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Determination of Rooting and Vine Sapling Rates of Single-Bud Cuttings Prepared from *Vitis labrusca* L. Grape Cultivars

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Abstract
In this study, rooting rate, root number, root length, root scale, basal callus ratio, and converting to sapling properties of single bud cuttings belonging to *Vitis labrusca* species were investigated. Single-bud cuttings were prepared from basal to upper nodes from annual shoots containing 10 buds in March, 2021. The cuttings of 'Concord', 'Rizellim', 'Ülkemiz', 'Çeliksu', and 'Rizessi' cultivars were rooted in the climate room. According to node numbers, the average highest rooting rate was obtained at the 3rd node with 90.3%. On the other hand, the lowest rooting rate (68.0%), root length (1.86 cm), and basal callus rate (23.1%) were found at the 10th node. In the study, the highest root number was found at the 3rd and 4th nodes (2.9 and 3.1). The highest basal callus formation values were found in the 1st and 2nd nodes (56.9% and 61.8%). The highest average rooting rate (91.4%) and root length (3.0 cm) were obtained in the 'Çeliksu' cultivar, whereas the highest root numbers (2.94) and root scale values (2.15) were determined in the 'Rizellim' cultivar. The average rooting rate (62.0%), root number (1.60), root length (1.35 cm), root scale (0.88), and vine sapling rate (63.3%) were the lowest in the 'Ülkemiz' cultivar. The rate of converting into saplings of cuttings in the cultivars ranged between 83.0% and 89.8%. In the study, the lowest rate of the single-bud cuttings converting to vine saplings was in the 'Ülkemiz' variety (63.3%). The obtained values are evaluated by the weighted-ranking method. According to the weighted-ranking method, the best cultivars were selected as 'Rizessi' and 'Çeliksu' in terms of rooting and converting to vine saplings ratios. In the research, the 4th node of the cuttings was determined as the most suitable for production.

Keywords Grapevine · *Vitis labrusca* · Single node cuttings · Rooting · Sapling ratio

Introduction

Türkiye is one of the gene centers of *Vitis vinifera* grapes in the world, due to its favorable climatic conditions. Türkiye has very valuable grape gene resources and more than 1500 grape varieties are grown in National Grape Gene Resources Centers (Aykas et al. 2018; Candar et al. 2020; Anonymous 2021). According to the latest statistics, Türkiye ranks sixth in the world in terms of grape production and fifth in terms of growing area, with a vineyard area of 390,221 ha and an annual grape production of 3,670,000 tons (FAOSTAT 2021). In addition to *vinifera* varieties, Türkiye has a rich genotype of *Vitis labrusca* L. species. *V. labrusca* L. grapes mostly grown in the Central and Eastern Black Sea Region, located in the north of the Türkiye (Cangi et al. 2006; Karabulut and Çelik 2022; Candar et al. 2021). *Vitis labrusca* L. grapes have a distinct aroma, a foxy flavor, a thick, slip skin and jelly-like flesh. Since the grapes has a great market value, it has widely sold as a table grape in local markets of the coastal cities in the Black Seas region (Kurt et al. 2017). *V. labrusca* L. grapes are consumed by local people as table grape, marmalade, grape molasses, pickle, jam or juice, depending on local needs (Çelik and Köse 2006; Çelik et al. 2005, 2009; Köse 2014; Kurt-Celebi et al. 2020). Many studies have reported that *V. labrusca* L. grapes are resistant to fungal diseases such as powdery mildew and downy mildew (Brown et al. 1999; Wan et al. 2007; Çelik et al. 2008; Köse 2014). The vines of this species grow by wrapping around trees, in home gardens, as a canopy as a pergola, or extended to the balconies of buildings and houses.

Grapevines belonging to the Vitaceae family are mostly propagated by cuttings and this propagation method is faster than seed propagation (Singh and Chauhan 2020). More

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than 60 species of *Vitis* have spread to Asia, America, and Europe. *V. labrusca* L. originate from America and they have adapted to many different climatic conditions from humid weather to dry weather and its varieties have been using breeding (Çelik et al. 2015). The vines of the *V. labrusca* L. species can grow stronger and reach the top of the trees (Çelik et al. 2015). Some varieties (for example, 'Concord' and 'Niagara') are grown commercially in the United States for use in making juices, jams, jellies, and wine (Nixford and Hermosín-Gutiérrez 2010; Burin et al. 2014; Lima et al. 2014; Toaldo et al. 2015; Coelho et al. 2018; da Silva et al. 2019; Güler 2022). These cultivars are hybrids of *V. labrusca* L. and *V. vinifera* L. that emerged as a result of natural hybridization and they are classified as *Vitis labrusca* L. Bailey (Keller 2015).

The use of cuttings, rooting, budding, layering and grafting is common in grape propagation for the establishment of new vineyards (Verdegaal 2009). Propagation of the vines with cuttings known is as the oldest and easy method. It has many advantages such as being economical (Hartmann et al. 1997), requiring limited space, preparing easily (Sabir and Kara 2004), and being quick to propagate selected clones or new varieties (Patil et al. 2001; Singh and Nair 2003; Alikhani et al. 2011). It can be produced by using different methods such as vine wood cutting, green cutting, bud cutting, grafting and layering (Çelik et al. 1998; Çelik 2007). Many studies have been carried out on the propagation of the vine by cuttings and practical benefits have been obtained from these studies (Patil et al. 2001; Verdegaal 2009; Abebe 2017; Cangi and Etker 2018; Özer 2023). Propagation with cuttings has taken place an important in the production of the grapevine. *Vitis* species show a great diversity in terms of adventitious root structures (Smart et al. 2002; 2006; Reinhart and Biasi 2017; Karakurt et al. 2009). In rooting of cuttings, rooting increases because lignification and carbohydrates are higher in the bottom than in the upper parts of the shoot. The region where the adventitious roots and the young roots, which are defined as the main roots, occur is the pericycle layer. Adventitious root formation in annual shoots: this is formed by the cambium, pericycle and phloem (Legué et al. 2014). Adventitious roots, which are white in the first place, then take a dark brown or brown color. Later, thin roots are formed on the adventitious roots (Çelik 2007; Bellini et al. 2014).

The quality of the shoots obtained in vine production is as important as the number (Waite et al. 2015). In many studies, researchers have expressed the quality of the annual shoot used for propagation by the value of cane width/pith, phloem+xylem/pith, xylem/pith, and bark+phloem/pith ratios (Hunter et al. 2004; Dardeniz et al. 2008; Gökdemir and Dardeniz 2014). The quality of the propagation material is determined by many parameters such as callus, root structure, and sprouting ability (Hunter et al. 2004). Dardeniz et al. (2008) found the lowest rooting rates in cuttings prepared from the nodes of 5BB and 140 Ru rootstocks in the 1st–4th nodes and 17th–20th nodes because the lignification of the shoot is low. The researchers stated that the 5th–16th node in 5BB rootstock and the 5th–12th node in 140Ru rootstock would be the most suitable region for graft of the cuttings.

In 2016, *V. labrusca* L. cultivars introduced by Ondokuz Mayıs University, Faculty of Agriculture, Department of Horticulture, Türkiye. The production of rooted vine saplings in vegetative ways is of great importance in establishing new vineyards and filling the empty spaces in existing vineyards, as the demand for *V. labrusca* L. grape varieties increases day by day in Black Sea Region, Türkiye. This is the first time the rooting specifications of these cultivars are investigated according to node positions. Because of the heavy demand for cultivars, the aim is their rapid propagation to meet consumer demands. This study is aimed at determining the rooting and sapling rates in the nodes of single-bud cuttings because this enables a fast and cost-effective way to obtain rooted vine saplings. In the research, the rooting status of the single-bud cuttings of Türkiye's first registered *V. labrusca* L. grape cultivars was evaluated according to the node position and the possibilities of use in sapling production.

Materials and Methods

This research was carried out in the climate room of Ondokuz Mayıs University, Faculty of Agriculture, Department of Horticulture in 2021. In the study, 'Rizessi', 'Rizellim', 'Çeliksu', 'Ülkemiz' and 'Concord' grape cultivars were investigated in terms of rooting rate (%), root numbers, root length (cm), root scale (0–4), basal callus ratio (%) and converting to sapling ratio (%). These cultivars belong to *V. labrusca* L. and were registered by the Ondokuz Mayıs University, Faculty of Agriculture, Department of Horticulture in 2016. The cultivars used in the research were 10 years old, grown on their own root and were formed according to the double-armed high training system (Fig. 1). The vines were irrigated with drip irrigation during the summer season. In total, 12 kg per acre

Table 1 Soil characteristics of the trial vineyard

Specification	Amount	Classification
Soil structure	110	Heavy Clay
pH	6.16	Slightly acid
Lime ($CaCO_3$) (%)	0.40	Slightly
Total Salt (%)	0.052	Unsalty
Phosporus (P_2O_5 Kg/da)	4.36	Little
Potassium (K_2O Kg/da)	91	High
Organic Matter (%)	2.98	Middle

Fig. 1 Image of grape varieties used in the experiment

fertilizing has been made with calcium ammonium nitrate (CAN) 26% N fertilizer after pruning in March, 2021. Soil characteristics of the trial vineyard are given in Table 1.

Root Development (0–4) Determination of root development in cuttings was carried out with the help of 0–4 scale according to Dardeniz (2001). (0: No roots, 1: one side weak root formation, 2: two-sided root formation, 3: three-sided strong root formation, 4: very strong root formation all around.)

Basal Callus Rates (%) It was determined by the ratio of the cuttings with callus at the basal to the total number of cuttings planted. 0: No callus formation; 1: exist only callus formation (Cangi and Etker 2018).

Rooting Rate (%) This was calculated by dividing the rooted cuttings by the total number of planted cuttings (Köse et al. 2015).

Converting to Sapling Rate (%) This was determined by the ratio of the number of plants with healthy shoots to the total number of rooted cuttings planted 1 month after planting in the pots (Cangi and Etker 2018).

Weighted-ranking Method In the study, in order to determine some rooting characteristics were evaluated by the modified weighted-ranking method used by Köse et al. (2015). In this method, relative and class scores of each characteristic were evaluated to obtain the best cultivar and node number in terms of rooting and converting to vine saplings (Table 2).

Table 2 Scores of some growth characteristics and their relative values in the weighted-ranking method

Parameters	Classification scores		Classification scores
Callus formation rate (%)	≤ 50: 1 51–60: 3 61–70: 5	71–80: 7 81–90: 9 ≥ 91: 10	15
Rooting percentage (%)	≤ 10: 1 11–30: 3 31–50: 5	51–70: 7 71–90: 9 ≥ 91: 10	20
Root length (cm)	≤ 0.5 cm: 1 0.6–1.0 cm: 3 1.1–2.0 cm: 5	2.1–2.5 cm: 7 2.5–3.0 cm: 9 ≥ 3.1 cm: 10	20
Root development level (0–4)	≤ 1.0: 1 1.1–2.0: 3 2.01–2.5: 5	2.51–3.0: 7 3.01–3.5: 9 ≥ 3.51: 10	15
Root number (pcs)	≤ 1.0: 1 1.1–2.0: 3 2.01–2.5: 5	2.51–3.0: 7 3.01–3.5: 9 ≥ 3.51: 10	10
Converting to sapling ratio (%)	≤ 10: 1 11–30: 3 31–50: 5	51–70: 7 71–90: 9 ≥ 91: 10	20
Total			*100*

Rooting in Climate Room Conditions

In March, 2021, while the shoots were still dormant, annual shoots contained 10 buds of each variety were cut and brought to the laboratory. In all, 10 pieces single-bud cuttings were prepared of each shoots from basal to upper side and planted in the boxes according to their node numbers. Each node is numbered from 1 to 10 throughout the basal to upper of the shoots. The prepared single-bud cuttings were planted in 58 × 40 × 18 cm foam boxes filled with moist perlite. Before planting, the perlite surface is covered with a stretch film in order to keep the single-bud cuttings stable. The planted cuttings were kept under climate room conditions at ±26 °C, 80% humidity and 12 h photoperiod (80 W m^{-2}) provided by cool-white fluorescent tubes (Fig. 2).

At 1 month after the planting of the cuttings, the rooted cuttings were removed and their rooting specifications were

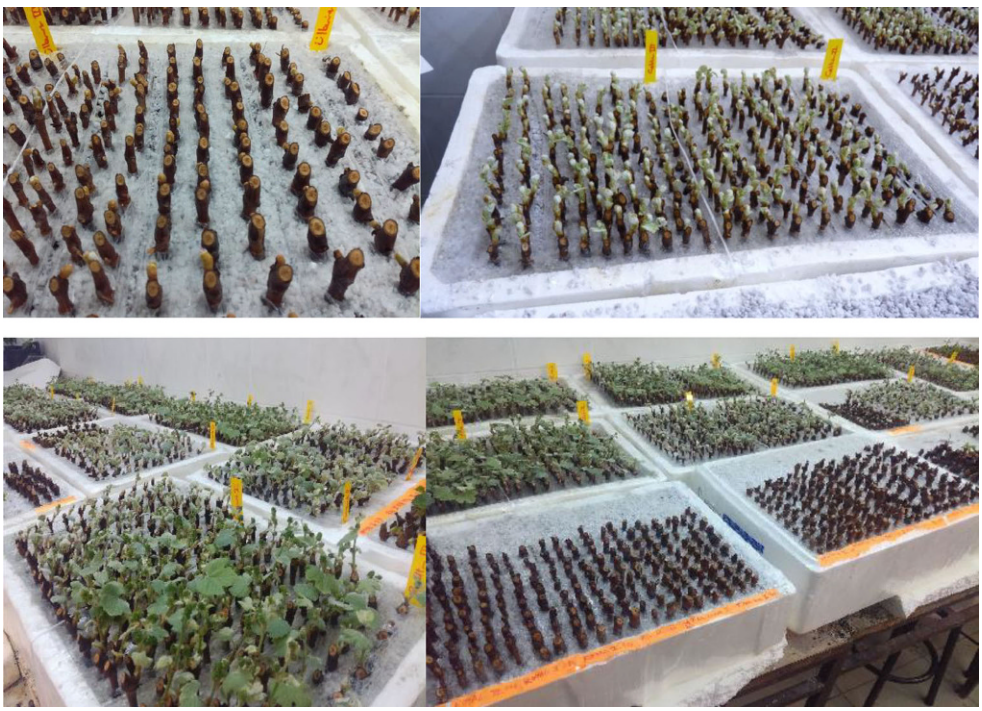

Fig. 2 Rooting of single-bud cuttings in the climate room

Fig. 3 Investigation of rooting properties of single-bud cuttings

determined. Cuttings with healthy shoots and roots were planted in black polyethylene pots. At 1 month thereafter, the cuttings that remained healthy and showed growth were counted, and the rate of converting to sapling (%) was determined (Fig. 3).

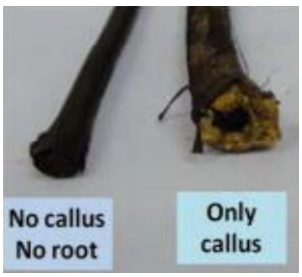

Fig. 4 Basal callus formation of the cuttings. (Evaluated according to Cangi and Etker 2018)

Data Analysis

The study was conducted in a randomized trial design with three replications, three vines in each replication, and three shoots for each vine. In the study, nine canes containing 10 buds were used in the study. The obtained results were subjected to Duncan Multiple Comparison test in the SPSS 16.0 program (IBM, SPSS Statistics V20, Chicago, IL, USA). The results were evaluated according to $P < 0.05$ significance level.

Results and Discussion

Rooting rates of single-bud cuttings prepared from one to 10 nodes of each cultivar are given in Table 3. Significant differences ($P < 0.05$) were determined between cultivar × node interaction, cultivars and nodes in terms of rooting rate. In the cultivar × node interaction, the highest rooting values were found at the 3rd and 4th nodes (100%) in 'Rizellim', and at the 8th and 9th nodes (100%) in Çeliksu cultivars. On the other hand, the lowest rooting rate was found at the 10th node (33.84% and 37.78%) in 'Ülkemiz' and 'Concord' cultivars. Among the cultivars, the highest rooting rate was found to be statistically significant in 'Çeliksu' (91.2%), 'Rizellim' (89.1%), and 'Rizessi' (87.4%) cultivars, which were in the same group. The lowest rooting rate was found in the 'Ülkemiz' cultivar with 62.0%. Rooting rates of the cultivars according to node numbers are given in Fig. 4. According to node number, the highest average rooting rates was determined at the 3rd node

Table 3 Rooting rate (%) of single-bud cuttings prepared from different nodes of *Vitis labrusca* grapes

Node number	'Concord'	'Rizellim'	'Ülkemiz'	'Çeliksu'	'Rizessi'	Node average
1	80.98 *a.h**	66.67 f.j	73.08 b.i	67.43 e.i	77.78 a.i	73.7 cd
2	61.97 g.j	88.64 a.f	75.00 b.i	83.08 a.h	82.83 a.h	78.9 bc
3	88.89 a.f	100 a	75.56 a.i	91.67 a.e	94.44 abc	*90.3 a***
4	88.89 a.f	100 a	66.67 f.j	88.38 a.f	94.45 abc	87.7 ab
5	80.77 a.h	91.67 a.e	69.19 e.i	96.97 ab	94.45 abc	86.0 ab
6	74.63 b.i	91.67 a.e	59.62 hij	94.45 abc	85.86 a.g	81.3 bc
7	81.20 a.h	77.78 a.i	69.45 d.i	94.19 a.d	88.13 a.f	82.2 abc
8	75.43 a.i	88.89 a.f	44.42 jkl	100 a	91.16 a.f	80.1 bc
9	70.51 c.i	88.89 a.f	55.56 ijk	100 a	85.61 a.g	80.1 bc
10	37.78 kl	92.10 a.e	33.84 l	94.19 a.d	80.30 a.h	67.5 d
Cultivar average	74.10 *b***	*88.63 a*	62.24 c	*91.04 a*	*87.50 a*	

**Cultivar × node $P < 0.05$, **cultivar $P < 0.05$, ***node $P < 0.05$*

Table 4 Callus formation rate of single-bud cuttings prepared from different nodes of *Vitis labrusca* grapes (%)

Node number	'Concord'	'Rizellim'	'Ülkemiz'	'Çeliksu'	'Rizessi'	Node average
1	86.5*	33.3	62.4	56.1	45.2	*57.0 a***
2	83.8	50.5	52.8	64.7	57.6	*61.8 a*
3	69.9	16.3	46.7	41.7	17.4	38.2 b
4	54.9	22.2	61.1	16.9	11.6	33.5 b
5	73.1	8.3	56.8	27.5	26.5	38.5 b
6	64.4	11.1	45.7	33.3	17.9	34.4 b
7	67.7	13.9	33.3	25.0	32.6	34.6 b
8	65.4	13.9	43.5	26.8	40.7	38.0 b
9	59.4	16.7	25.0	19.4	18.2	27.8 bc
10	43.9	13.9	25.8	14.9	17.7	23.1 c
Cultivar average	*67.3 a***	20.1 d	45.3 b	32.3 c	28.0 c	

**Cultivar × node ns, *cultivar $P < 0.05$, **node $P < 0.05$*

(91.2%), and the lowest rooting rates was determined at the 10th node (67.6%) (Table 3).

According to Hartmann et al. (1990), the cuttings should be prepared from 2/3 of the basal in 1-year shoots, and that cuttings should not be taken from the tips because there is not enough carbohydrate accumulation in the upper part. Many researchers have stated that rooting and callus formation levels in grape shoot cuttings may differ according to grape cultivars (Abido et al. 2013; Somkuwar et al. 2017; Chang et al. 2022) and species as well (Castro et al. 1994; Keeley et al. 2004; Satisha et al. 2007; Shiozaki et al. 2013). Carbohydrates stored in annual shoots indicate the health and vigor of the vines (Somkuwar et al. 2011; Köse and Ateş 2017). It was determined that the number of adventitious roots increased towards the lower nodes in cuttings prepared from American rootstocks (Çelik 2007). In this subject, researchers stated that the sprouting of buds on cuttings may affect rooting of the cuttings (Smart et al. 2002; Zhou et al. 2020). As a matter of fact, it has been reported that the C/N ratio of 1-year canes is related to the rooting (Hartmann et al. 1997).

Statistically significant differences ($P < 0.05$) were obtained in the rate of callus formation in single-bud cuttings prepared from different nodes of grape cultivars, while any statistical difference was found in the cultivar × node interaction (Table 4). The highest callus formation rate in the cultivar × node interaction was determined as 86.5%, 83.8% and 73.1% in the 1st, 2nd and 5th nodes of the 'Concord' cultivar, respectively. Among the cultivars, the highest rate of callus formation at basal was determined as 67.3% in 'Concord' cultivar. 'Concord' cultivar was followed by 'Ülkemiz' cultivar with a rate of 45.3%. The highest basal callus formation was also observed in cultivars with the lowest rooting (Table 4). According to the node number, the basal callus formation rates were highest in the 1st and 2nd nodes, with the rates of 57.0% and 61.8%, respectively. According to nodes, the lowest callus rate was obtained from the 10th node.

As a result of this study, the lowest rate of callus was found in the 10th node in general (Table 4). In the obtained data, it was determined that rooting was the low in the 1st and 2nd nodes, but the callus ratio was high. In general, 1-year-old shoots are used in grape propagation with cuttings. Since the maturation status and development of these shoots are not the same on all sides, the level of callus formation is not the same. According to Dardeniz et al. (2008), the lowest rooting rates in the cuttings prepared from the same canes are maintained in the basal 1st–4th where the anatomical structure is the hardest and occurred in 17th–20th nodes when lignification is low. In this subject; Hartmann and Kester (1983) stated that the best rooting in shoots occurred in cuttings prepared from the basal part. However, it is thought that callus is necessary for root formation (Ağaoğlu 1999). As seen in the results obtained from our study, it was determined that the rate of callus formation was higher in the bottom part of the cuttings where the lignification was higher. The reason for the high rate of callus in the bottom may be due to the intense reserve carbohydrate content accumulated by the cells (Somkuwar et al. 2017). Towards the upper parts of the shoot, carbohydrate accumulation decreases and its quality decreases (Dardeniz et al. 2008). The basal section of vine cuttings (one to four buds) accumulates large amounts of carbohydrates in the cells (Somkuwar et al. 2017). Dardeniz et al. (2008) stated that upper side of the cane has less and lower quality carbohydrate reserve.

The values for the number of roots occurring in single-bud cuttings in the study are given in Table 5. Statistically significant differences were determined between cultivar × node interaction in terms of root number, cultivar and node ($P < 0.05$). In the cultivar × node interaction, the highest root number was obtained in the 10th node of 'Çeliksu' cultivar with 3.78. This was followed by the 'Concord' cultivar with 3.67 in the 3rd node and the 'Rizellim' cultivar in the 4th node with 3.58.

Table 5 Root number of single-bud cuttings prepared from different nodes of *Vitis labrusca* grapes

Node number	'Concord'	'Rizellim'	'Ülkemiz'	'Çeliksu'	'Rizessi'	Node average
1	2.99 a.j*	2.39 c.n	1.87 i.p	2.25 e.o	2.21 e.o	2.3 bc
2	2.03 g.p	1.99 h.p	2.36 d.n	1.87 i.p	1.29 n.r	1.9 d
3	3.67 ab	3.25 a.f	2.55 b.m	2.31 d.n	2.67 a.k	*2.9 a***
4	3.51 a.d	3.58 abc	1.81 j.r	3.29 a.e	3.21 a.g	*3.1 a*
5	2.93 a.j	3.16 a.h	1.55 k.r	3.07 a.i	2.83 a.j	2.7 ab
6	1.89 i.p	2.72 a.k	1.37 m.r	2.78 a.j	2.62 a.k	2.3 cd
7	2.07 f.p	2.75 a.j	1.81 j.r	2.58 a..l	2.71 a.k	2.4 bc
8	2.09 e.p	2.91 a.j	0.92 pr	2.87 a.j	2.88 a.j	2.3 bc
9	1.40 l.r	3.50 a.d	1.11 opr	3.58 abc	2.86 a.j	2.5 bc
10	0.94 pr	3.23 a.g	0.70 r	3.78 a	2.47 b.m	2.2 cd
Cultivar average	2.4 c	*2.9 a***	1.6d	2.8ab	2.6bc	

**Cultivar × node P < 0.05, **cultivar P < 0.05, ***node P < 0.05*

Table 6 Root length of single-bud cuttings prepared from different nodes of *Vitis labrusca* grapes (cm)

Node number	'Concord'	'Rizellim'	'Ülkemiz'	'Çeliksu'	'Rizessi'	Node average
1	2.46 a.k*	1.68 g.m	2.01 d.l	2.27 c.k	2.53 a.j	2.2 bcd
2	1.75 f.m	2.30 b.k	1.70 g.m	2.06 c.l	2.39 a.k	2.0 cd
3	2.89 a.f	2.74 a.h	2.00 d.l	2.83 a.g	2.77 a.g	2.6 a
4	2.47 a.j	3.00 a.e	1.60 h.n	2.86 a.f	3.07 a.e	2.6 a
5	2.65 a.j	3.01 a.e	1.33 kmn	3.44 ab	2.98 a.e	2.7 a**
6	1.92 e.m	2.40 a.k	1.55 i.n	3.03 a.e	2.97 a.e	2.4 abc
7	2.08 c.l	2.26 c.k	0.98 lmn	3.16 a.d	3.22 abc	2.3 abc
8	1.54 i.n	2.70 a.h	0.87 mn	3.09 a.d	2.53 a.j	2.1 cd
9	1.51 j.n	2.59 a.j	1.08 lmn	3.44 ab	2.47 a.j	2.2 bcd
10	0.54 n	2.67 a.i	0.52 n	3.54 a	2.00 d.l	1.9 d
Cultivar average	2.0 c	2.5 b	1.4 d	*3.0 a***	2.7 b	

**Cultivar × node P < 0.05, **cultivar P < 0.05, ***node P < 0.05*

In the study, the lowest root number was 0.7 in 'Ülkemiz' cultivar at the 10th node. Among the cultivars, the highest average root number was found in 'Rizellim' with 2.9 and 'Çeliksu' with 2.8. The lowest average root number was determined in 'Ülkemiz' cultivar with 1.61. In the study, the highest root number according to the nodes of the cultivars was determined as 3.1 and 2.9 in the 3rd and 4th nodes, respectively. The average lowest root number was found 1.9 at the 2nd nodes of the cultivars.

In terms of root length, significant differences were measured between cultivars and nodes ($P < 0.05$). Root length in cuttings was between 0.52 cm and 3.44 cm in cultivar × node interaction. The highest root length was found in 'Çeliksu' cultivar as 3.44 cm in 5th node, and the lowest root length was determined at 10th node in 'Ülkemiz' and 'Concord' cultivars as 0.52 and 0.54 cm, respectively (Table 6).

When the callus development in the basal of single-bud cuttings was evaluated, it was determined that the 3rd and 4th nodes gave the best results in terms of rooting rate and the number of roots, although the amount of callus was higher in the basal of the cuttings obtained from the 1st and 2nd nodes. In the study, it was concluded that the 3rd and 4th nodes are suitable for rooting performance for using cultivars. In this regard, it has been stated that the nutrition and lignification status of the canes is quite effective in callusing and rooting (Rodoplu and Dardeniz 2015). In grapevine propagation, preferring the mid and basal nodes of shoots because of having enough carbohydrates compared to the upper sides is important. Due to the well-lignified, they show better rooting performance and sprouted earlier than the apical cuttings (Dardeniz et al. 2008).

While the average highest root length was 3.0 cm in 'Çeliksu' cultivar, the lowest average root length was in 'Ülkemiz' cultivar with 1.4 cm. In terms of root length of the cultivars, 'Rizessi' and 'Rizellim' cultivars were in the same group with 2.5 cm and 2.7 cm root lengths, respectively. In this study, it was determined that the root length changed according to the nodes from which the cuttings were prepared (Table 6). In general, it was determined that the root length differs according to the cultivars. The highest average root lengths were measured between the 3rd and 5th nodes. The highest root length in the nodes was at the 5th node with 2.68 cm, and the lowest at the 10th node with 1.85 cm. The number of roots in vine sapling

Table 7 Root scale of single-bud cuttings prepared from different nodes of *Vitis labrusca* grapes (0–4)

Node number	'Concord'	'Rizellim'	'Ülkemiz'	'Çeliksu'	'Rizessi'	Node average
1	1.73 c.n*	1.56 e.r	0.99 o.u	1.47 i.r	1.55 f.r	1.5 de
2	1.10 n.u	1.44 j.r	1.32 k.s	1.20 n.t	1.14 n.t	1.2 e
3	1.97 b.l	2.36 a.k	1.51 h.r	1.53 g.r	2.18 a.i	1.9 ab
4	1.93 b.m	2.52 ab	1.00 n.u	2.18 a.i	2.71 a	*2.1 a***
5	1.69 d.o	2.31 a.e	0.85 r.u	2.18 a.i	2.28 a.f	1.9 abc
6	1.29 l.t	2.25 a.g	0.71 stu	1.98 a.l	2.14 a.j	1.7 bcd
7	1.24 m.t	2.08 a.j	0.89 p.u	1.59 e.p	2.04 a.k	1.6 cd
8	1.33 k.s	2.16 a.j	0.62 stu	2.07 a.j	2.21 a.h	1.7 bcd
9	0.90 p.u	2.51 ab	0.61 stu	2.46 abc	2.32 a.d	1.8 bc
10	0.58 tu	2.40 a.d	0.42 u	2.60 ab	2.02 a.k	1.6 bcd
Cultivar average	1.4 c	*2.2a***	0.9 d	1.9 b	2.1ab	

**Cultivar × node $P < 0.05$, **cultivar $P < 0.05$, ***node $P < 0.05$*

Table 8 Converting rate of single-bud cuttings prepared from different nodes of *Vitus labrusca* grapes (%)

Node number	'Concord'	'Rizellim'	'Ülkemiz'	'Çeliksu'	'Rizessi'	Node average
1	67.6*	96.9	48.6	88.2	90.6	77.8***
2	85.3	87.5	61.8	82.9	84.8	80.4
3	88.2	87.9	67.6	81.8	*96.9*	84.3
4	91.2	*97.0*	58.8	88.6	86.7	84.3
5	*94.1*	93.9	45.5	88.9	93.5	83.2
6	87.9	90.9	66.7	88.9	83.9	83.7
7	85.3	81.8	*73.5*	77.1	*96.7*	82.5
8	73.5	90.9	*72.7*	*94.1*	90.6	84.3
9	85.3	90.6	71.4	84.8	87.5	83.7
10	80.0	78.8	66.7	85.3	87.1	79.5
Cultivar average	83.9a**	89.6a	63.3b	86.1a	89.8a	

**Cultivar × node ns, **cultivar $P < 0.05$, ***node ns*

production is affected by similar factors such as the cultivar used (Samancı and Uslu, 1992), the rooted environment (Sivritepe and Türkben 2001) and the pots in which they are planted (Akman and Ilgın 1990; Akman et al. 1989). In our evaluation, 'Çeliksu' cultivar gave better results than the others in terms of root length among the cultivars. On the other hand, between three and five nodes gave the highest average root lengths in the study.

The root scale values of single-bud cuttings obtained from *V. labrusca* grapes are given in Table 7. In terms of root scale, the interaction of cultivar × node, statistically significant ($P < 0.05$) differences between cultivars and nodes were determined. The highest value in the cultivar × node interaction was obtained at the 4th node (2.71) of 'Rizessi', followed by the 10th node (2.60) of the 'Çeliksu' cultivar and the 4th node (2.52) of in the 'Rizellim'. When we look at the values among the cultivars in terms of root scale, the highest value was found in 'Rizellim' (2.16), and the lowest value was found in our 'Ülkemiz' (0.89). The highest value in the effect of nodes on the root scale was obtained at the 4th node (2.07), followed by the 3rd node (1.91) and the 5th node (1.86).

The cuttings were removed from the perlite medium after 1 month and were planted in black polyethylene pots. The data belonging to the rates of converting to vine saplings obtained by rooting different nodes of *V. labrusca* grapes are given in Table 8. While the statistical differences between cultivar × node interaction and nodes were insignificant in terms of converting to sapling rate, the differences between cultivars were found to be significant ($P < 0.05$). In terms converting to sapling rate, the highest values in cultivar × node interaction were determined in the 4th node of 'Rizellim' cultivar (97.0%), in the 3rd node of 'Rizessi' cultivar (96.9) and in the 1st node of 'Rizellim' cultivar (96.7%). Considering the average of the cultivars, 'Rizessi' 89.8%, 'Rizellim' 89.6%, 'Çeliksu' 85.9% and 'Concord' 83.95% took place in the first group statistically in terms of the rate of saplings, and 'Ülkemiz' cultivar has the lowest sapling rate with 63.3%. According to the average values obtained from the nodes, the highest sapling transformation rate was 84.6% at the 3rd node; this was 84.5% in the 4th node and 84.1% in the 8th node.

According to the weighted ranking result, the highest scores were calculated in 'Rizessi' as 770 point and 'Çe-

Table 9 Evaluation of cultivars with weighted-ranking method

Cultivars	*Scores for callus formation*		*Scores for rooting percentage*		*Scores for root length*	
	CS	*CS*RS*	*CS*	*CS*RS*	*CS*	*CS*RS*
'Concord'	5	75	9	180	3	60
'Rizellim'	1	15	9	180	5	100
'Ülkemiz'	1	15	7	140	3	60
'Çeliksu'	1	15	10	200	7	140
'Rizessi'	1	15	9	180	7	140
Cultivars	*Scores for root development level*		*Scores for root number*		*Scores for converting to sapling ratio*	
	CS	*CS*RS*	*CS*	*CS*RS*	*CS*	*CS*RS*
'Concord'	3	45	7	140	9	180
'Rizellim'	5	75	9	180	9	180
'Ülkemiz'	1	15	5	100	7	140
'Çeliksu'	3	45	9	180	9	180
'Rizessi'	5	75	9	180	9	180
Total score of cultivars						
'Concord'	'Rizellim'		'Ülkemiz'	'Çeliksu'		'Rizessi'
680	730		470	*760*		*770*

Table 10 Evaluation of node numbers with the weighted-ranking method

Node numbers	*Scores for callus formation*		*Scores for rooting percentage*		*Scores for root length*	
	CS	*CS*RS*	*CS*	*CS*RS*	*CS*	*CS*RS*
1	3	15	9	180	5	100
2	5	75	9	180	3	60
3	1	5	10	180	7	140
4	1	5	9	180	7	140
5	1	5	9	180	7	140
6	1	5	9	180	5	100
7	1	5	9	180	5	100
8	1	5	9	180	5	100
9	1	5	9	180	5	100
10	1	5	7	140	3	60
Node numbers	*Scores for root development level*		*Scores for root number*		*Scores for converting to sapling ratio*	
	CS	*CS*RS*	*CS*	*CS*RS*	*CS*	*CS*RS*
1	3	45	7	140	9	180
2	3	45	5	100	9	180
3	3	45	9	180	9	180
4	5	75	10	200	9	180
5	3	45	9	180	9	180
6	3	45	7	140	9	180
7	3	45	7	140	9	180
8	3	45	7	140	9	180
9	3	45	9	180	9	180
10	3	45	7	140	9	180

Total score for node numbers									
1	2	3	4	5	6	7	8	9	10
660	640	730	*780*	730	650	650	650	690	570

liksu' as 760 points. The results showed that 'Rizessi' and 'Çeliksu' were the best cultivars in terms of rooting and converting to grapevine saplings. On the other hand, 'Ülkemiz' cultivar showed the worst performance for the rooting and sampling ratio (Table 9).

When the cultivars were evaluated according to nodes numbers with weighted ranking, the highest score was obtained from 4th nodes, while the lowest scores was in 10th nodes. The results show that using the 3rd–5th node will give the best results to achieve successful rooting rate (Table 10).

Conclusion

In this study, rooting and converting to sapling ratio of single-bud cuttings prepared from basal to upper side in five different grape cultivars belonging to *V. labrusca* were determined. 'Çeliksu' cultivar in terms of average rooting rate and root length, 'Rizellim' for root number and root scale and 'Concord' for basal callus formation rate gave the best results. 'Rizellim' and 'Çeliksu' cultivars gave the the highest results in terms of sapling transformation rate. Among the nodes, the 3rd, 4th, and 5th parts were prominent in the research. According to the weighted grading method, 'Rizessi' and 'Çeliksu' cultivars and 4th node gave the best total scores in the light of the examined parameters. When preparing the cuttings for rooting, the preparation of cuttings after removing the first two to three nodes at the bottom will increase the success of rooting.

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Author Contribution Bülent Köse performed the statistical analysis. Yahya Uray, Kevser Bayram, Fatma Türk and Besim Karabulut conducted field, laboratory and growth room works. Bülent Köse, Yahya Uray and Hüseyin Çelik wrote the manuscript.

Conflict of interest B. Köse, Y. Uray, B. Karabulut, F. Türk, K. Bayram and H. Çelik declare that they have no competing interests.

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