COMPARATIVE ANALYSIS OF ROOTSTOCK-VARIETY COMBINATIONS FOR TABLE GRAPE SAPLINGS

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Abstract. This study aimed to determine the vegetative features and total yields of tubed saplings obtained in viticulture application and greenhouse areas that belong to the Faculty of Agriculture, Dicle University, Turkey. Omega grafting technique was used to graft scion obtained table grape varieties (Razaki, Yalova Incisi, Hamburg Misketi, Italia, and Alphonse Lavellee, all belong to *Vitis vinifera* L.) onto six distinct American rootstocks (41B, 5BB, SO4, 420A, 5C, and 1613C). Two months after the grafted cuttings were planted in tubes for rooting in the greenhouse, shoot length (SL), leaf number (LN), and total sapling yield (TSY) parameters were investigated on the saplings. The statistical analysis revealed a significant difference at a 5% significance level for SL and LN between cultivar, rootstock, and cultivar × rootstock combinations. However, a significant difference was observed only at the rootstock level in terms of TSY. Depending on the rootstock and variety, the TSY ranged from 84% to 94%. On the other hand, the average LN per rootstock and cultivar was between 5.5 and 7.5, while the average SL ranged from 12.20 cm to 20.00 cm.
Keywords: *tubed sapling, American grape rootstocks, grafting, Vitis vinifera L., compatibility*

Introduction

Table grapes are in a highly sought-after product category globally and in Turkey due to their wide range of cultivation. However, grapevine yield can be adversely affected by various biotic and abiotic stress factors in areas where table grape varieties are grown. To overcome this problem, grafting grape varieties on American grapevine rootstocks resistant to biotic and abiotic stresses has been identified as necessary for successful viticulture by researchers such as Cookson et al. (2013), Corso and Bonghi (2014), Rashedy (2016), Opazo et al. (2020), and Tedesco et al. (2020).

Since grape varieties of *Vitis vinifera* L. species, both domestic and foreign, are unable to resist biotic stress conditions such as phylloxera and nematodes, grafting them on American grapevine rootstocks with different resistance strengths often results in affinity problems between the rootstock and scion. To address this issue, scientific studies have been conducted to determine combinations that do not have affinity problems, and have played an essential role in viticulture, as noted by Isci et al. (2015).

The present study aimed to investigate the vegetative growth characteristics and sapling yield levels obtained by grafting combinations between table grape varieties and American grape rootstocks.

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Material and methods

This study was conducted in both greenhouse and viticulture areas of the Department of Horticulture, Faculty of Agriculture at Dicle University, Türkiye.

Plant materials

The plant materials used in this study were scions of Razaki, Yalova İncisi, Hamburg Misketi, Italia, and Alphonse Lavellee grape varieties (*Vitis vinifera* L.), and cuttings of 41B, 5BB, SO4, 420A, 5C, and 1613C American vine rootstocks. The trail was conducted with three replications consisted of 20 grafts per replicate.

Method

During the pruning period, healthy and fully developed cuttings were collected and bundled in sets of 50. These bundles were labeled and stored in nylon bags in a cold air store with an average temperature of +4˚C and humidity of 85-90% until the grafting period. Before the grafting process, the cuttings were kept in a water pool for a day to restore the water lost in cold storage and soften the wood tissue. The Omega grafting method was used for grafting (*Figure 1*), and in order to ensure callusing at the grafting point, the grafted cuttings were swiftly submerged in paraffin heated at 70–75 °C, then stacked in sawdust. The callusing crate was moved to a fully automated callusing room with a temperature of 25˚C ±1 and humidity of 85- 90%. After three weeks in the callusing room, the grafted cuttings, which had formed all-round callus, were transferred to the greenhouse and planted in 12×24 cm polyethylene tubes containing peat, perlite, and sand (2:2:1).

Figure 1. *A picture of the showing the production stages of grafted vine sapling. Note: A displays how scions and rootstocks had grafted each other by omega grafting machine. B taken in callusing room illustrates the callus formation at the point of grafting. C shows shoot formation in polyethylene tubes. D shows turning of grafted cutting to saplings*

Examined parameters

In addition to the parameters of shoot length (SL, cm) and leaf number (LN, n), which are the quality characteristics of the saplings, the total sapling yield (TSY, %) representing

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the transformation of the grafted cuttings planted in the greenhouse into saplings has been examined. The reason why only two simple phenological measurements were included in the analysis is that other studies have mostly focused on these parameters.

Statistical analysis

The study employed a randomised plots factorial experimental design and used the JMP Pro 16 statistical program to analyze the data. The SL and LN parameters, which are quality characteristics of the saplings, were transformed using a logarithmic scale. The analysis of variance was then applied to all parameters, and TUKEY HSD was performed to compare the means.

Findings and discussions

Findings

Two months after planting, the parameters of SL (cm), LN (n), and TSY (%) are presented below as a result of analyses performed on 60 saplings in each combination.

Shoot length

The analysis of SL revealed a statistically significant difference of 5% among cultivar, rootstock, and cultivar×rootstock combinations (*Table 1*).

Table 1. *Analysis of variance results in terms of shoot length (SL) parameter of the combinations*

Source	Nparm	DF	Sum of Squares	F ratio	Prob > F
Variety	4	4	12.959097	20.4679	<.0001*
Rootstock	5	5	41.142703	51.9854	<.0001*
Replication	2	2	0.082837	0.2617	0.7698
Variety × Rootstock	20	20	40.194578	12.6968	<.0001*
CV	14.6				

* denotes a significant difference at 5%. CV means coefficient of variation

The saplings with the longest average SL were observed in combinations with SO4 rootstock, while those obtained in combinations with 41B rootstock had shorter SL than other combinations. When the average SL observed in cultivars grown on different rootstocks, while the Yalova Incisi variety had longer shoots with an average of 19.29 cm, it was observed that the remaining varieties exhibited an average SL of approximately 15 cm. Additionally the combination of SO4 rootstock with Yalova Incisi grape variety exhibited the longest shoots, with an average length of 24.9 cm. Conversely, the 5BB rootstock combined with Alphonse Lavellee variety displayed the shortest shoots, averaging 7.10 cm in length (*Table 2*).

Leaf number

In terms of LN, a statistical difference of 5% was observed between cultivar, rootstock, and cultivar×rootstock combinations (*Table 3*).

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Table 2. *Average values of shoot length (SL) parameter observed in grafting combinations (cm)*

Variety / Rootstock	Razaki	Yalova Incisi	Italia	Alphonse Lavellee	Hamburg Misketi	Mean
41B	10.2 c	18.6 b	11.2 cd	10.8 cd	10.3 b	12.22 c
5BB	11.6 bc	15.87 b	13.37 bc	7.1 d	15.47 a	12.68 c
SO4	14.87 b	24.9 a	21.37 a	19.1 a	17.87 a	19.62 a
420A	14.57 b	19.73 b	7.87 d	18.5 ab	16.2 a	15.37 b
5C	20.27 a	18.07 b	20.63 a	21.2 a	17.7 a	19.57 a
1613C	21.53 a	18.6 b	17.37 ab	14.6 bc	17.3 a	17.88 a
Mean	15.51 b	19.29 a	15.3 b	15.22 b	15.81 b	

*A significant variation between rootstocks ($P < 0.05$) is shown by different letters in the same column and the last row

Table 3. *Analysis of variance results in terms of leaf number (LN) parameter of the combinations*

Source	Nparm	DF	Sum of Squares	F ratio	Prob > F
Variety	4	4	4.323654	15.7996	<.0001*
Rootstock	5	5	18.152566	53.0669	<.0001*
Replication	2	2	0.108092	0.79	0.4542
Variety × Rootstock	20	20	17.568134	12.8396	<.0001*
CV	14.2				

* denotes a significant difference at 5%. CV means coefficient of variation

While the average LN formed by the saplings was recorded as 3.63 in the combination of 5BB×Alphonse Lavellee at least, the highest leaf average was seen in the combination of 1613C×Italia with 8.57. The average LN formed by Yalova Incisi and Hambur Misketi grape varieties on different rootstocks was almost the same with 7.04 and 7.03, respectively, and these are the varieties with the highest leaf formation on average. On the other hand, when the LN per rootstock parameter is evaluated, the highest LN on average was recorded in combinations with 5C rootstock. The combinations with the fewest leaves, on average, had 5.43 in combination of 41B rootstock (*Table 4*).

Table 4. *Average values of leaf number (LN) parameter observed in grafting combinations (n)*

Variety / Rootstock	Razaki	Yalova Incisi	Italia	Alphonse Lavellee	Hamburg Misketi	Mean
41B	4.9 c	6.5 bc	5.13 cd	5.13 c	5.47 b	5.43 c
5BB	5.73 c	6.03 c	5.67 c	3.63 d	6.77 a	5.57 c
SO4	5.77 c	8.2 a	6.93 b	7.83 a	7.13 a	7.17 a
420A	5.97 bc	7.23 b	4.13 d	7.23 ab	7.47 a	6.41 b
5C	7.0 ab	7.03 b	7.77 ab	8.43 a	7.6 a	7.57 a
1613C	7.67 a	7.23 b	8.57 a	6.2 bc	7.73 a	7.48 a
Mean	6.17 b	7.04 a	6.37 b	6.41 b	7.03 a	

*A significant variation between rootstocks ($P < 0.05$) is shown by different letters in the same column and the last row

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Total sapling yield

Although there was no statistical difference between cultivar and cultivar×rootstock combinations, a significant statistical difference was observed at the 5% significance level in terms of TSY based on rootstock (*Table 5*). The coefficient of variation value, which represents the reliability of the study, was 32.22 due to the use of 0 and 1 values when determining the total sapling yield.

Table 5. *Analysis of variance results in terms of total sapling yield (TSY) parameter of the combinations*

Source	Nparm	DF	Sum of Squares	F ratio	Prob > F
Variety	4	4	0.5588889	1.5929	0.1736
Rootstock	5	5	2.0916667	4.7693	0.0002*
Replication	2	2	0.04	0.228	0.7961
Variety × Rootstock	20	20	1.8277778	1.0419	0.4077
CV	32.22				

* denotes a significant difference at 5%. CV means coefficient of variation

Regarding the rootstock and cultivar, the TSY ranged from 84% to 94%. While there was no significant difference in the average TSY based on cultivars, there were differences at the rootstock level. On average, the highest TSY was found in combinations with SO_4 rootstock with 94% on the rootstock basis, and Yalova Incisi combinations with 93% on the variety basis. The lowest average rates were determined in the 41B rootstock on the rootstock basis and in the Alphonse Lavellee grape variety with 84% and 88%, respectively. The lowest TSY (77%) was recorded in the 5BB×Alphonse Lavellee combination, while the highest TSY was determined with 97% in the combinations of Yalova İncisi grape variety formed with SO4 and 420A American rootstocks (*Table 6*).

Table 6. *Average values of total sapling yield (TSY) parameter observed in grafting combinations (%)*

Variety / Rootstock	Razaki	Yalova Incisi	Italia	Alphonse Lavellee	Hamburg Misketi	Mean
41B	0.82	0.85	0.88	0.83 ab	0.83	0.84 c
5BB	0.82	0.92	0.92	0.77 b	0.95	0.87 bc
SO4	0.95	0.97	0.95	0.93 ab	0.92	0.94 a
420A	0.9	0.97	0.87	0.85 ab	0.93	0.9 a-c
5C	0.95	0.93	0.92	0.92 ab	0.93	0.93 ab
1613C	0.9	0.92	0.92	0.95 a	0.9	0.92 ab
Mean	0.89	0.93	0.91	0.88	0.91	

*A significant variation between rootstocks ($P < 0.05$) is shown by different letters in the same column and the last row

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Discussion

Shoot length

Cangi and Deveci (2018) reported that in the control group of their study, where scions of the Royal grape variety were grafted on 5BB, 1613C, and 140Ru American grapevine rootstocks, the SL values were 30.0, 26.27, and 15.83 cm, respectively. In another study, Yildirim and Dardeniz (2021) grafted scions of the Red Globe grape variety on 5BB, 41B, 110R, 1613C, and 1103P American vine rootstocks, and found primary SL of 11.23, 8.13, 6.87, 7.74, and 13.21 cm, respectively. Celik et al. (2019) used Alphonse Lavellee grape variety and 1103P and 5BB rootstocks in their grafting study and found SL of 17.76 cm and 13.25 cm for Alphonse Lavellee x 1103P and Alphonse Lavellee x 5BB combinations, respectively, measured 1.5 months after planting. After 2.5 months, the SL were 24.33 cm and 19.70 cm in the same combination order. In the study conducted by Simsek Gozlemeci (2013), the SL was 20.88 cm in the Yalova Incisi x 110R grafting combination in the control group, while it was 23.00 cm in the Italia x 140Ru combination. Schafer (1982) stated that the reason why the SL values in this study did not show parallelism with the mentioned studies is due to the different callus grades observed in the grafted cuttings.

Leaf number

In the grafting study of the Red Globe grape variety with different American rootstocks, the number of nodes observed in the saplings was determined as 6.32, 4.80, 5.13, 5.83, and 6.37 in 5BB, 41B, 110R, 1613C, and 1103P rootstocks, respectively (Yildirim and Dardeniz, 2021). In another research, a scion of the Sire grape variety was grafted on seven distinct American grapevine rootstocks, and the LN identified by the researcher was 7.89, 8.91, 8.54, 7.52, 7.23, 7.06, and 7.04 in combinations of 1103P, 1613C, 41B, 5BB, 420A, 99R, and 110R, respectively (Kaya and Karataş, 2023). According to the data collected under nursery environments by Dardeniz et al. (2017), the number of nodes on the main shoot in the 41B×Alphonse Lavellee combination was 24.8 in the first year and 20.3 in the second year of the grafting research performed using various rootstock and variety combinations. It can be argued that there is some partial similarity between the combinations when the SL values observed in this study are compared with the observations found in previous studies, but there is no general similarity between the combinations. This difference is caused by the affinity status of genotypes.

Total sapling yield

In the study by Cangi and Deveci (2018) the TSY of the Royal grape variety on the 5BB and 1613C rootstocks was calculated as 78.0% and 70.0%, respectively. The TSY values for both rootstocks, with the exception of the 5BB×Alphonse Lavellee combination, are lower when compared to the figures from this study. In another study, when researchers grafted scions of Razaki, Alphonse Lavellee and Italia grape varieties on SO4, 5BB and 1103P rootstocks in Isparta province conditions, the TSY in combination with SO4 rootstock was 59.0%, 52.33% and 58.0% for Razaki, Alphonse Lavellee, Italia grape varieties, respectively. However, these rates were determined as 61.0%, 32.67%, and 34.0%, respectively, for 5BB combinations (Baydar and Ece, 2005). Dolgun et al. (2016) in the grafting combination of Bornova Misketi, Sultan 1 and Trakya Ilkeren grape varieties with 5BB rootstock, the TSY was determined as 86.66, 66.66, and

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71.66%, respectively. Comparing total sapling yields reveals that they are significantly less than the values obtained in this study, the success ratio differs, and controlled conditions have a favourable impact on ensuring high yield.

Conclusion

The growth status of five different table grape varieties on six different American grape rootstocks was examined in this experiment. As a result of the analyses made from the data obtained, the combinations of 5C and 1613C for the Razaki variety; SO4 combination for Yalova Incisi and Italia grape varieties; except for the 5C combination for the Alphonse Lavellee grape variety and the 41B combination for the Hamburg Misketi grape variety, the remaining combinations provided the best results due to the absence of statistical differences. These inferences were derived based on the LN and SL as the TSY was approximately 90% on all rootstocks and cultivars, barring the combinations of 5BB×Alphonse Lavellee and 41B rootstock with all cultivars. However, it should not be forgotten that the sapling environment, environmental circumstances, and practices are the most important elements influencing the performance of rootstock and variety sapling combinations. Since this study was conducted under controlled conditions superior results were obtained when compared to prior investigations on grafted vine saplings.

REFERENCES

[1] Baydar, N. G., Ece, M. (2005): Comparation of Different Scion/Rootstock Combinations in the Production of Grafted Grapevines in Isparta Condition. – Suleyman Demirel University Journal of Natural and Applied Science 9(3): 49-53.

[2] Cangi, R., Deveci, G. Ö. (2018): Effects of disbudding, re-cutting and wounding in grafted grapevine sapling production. – Turkish Journal of Agriculture-Food Science and Technology 6(11): 1630-1639.

[3] Celik, M., Tanrikulu, A., Ersoy, A., Gunenc, A., Gunyuz, D. (2019): Callusing Conditions and Rootstocks Effects on Summer Tubed Sapling Ratio and Quality in Alphonse Lavallée Grape Cultivar. – Adnan Menderes University Journal of Agriculture Faculty 16(2): 153-160.

[4] Cookson, S. J., Clemente Moreno, M. J., Hevin, C., Nyamba Mendome, L. Z., Delrot, S., Trossat-Magnin, C., Ollat, N. (2013): Graft union formation in grapevine induces transcriptional changes related to cell wall modification, wounding, hormone signaling, and secondary metabolism. – Journal of Experimental Botany 64(10): 2997-3008.

[5] Corso, M., Bonghi, C. (2014): Grapevine rootstock effects on abiotic stress tolerance. – Plant Science Today 1(3): 108-113.

[6] Dardeniz, A., Baboo, A. L. I., Gundogdu, M. A. (2017): Determination of Yield Efficiencies of Open–rooted Grapevine Saplings Grafted on Different Variety/rootstock Combinations. – Conference book, 2nd International Balkan Agriculture Congress, 16-18 May 2017, 605p.

[7] Dolgun, O., Ulas, S. S., Teker, T. (2016): Determination of graft success of grape cultivars grafted on two different roostocks. – Acta Scientiarum Polonorum Hortorum Cultus 15(4): 135-145.

[8] Isci, B., Altindisli, A., Kacar, E., Yildiz, D., Soltekin, O., Onder, S., Savas, Y. (2015): A Study on Grafted Take Ratio of Red Globe Grape Variety Grafted onto Different Rootstocks. – Selcuk Journal of Agriculture and Food Sciences-A 27: 17-26.

[9] Kaya, M., Karatas, H. (2023): Investigation of tubed sapling yield and quality characteristics of Sire (Mazrumi) grape varieties grafted on different American rootstocks. – Bahçe 52 (Özel Sayı 1): 78-84.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2105_46774684

[10] Opazo, I., Toro, G., Salvatierra, A., Pastenes, C., Pimentel, P. (2020): Rootstocks modulate the physiology and growth responses to water deficit and long-term recovery in grafted stone fruit trees. – Agricultural Water Management 228: 105897.
[11] Rashedy, A. A. (2016): Effect of pre-grafting incubation and grafted cuttings position on grape grafting success. – Egypt. J. Hort. 43: 225-240.
[12] Schafer, H. (1982): Physiologische untersuchungenzur veredlung saffinitatund veredelten stecklingen. – Wein Wissenschft. 37(3): 147-160.
[13] Simsek Gozlemeci, E. (2013): Effects of micronized calcite (herbagreen) applications on vegetative development of some grafted and potted grape rootstock-scion combinations. – Selcuk University, Department of Horticulture, master's thesis, Konya.
[14] Tedesco, S., Pina, A., Fevereiro, P., Kragler, F. (2020): A phenotypic search on graft compatibility in grapevine. – Agronomy 10(5): 706.
[15] Yıldırım, E., Dardeniz, A. (2021): Determination of the Effects of Different Rootstocks on the Yield and Development of Potted (Coated) Saplings in 'Red Globe' Grape Varieties. – Lapseki Vocational School Journal of Applied Studies 2(4): 16-22.

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