 0.05, **: Significant at P < 0.01, NS: Non significant

Petiole Nutrient Content (At 45 days after fruit pruning):

Among the rootstocks, 1103P had the highest nitrogen content (0.99 %), while 140Ru exhibited the lowest nitrogen (0.85 %). Rootstock 140Ru had the highest concentrations of phosphorus (0.60 %), potassium (1.64 %) and magnesium (0.75 %) whereas, Dogridge recorded the lowest levels of these nutrients (0.52, 1.33 and 0.61 %, respectively). The differences among rootstocks could be due to the genetic factors affecting the root system (Ibacache and Carlos, 2009).

Similar results were reported by Vijaya and Rao (2015). The highest sodium content was found in Dogridge (0.34 %), while 1103P had the lowest sodium content (0.25 %). This might be due to the variations in the preferential nutrient absorption by rootstocks (Upadhyay *et al.*, 2013).

Vine grafted on Dogridge rootstock showed the highest calcium content (1.13%) followed by 140Ru rootstock (1.01 %), while the lowest calcium content was recorded in 1103P (0.97%). This might be due the genetic differences and capacity of absorption of nutrients by rootstocks. The rootstock showed the variation for preferential nutrient absorption which might result in variation of nutrients (Upadhyay *et al.*, 2013). Venugopal (2007) also reported that Thompson Seedless vines grafted on Dogridge rootstock recorded higher petiole Ca content. The zinc content in petioles was highest in vines grafted on 1103P (89.69 ppm) while Dogridge had the lowest zinc content (69.60 ppm). Furthermore, the highest copper content was found in vines grafted on 110R (10.57 ppm) while the lowest in 140Ru (9.10 ppm). The genotypic variation among the rootstock contributed to various levels of nutrient absorption, which affect the nutrient concentration among the vines grafted on different rootstocks (Fazio *et al.*, 2015).

Table 5: Effect on different rootstocks on petiole nutrient content in Manjari Kishmish (pooled mean for three year)

Rootstocks	Flowering (45 DAP Fruit pruning)							
	N (%)	P (%)	K (%)	Na (%)	Ca (%)	Mg (%)	Zn (ppm)	Cu (ppm)
110R	0.87	0.55	1.48	0.27	0.98	0.66	89.37	10.57
140Ru	0.85	0.60	1.64	0.27	1.01	0.75	86.14	9.10
1103P	0.99	0.59	1.55	0.25	0.97	0.71	89.69	10.34
Dogridge	0.92	0.52	1.33	0.34	1.13	0.61	69.60	9.67
SEm±	0.01	0.02	0.04	0.01	0.02	0.03	1.41	0.26
CD (P=0.05)	0.04	0.07	0.13	0.02	0.06	0.09	4.36	0.80
Sig	**	NS	**	**	**	*	**	**

*: Significant at P < 0.05, **: Significant at P < 0.01, NS: Non significant

Conclusion

Based on the results obtained in the present study, it can be concluded that there was significant difference among the rootstocks in term of growth, yield, quality, raisin recovery photosynthetic activity and nutrient contents. Among the four rootstocks evaluated, Manjari Kishmish variety performed best when grafted onto Dogridge rootstock, showing superior results in various parameters including pruning weight, shoot diameter, leaf area, days to flowering, days to berry setting, 50 berry weight, yield per vine, berry diameter, raisin recovery, followed by vines grafted on 110R and 1103P rootstock. Overall, the Manjari Kishmish grapevines grafted on Dogridge rootstock performed better than those grafted onto the other rootstock.

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