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Influence of rootstocks on yield, fruit and wine quality of Cabernet Sauvignon grape in western region of Maharashtra

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Abstract

The present study was conducted at ICAR-National Research Centre for Grapes, Pune, during the fruiting season of 2022–2023, and the experiment was laid out using a Randomized Block Design with 8 rootstocks. Research findings revealed that yield and quality are affected by rootstocks. Yield/vine (7.24 kg), number of bunches (78.41), TSS (23.88 ºBrix), phenol content (0.250 mg/g), reducing sugar (398.98 mg/g) and flavonoid content (5.85 mg/g) was higher in Cabernet Sauvignon grafted on 110R rootstock. A higher number of berries/bunch (133.67), juice recovery (64.07%) and anthocyanin content (2304.12 mg/L) were recorded in Dogridge grafted vines. The vines grafted on Gravesac rootstock had a higher 50-berry weight (53.67 g) as compared to other rootstocks. A higher bunch weight (110.23 g) was recorded in grafted vines on SO4. Cabernet Sauvignon grafted on 140 Ru recorded higher acidity (6.67 mg/L), colour intensity (0.680) in juice, total acids (7.5 g/L) in wine and better wine colour (8.7). Higher tannins (2.52 and 2.641 mg/g in juice and wine, respectively), proline content (2.196 mg/g), alcohol content (13.53%) and volatile acids (0.44 g/L) were estimated in wine prepared from Cabernet Sauvignon grafted on 1103P rootstock. Higher anti-oxidant (51.57 µ.moles/g) and acidity (1.50%) of wine were recorded in Fercal grafted vines. Higher glucose content (2.65 g/L), mallic acid (2.48 g/L), aroma, taste, flavour and overall acceptability of wine (7.3) was found in Cabernet Sauvignon grafted on 101.14 Mgt.

Key words: Cabernet Sauvignon, grafted, grapes, rootstocks, vines, wine quality and yield

Introduction

Grape (*Vitis vinifera* L.) is one of the most important fruit crops of the temperate zone, which has acclimatized to sub-tropical and tropical agroclimatic conditions prevailing in the Indian Sub-Continent (Ghule *et al.,* 2021; Somkuwar *et al.,* 2021). It is an important remunerative fruit crop in the world (Somkuwar *et al.,* 2020). The world vineyard surface area is estimated to be 7.3 Mha, the production of grapes is 27.9 million metric tonnes, and wine production is estimated at 258 mhl (OIV, 2023). Presently, grapes are grown in India over an area of 1.62 lakh ha with a production of 37.45 lakh MT and productivity of 22.10 MT/ha. The major grape-growing states 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%) amounting to nearly 99 % of the total production (NHB, 2022). India ranks first in the world for grape productivity and secured 7th position in the world for grape production during 2022-23 (APEDA, 2023).

Traditionally grape is grown in India on its own roots. However, subsequent deterioration in soil and water, and use of rootstock has become important in semi-arid tropical climates to sustain production and fruit quality (Somkuwar *et al.,* 2023). The choice of specific rootstock for the establishment of vineyard is difficult due to wider options. Vitis species, such as *V. champinii, V. rupestris, V. berlandierii, V. longii, V. parviflora*, *etc.* can synthesize biochemical constituents modulating scion physiology, root morphology, development, and distribution (Somkuwar *et al.,* 2023; Somkuwar *et al.,* 2012). Rootstock has the potential to manipulate vine growth and productivity (Dias *et al.,* 2017). In India 71% of grape produce is consumed as fresh, nearly 27% of dried for raisin production, 1.5% for wine making and 0.5% is used for juice (Sharma *et al.,* 2018). Our country's fresh grape industry is facing problems in selling during peak season, as large quantities of fresh grapes are being dumped in the markets. o address this issue, the surplus grapes should be processed into products like raisins, wine, and juice, which have demand both domestically and internationally. However, the average production of wine is significantly less in the country due to the unavailability of compatible rootstocks to adopt adverse conditions during cultivation. With increased awareness about the use of rootstocks in overcoming the adverse effects of drought and salinity, it is persuasive to evaluate the effect of different rootstocks on grapevine cultivars.

In India's tropical climate, the adaptability of wine grape varieties is widely recognized. Among the grape varieties cultivated, Cabernet Sauvignon stands out as a preferred choice for its exceptional wine quality potential (Sharma *et al.,* 2016). Rootstocks significantly influence many of the must composition parameters such as sugars, organic acids, phenolic compounds, potassium, and pH. A significant and positive correlation was observed between potassium content, juice pH and malic acid (Jogaiah *et al.,* 2015). The grapevine's growth and performance are greatly influenced by its rootstock, which acts as the foundation for its development and nutrient uptake (Migicovsky *et al.,* 2021). Rootstocks are tolerant of varied abiotic stresses

(Serra *et al.,* 2014) and resistant to pests and diseases (Ferris *et al.,* 2012; Hwang *et al.,* 2010).

A certain amount of everyday wine consumption may prevent various chronic diseases. This is due to the presence of a number of important antioxidants in red wine like resveratrol, anthocyanins, and catechins. Resveratrol is active in the prevention of cardiovascular diseases by neutralizing free oxygen radicals and reactive nitrogenous radicals; it penetrates the blood-brain barrier and, thus, protects the brain and nerve cells. It also reduces platelet aggregation and so counteracts the formation of blood clots or thrombi (Snopek *et al.,* 2018).

The investigation focused on understanding the intricate connection between choosing appropriate rootstock varieties for growing Cabernet Sauvignon grapes in Western Maharashtra. This research investigated the effects of rootstock selection on vineyard productivity and their impact on grape quality and wine quality. The evaluation of rootstock varieties seeks to enhanceCabernet Sauvignon cultivation in this distinct viticultural area for both grape growers and winemakers.

Materials and methods

The study was carried out at the National Research Centre for Grapes, Pune during the year 2022-23. Pune is in mid-western Maharashtra (latitude 18°32′N and longitude 73°51′E), with sub-tropical and semi-arid climatic conditions with a temperature range of 7.2°C (minimum) and 37.9°C (maximum) during the trial period. In this region, maximum rainfall is received from mid-June to September. The total rainfall was 509.60 mm during the trial period; the south-west monsoon is responsible for a major part of annual precipitation.

Seven-year-old 'Cabernet Sauvignon' grapevines grafted on Dogridge (*Vitis champini*), Gravesac, Fercal, 110 Richter (110 R, *Vitis berlandieri* × *Vitis rupestris*), 140-Ru (*Vitis berlandieri* × *Vitis rupestris*), 101.14 Mgt, SO4 (*Vitis berlandieri* × *Vitis riparia*), 1103 Paulsen (110 3P, *Vitis berlandieri* × *Vitis rupestris*) were evaluated in a randomized block design with three replicates represented by five vines per treatment.

The rootstocks were chosen mainly based on differences in vigour and genetic origin. The grapevines were spaced at 4 feet between vines and 8 feet between rows, trained on a mini-Y-trellis and were east-west oriented. All vines were spur pruned with two spur nodes, twice a year: the first pruning was carried out in April 2022 while the second was in September 2022. Yield, biochemical and quality parameters were studied after the winter pruning (September).

Wine-making: At harvest, 20 kg of grapes from each replicate were manually crushed and placed in stainless steel containers for winemaking. After that, 0.6 g SO_2 and 0.4 g pectinase (Optivin, Australia) were added to the must, and SO_2 content reached about 60 mg/L. Then pre-fermentation maceration was conducted at 18-20°C for 24 h and 3.6 g commercial Lalvin strain D254 yeast (Laffort, France) was activated and inoculated into the must. In a temperature-controlled brewery workshop (23-25°C), alcoholic fermentation was carried out. The skins were punched down twice a day. When the reducing sugar level dropped below 1 g/L, the skins and seeds were then removed, and 0.02 g of Lactobacillus (Lalvin31, Lallemand Inc., French) was added to start the malolactic fermentation. When the malolactic fermentation ended, 1.2 g SO_2 was added and the total SO_2 content reached about 80 mg/L. After that, the wines were bottled in 750 mL bottles and refrigerated in a cold chamber (12-16°C, without light) until analysis.

Physiochemical parameters: In each replicate, 100 berries were randomly selected for weighing and then squeezed into the juice. The juice was then centrifuged at 5,000 rpm for 5min to extract the supernatant. The juice's total soluble solids were determined using a portable refractometer (ATC 0-32 °Brix, Japan). A pH meter was used to determine the pH of the wine or juice (LMPH-12, Wensar). The titratable acidity of the juice was measured by 0.5 N NaOH.

Determination of chromatic characteristics of berries and wine: Wine biochemical parameters *viz*., phenol, tannins, colour intensity, total sugar, reducing sugar, protein, proline, anthocyanin, flavonoids, and anti-oxidants were measured with a Shimadzu UV-2450 UV–Visible spectrophotometer (Shimadzu Co., Kyoto, Japan) using 10mm path length glass quartz cells and distilled water as a blank. The visible spectrum (400-700 nm) of wine was recorded and each analysis was carried out in replicates. The wine's alcohol percentage, residual sugar, volatile acidity, and total acidity were measured by the FOSS machine (Oenofoss).

Statistical analysis: A randomized block design was used and all data sets were subjected to analysis of variance (ANOVA). OP STAT software was used for one-way ANOVA at $P < 0.05$ (Tuckey's test).

Results and discussion

Effect of rootstocks on yield: Rootstocks with different genetic constitutions affect growth characteristics on scions. In the present study, the yield was higher in 110 R grafted vines, however no significant difference between Cabernet Sauvignon vines grafted on 110R and 140 Ru was recorded. The differences for average bunch weight were non-significant in SO4, Gravesac and 1103 P grafted vines (Table 1). The number of berries/bunches in Dogridge, 140 Ru and 101.14 Mgt grafted vines were higher than rest of the rootstocks while the number of bunches/vines were higher in 110 R grafted Cabernet Sauvignon vines. Yield/vine was higher in 110R grafted vines as compared to other rootstocks grafted vines except 140 Ru which was statistically similar with 110R rootstock. The results of the present study confirm the result of Satisha *et al.* (2010) who found that Thompson Seedless grafted on five different rootstocks had the highest number of clusters from vines grafted on 110 R rootstocks, while the lowest cluster weight from their own-rooted vines. Kara *et al.* (2023) reported that higher number of clusters, weight of cluster, length of cluster and width of cluster was obtained from Eksi Kara grape cultivar on its own roots. Miele *et al.* (2017) observed that higher yield/vine in Solferino followed by SO4 and Gravesac. Ghule *et al.* (2019) compared Thompson Seedless grafted on five different rootstocks and its own-rooted vines and obtained a higher number of bunches on 110R rootstock grafted vines. It might be due to higher phosphorus uptake by the 110R rootstock which results in a higher number of bunch per vine.

Higher berry weight was recorded in Cabernet Sauvignon vines grafted on Gravesac rootstock which were statistically similar with 1103P and 101.14 Mgt. However, the rootstocks had a non-significant effect on berry diameter. Satisha *et al.* (2010) found that higher berry diameter and berry weight were recorded on Dogridge rootstocks during all the years of study. Ghule *et al.*

(2021) reported that the higher single berry weight was noted in Red Globe grafted on Dogridge rootstock (5.83 and 5.82 g) which was followed by 110R (5.50 and 5.52 g) while the lowest berry weight was recorded in 140Ru rootstock (4.69 and 4.77 g) during 2018-19 and 2019-20 respectively. This might be due to the environmental conditions at the time of maturity and the different genetic constitution of rootstocks as well as the higher carbohydrate and protein responsible for source-sink balance which results in the utilization of more stored carbohydrates for available berries (Somkuwar *et al.,* 2020).

Table 1. Effect of different rootstock on yield of Cabernet Sauvignon

Treatments	Average bunch weight (g)	Number of berries/ bunches	50 berry weight (g)	Berry diameter (mm)	No. of bunches / vine	Yield/ vine (kg)
Dogridge	97.50	133.67	44.00	12.67	54.53	6.45
Gravesac	104.17	99.00	53.67	13.60	62.18	6.61
Fercal	95.40	105.00	40.33	11.59	63.06	5.32
110 R	96.43	102.67	44.67	12.13	78.41	7.24
140 Ru	81.80	128.00	43.00	12.67	64.38	7.04
101.14 Mgt	90.37	126.00	49.83	12.98	51.30	6.43
SO4	110.23	106.67	42.87	12.22	69.84	6.39
1103 P	102.26	77.33	52.67	12.76	69.32	5.65
S.Em (±)	2.868	2.175	1.261	0.180	1.478	0.128
CD (5%)	8.698	6.597	3.824	0.547	4.483	0.389

Effect of rootstocks on berry quality: The introduction of rootstock in grape cultivation was mainly to overcome the problems of soil and water. In addition, the use of rootstock has improved the berry quality in table grapes as well as wine quality in winemaking. In the present study, significant differences were recorded for berry quality. The data from Table 2 showed that with the use of rootstocks, berry quality was also improved. In terms of total soluble solids in berries, the vines grafted on 110 R rootstocks observed higher content but did not find a significant effect on the TSS of berry juice. Nuzzo and Mathew (2006) reported that the accumulation of sugar was notably reduced in vines that were grafted onto the 5C rootstock compared to those on different rootstocks. In their study, Miele and Rizzon (2017) examined Cabernet Sauvignon grapevines that had been grafted onto various rootstocks and observed that 101-14Mgt., 161-49C, 3309C, Rupestris du Lot, and Gravesac grafted vines exhibited high levels of density, total soluble solids, pH, and the sugar-to-acid ratio while displaying low titratable acidity. Some researchers reported that there was no effect, or a little one, of the rootstock on the total soluble solids of the grape juice (Satisha *et al.,* 2010; Sato *et al.,* 2008; Dias *et al.,* 2012; Keller *et al.,* 2012; Chou and Li, 2014). However, other works showed that the total soluble solids were significantly affected by the rootstock (Kara *et al.,* 2023; Kodur *et al.,* 2013; Bardeja *et al.,* 2014).

In the present study rootstocks also had an impact on the titratable acidity and pH of juice. The rootstock influences titratable acidity in warmer climates but year and soil type may have more impact on titratable acidity than rootstock (Keller *et al.,* 2001). In this study, 140 Ru significantly improved the juice titratable acidity and showed significant differences with other combinations except 110R and Dogridge. Miele and Rizzon (2017) reported that Cabernet Sauvignon grafted onto the 99R, 110R, Dogridge, and 1103P rootstocks exhibited higher titratable acidity. Mota *et al.* (2009) reported that higher titratable acidity values were found in the grape must of Folha de Figo (syn. Ives), an American variety, grafted on the IAC 572 Jales rootstock. However, it was also shown that titratable acidity was not strongly affected by rootstocks (Reynolds and Wardle, 2001) or it had no effect on it at all (Leao *et al.,* 2011; Kamiloglu, 2012). Kara *et al.* (2023) recorded the highest TA from vines on their own roots (5.03 ± 0.14) and the lowest from vines on 110 R (3.98 ± 0.15) rootstock. pH of the juice was higher in 1103P grafted Cabernet Sauvignon which was at par with SO4 and Fercal rootstocks. The pH had similar behaviour as titratable acidity, it was higher or lower depending on the rootstock (Miele and Rizzon, 2017; Alvarenga *et al.,* 2002) or very low differences were found among them (Kara *et al.,* 2023; Reynolds and Wardle, 2001). It was also demonstrated that own-rooted grapevines showed higher pH compared with grafted Merlot and Chardonnay (Keller *et al.,* 2012). Jogaiah *et al.* (2015) found that maximum total soluble solids, minimum titratable acidity, and maximum juice pH of 'Cabernet Sauvignon' grafted on Gravesac and 101-14 Mgt rootstocks. The lowest pH and potassium content was recorded on Fercal rootstock.

Effect of rootstocks on biochemical parameters of grape berries: Biochemical constituents of grape berries were significantly affected by the use of rootstocks. Maximum phenol content in berries was observed in 110R grafted vines. Higher tannin content was found in berries of 1103P grafted Cabernet Sauvignon vines which was statistically similar with Fercal, SO4 and Gravesac. This might be due to the low TSS at harvest (around 21°Brix), which could have resulted in more condensed tannin accumulation (Han *et al.,* 2019). Ghule *et al.* (2021) found that higher cane total phenol content was recorded in Red Globe grapevines grafted on Dogridge rootstock (3.88 mg/g DW) which was at par with vines grafted on Salt Creek rootstock. Reducing sugars was higher in grape berries of 110R grafted vines. Juice recovery was also affected by rootstocks with higher juice percentage in berries of Dogridge grafted vines and was at par with 140 Ru.

The results from Table 2 indicated that colour intensity was higher in 140 Ru grafted vines while higher anthocyanin content in Dogridge rootstock, flavonoids were higher in 110 R and higher anti-oxidants were observed in Fercal rootstock. The results of the present study showed that the rootstock can change the biochemical constituents in the scion variety. Gollop *et al.* (2001) reported that the expression of the genes encoding key enzymes in the anthocyanin biosynthesis pathway was regulated by sugars. Wang *et al.* (2019) observed that SO4 decreased the anthocyanin concentrations in Cabernet Sauvignon skins, also found Cabernet Sauvignon/5A combination with higher anthocyanin concentrations compared with Cabernet Sauvignon/SO4. Oliveira *et al.* (2020) used IAC 572 and 1103P to graft Alicante Bouschet and found that rootstock and year had a synergistic effect, and year had a greater effect on flavonoid compound concentrations. A similar result was reported on Syrah (Dias *et al.,* 2017). Protein content was higher in Fercal grafted Cabernet Sauvignon vines and higher proline content was recorded in 110 R grafted vines. Ghule *et al.* (2021) reported that the protein content in cane was significantly influenced by different rootstocks. Red Globe grapevines grafted on Dogridge rootstock recorded the highest cane protein content. This might be due to the alterations in the growth pattern of the vines by rootstocks as well as the differences in their uptake of nutrients and water from soil solution, as root development patterns vary with the rootstocks (Somkuwar *et al.,* 2014b). Ghule *et al.* (2021) also found that vines grafted on 110R rootstock recorded higher cane proline content in Red Globe. These findings are in close conformity with the results of Ulas *et al.,* (2014) who reported that vines on 110R rootstock have higher proline content. Ulas *et al.* (2014) also reported that Syrah grafted on 110R rootstock had more proline content than other rootstocks.

Effect of rootstocks on wine quality: The rootstocks are known to alter the scion physiology. The effect of rootstocks on pH of wine was non-significant. Jogaiah *et al.* (2015) reported that acidity was highest on 140 Ru and 101-14 Mgt and was least on Gravesac and 110R. they found that the highest wine pH (3.8) was recorded in Gravesac, while it was lowest in 140 Ru. The acidity of wine was affected by rootstock and higher acidity content found in Dogridge (1.43 %). Miele and Rizzon (2017) found higher values ($P< 0.001$) for pH in the Cabernet Sauvignon/ Rupestris du Lot, Cabernet Sauvignon/5BB K and Cabernet Sauvignon/Gravesac wines and lower in Cabernet Sauvignon/420A Mgt, Cabernet Sauvignon/110 R and Cabernet Sauvignon/Isabel. Higher glucose content was observed in 101.14 Mgt which was significantly higher than other treatments. Mallic acid was higher in 101.14 Mgt which was at par with 110R, 140 Ru and 1103 P. Total acid content was higher in 140 Ru. Miele and Rizzon (2017) found that the titratable acidity and fixed acidity were higher ($P< 0.05$) in Cabernet Sauvignon/Isabel wine and lower in Cabernet Sauvignon/3309 C. Proline content of wine was significantly higher in 1103P rootstock. Rootstock did not affect the volatile acid in wine, however, higher volatile acid was found in 101.14 Mgt. Jogaiah *et al.* (2015) reported the least volatile acidity on 110R while it was higher on Gravesac and SO4.

Higher phenol content was recorded in 110-R grafted vines (0.123 mg/g). A study showed that 110R improved total phenol and anthocyanin content in Monastrell wines (Navarro *et al.,* 2021). According to Jogaiah *et al.* (2015), phenolic compounds of wines also differed significantly between rootstocks and found that total phenolic compounds were significantly higher on wines made from 'Cabernet Sauvignon' grapes grafted on 110R while lowest on 140 Ru and Fercal rootstocks. The highest tannin content was recorded in 1103 P grafted Cabernet Sauvignon vines which were at par with Fercal. Tannin concentration in wines depends on the rootstock (Blank *et al.,* 2022). Alcohol content was higher in 110R which was statistically non-significant to other treatments. Miele and Rizzon (2017) found that results of the alcohol content where the Cabernet Sauvignon/101-14 Mgt wine had the highest content ($P< 0.01$) and Cabernet Sauvignon/Dogridge and Cabernet Sauvignon/ Isabel the lowest.

Better colour was recorded in 140 Ru, and better aroma, taste, and flavour were found in 101.14 Mgt (Fig. 1). Overall qualities were recorded in 101.14 Mgt grafted vines which was at par with Dogridge and 110 R. According to Sivilotti *et al.* (2007) Cabernet Sauvignon wines obtained 161.49 and 420A rootstocks reported the best sensory evaluation, while with SO4 and 1103P the results changed by one year another. Fercal and Kober 5BB wines were found as intermediate in all 3 years. Earlier studies carried out with the same rootstocks did not had signifucant differences in the Cabernet Sauvignon wine physicochemical composition (Miele and Rizzon, 2019a) and wine sensory characteristics (Miele and

Table 2. Effect of different rootstock on quality and biochemical parameters of berries of Cabernet Sauvignon

Treatments	TSS (°Brix)	pH	Acidity (mg/L)	Phenol content (mg/g)	Tannin content (mg/g)	Reducing Sugar (mg/g)	Juice Recovery (%)	Colour intensity (%)	Anthocyanin content (mg/L)	Flavonoid content (mg/g)	Anti-oxidant content (μ moles/g)	Protein content (mg/g)	Proline content (moles/ g)
Dogridge	23.20	3.63	6.41	0.168	1.87	235.06	64.07	1.58	2304.12	5.53	41.81	26.309	12.71
Gravesac	23.60	3.63	6.16	0.102	2.10	214.56	58.80	1.09	1321.24	4.60	49.49	24.266	13.22
Fercal	23.40	3.65	6.35	0.045	2.25	228.65	57.25	1.33	1825.01	3.82	51.57	39.330	4.17
110 R	23.88	3.57	6.66	0.250	1.52	298.98	59.15	1.28	1839.10	5.85	40.27	29.822	13.61
140 Ru	23.41	3.57	6.67	0.100	2.06	255.56	62.98	1.70	1197.94	5.11	44.05	29.800	13.33
101.14 Mgt	23.39	3.54	6.30	0.128	2.01	214.48	61.42	1.17	2001.16	4.94	48.21	25.634	13.52
SO4	23.11	3.68	5.96	0.108	2.10	236.15	53.43	1.39	1821.49	4.40	46.56	27.599	12.48
1103 P	23.28	3.69	6.32	0.093	2.52	234.06	60.25	1.26	1599.55	3.48	44.48	38.732	13.18
S.Em (±)	0.177	0.016	0.092	0.0024	0.141	9.183	0.478	0.036	50.480	0.094	1.665	0.9871	0.315
CD (5%)	0.538	0.050	0.278	0.0072	0.428	27.854	1.451	0.110	153.116	0.286	5.049	2.9941	0.955

Table 3. Effect of different rootstock on wine quality parameters of Cabernet Sauvignon

Treatment	pH	Acidity (%)	Glucose content (g/L)	Mallic acid (g/L)	Volatile acid (g/L)	Total acid (g/L)	Ethanol (%)	Phenol content (mg/g)	Colour intensity (%)	Tannin content (mg/g)	Total Proline (u.moles/g)
Dogridge	3.57	1.43	1.43	1.61	0.38	6.8	12.02	0.099	1.79	1.819	1.180
Gravesac	3.50	1.13	1.43	1.56	0.42	6.9	12.52	0.081	2.41	2.109	1.256
Fercal	3.21	1.50	1.35	1.47	0.36	6.9	12.27	0.065	2.30	2.299	0.989
110 R	3.58	1.20	2.58	2.45	0.35	7.0	12.53	0.123	1.81	1.379	1.331
140 Ru	3.45	1.13	1.37	2.42	0.37	7.5	12.48	0.080	3.42	2.065	1.283
101.14 Mgt	3.35	1.35	2.65	2.48	0.43	6.9	12.20	0.088	2.68	1.997	1.300
SO4	3.40	1.29	1.81	1.66	0.40	6.3	11.62	0.083	2.34	2.107	1.636
1103 P	3.57	1.35	1.26	2.17	0.44	6.6	12.11	0.078	2.57	2.641	2.196
S.Em (±)	0.035	0.029	0.016	0.142	0.019	0.09	0.159	0.0025	0.103	0.1148	0.0522
CD (5%)	0.107	0.088	0.049	0.432	0.059	0.27	0.484	0.0077	0.313	0.3483	0.1584

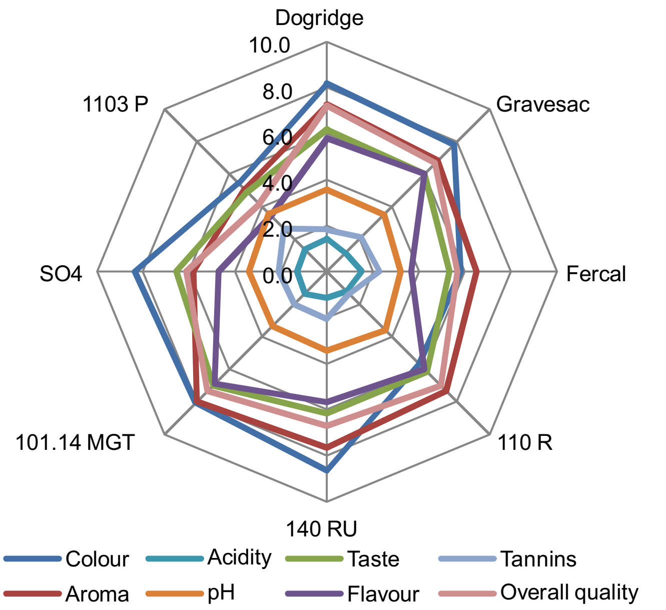

Fig. 1. Effect of rootstocks on organoleptic taste and quality of wine prepared from Cabernet Sauvignon

Rizzon, 2019b). An absence of correlation was found between soluble solids and the sum of the sensory scores (Sivilotti *et al.,* 2007; Zulini *et al.,* 2002) thus revealing the inconsistency of the relationship between soluble solids accumulation and wine quality.

The findings of the research revealed that rootstock affects Cabernet Sauvignon yield and quality in a considerable way. 110R and 101.14 Mgt were identified as the best rootstocks for yield and alcohol content respectively, while 101.14 Mgt was the best for wine quality. Other rootstocks affected one or several characteristics such as berry weight, yield, juice percentage, and wine quality and thus offered growers the choice of rootstocks for achieving certain objectives.

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