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Cane Quality Determination of 5 BB and 140 Ru Grape Rootstocks

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Summary

This study was conducted to investigate best cane quality level in 140 Ru and 5 BB grape rootstocks through morphological changes when the canes were sectioned into 4-bud segments from base to tip. Canes were later forced to grow in plastic pots to determine the relationship between cane quality and root-shoot growth characteristics. The results suggested that rootstocks differ along their canes length for best quality to use in propagation. Cuttings should be prepared in 5 BB between 5 to 16th internodes, and in 140 Ru between 5–12th nodes, because of better quality and well balanced root-shoot growth.

Key words. cane quality – cutting – grafting – propagation – rooting – *Vitis*

Introduction

In grapevine propagation, cutting quality is as equally important as the quantity. The quality of propagation material could be defined as the ability for callusing, root formation, budding and growth during both the callusing period and in the nursery (Hunter et al. 2004). With some wood plants, hardwood cuttings are made by sectioning shoots a meter long and obtaining four to eight cuttings from a single shoot. Marked differences are known to exist in the chemical composition of such shoots from base to tip (Tukey and Green 1934). Variations in root production on cuttings taken from different portions of the shoot are often observed, with the high rooting, in many cases, found in cuttings taken from the basal portions of the shoot. The shooting capacity of basal portions of such shoots would be considerably higher than that of the apical parts (Subbotovich and Perstnev 1971; Winkler et al. 1974; Nicholas et al. 1992; Hartmann et al. 1997).

Cane cuttings well lignified and rich in reserves develop better root and shoots than otherwise weak cuttings (Bartolini et al. 1996; Hartmann et al. 1997; Dardeniz 2001; Hunter et al. 2004). Cane tips do not lignify properly and callus and root formations are disrupted (Weaver et al. 1975).

Hunter et al. 2004 stated that as a general rule in grapevine propagation, the surface area of the pith should not be more than a quarter of the surface of the diameter of the cane. Çelik (1998) reported that when portions of a cane in which bark+phloem tissues are better developed compared to diameter of the cane, its adventitious root development is easier. Dardeniz et al. (2007) reported that quality of a cane for propagation could be determined by using the ratios of cane width/pith and phloem+xylem/pith values.

This present study was conducted for three years to investigate the rooting and development performance of rootstocks when sectioned into 4–node portions along a cane. Internal morphological changes in the transverse sections of one-year old canes were determined through using different measurements and characteristics to determine best cane quality. Growth performance of the cuttings after planting was also determined.

Material and Methods

Morphological assessments

Morphological measurements were made on the canes of grapevine rootstocks, 140 Ru and 5 BB, taken during dormant periods of 2003–2004 and 2004–2005 from the Fruit Propagation Station, located in Umurbey, Çanakkale, Turkey. All rootstock plants were managed the same such as irrigation, fertilization, soil management, pruning and disease controlling. The vines were on the ground and spaced 2 m apart within the row and 2 m apart between the rows. The trial was designed in randomized plots with four replicates and three vines per replicate. Canes were randomly chosen on the basis of equal thickness. 8 canes about 4–6 m long per vine were selected and sectioned into 4-node segments from base to tip (1–4, 5–8, 9–12, 13–16, and 17–20). Morphological measurements listed below were done on the transverse cuts made in the middle of the internodes (Fig. 1). The number of the transverse cuts per rootstock per year was 1440 (3 vines x 4 replicates x 8 canes x 15 cuts).

Cane width (mm); the arithmetic mean of the thinnest (CW_1) and the thickest (CW_2) points of the cane, wood (xylem) width (mm); the arithmetic mean of four corresponding point measurements at cut surface (X_1, X_2, X_3,

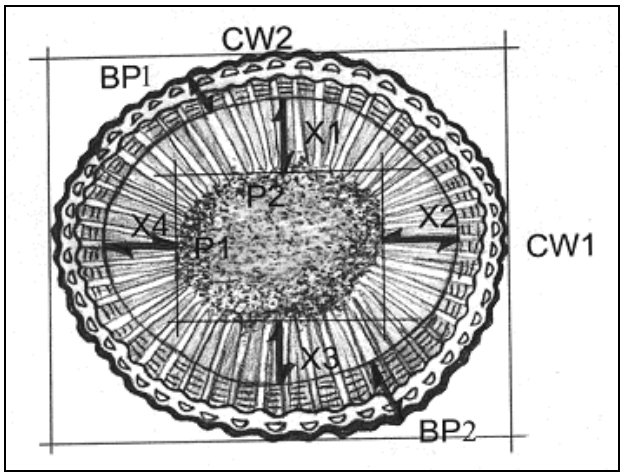


Fig. 1. Diagram showing how the measurements were taken CW: cane width, P: pith, X: xylem, and BP: bark+phloem.

X_4), pith width (mm); the arithmetic mean of the thinnest (P_1) and thickest (P_2) points of the pith, bark+phloem width (mm); the arithmetic mean of the visually determined thinnest (BP_1) and thickest (BP_2) points of the bark+ploem width. Moisture content (%) as described by (KACAR 1995); [(fresh weight – dry weight) x 100/fresh weight]. The ratios of cane width/pith, xylem/pith, cane width/bark phloem and xylem/bark+phloem were calculated to determine cane quality. The other parameters offered (Table 1) were calculated from the main characteristics mentioned before: P1:P2 for pith flattening, CW1:CW2 for cane flattening, BP1:BP2 for determining differences in the corresponding internodes, CW_1:CW_2/P_1:P_2 for assessing pith flattening in relation to cane flattening.

Growth performance

The objective of the second part of the study was to compare and relate the morphological changes with the vegetative growth of the canes. The canes were collected and prepared the same way in the winter season of 2005–2006. Cuttings later treated with a fungicide (Captan, Southern Agricultural Insecticides, Inc. Fla, USA) and stored at 4 °C and 80–90 % relative humidity until planting in April, 2006. Before planting, canes were soaked in water for 24 h (SARASWAT 1973), and later cut into 2-bud cuttings with lower bud disbudded. The trial was designed in randomized blocks comprising four replicates and 60 cuttings per nodal segment in every replication. The total number of the cuttings planted for each rootstock was 1200 (240 cuttings x 5 nodal sections). Cuttings were potted into plastic pots filled with equal weight of perlite. Every pot was fertilized with 166 mg l^{-1} N (ammonium nitrate 33% N), 66 mg l^{-1} P_2O_5 (di-ammonium phosphate 18–46% P_2O_5) and 250 mg l^{-1} K_2O (potassium sulphate 50% K_2O). Water (1000 ml) was added and pots were weighed. Following irrigations were based on this initial weight. The cuttings were grown to marketable size in room conditions until plants stopped growing.

The following characteristics were determined: viable plant ratio (%) – cuttings with healthy root and shoot/total cutting number; shoot ratio (%) – number of cuttings with at least 10 cm shoot/number of total cuttings; rooting ratio (%) – number of cuttings with a least one healthy root/number of total cuttings; root–shoot fresh weight (g/plant) – total root–shoot weight/number of total cuttings; cutting weight (g) – cutting was weighed after removal of shoot and root and the weight was divided by the total number of cuttings; number of node and shoots per plant; shoot length (cm/plant).

Statistical Analysis

Data obtained both from the morphological measurements and growth performance was evaluated with Minitab (version 13.1) statistical package program. Mean differences were tested with Duncan's multiple range test.

Results

Morphological assessments

Mean data obtained in two year study from the measurements of the 4-bud cane sections from base to tip were presented in Table 1. Cane width of the canes of 5 BB and 140 Ru significantly decreased from base to the tip. Decreases in xylem width also followed the same pattern but it was more prominent in 140 Ru than in 5 BB.

Pith widened towards the tip in the canes of 5 BB, but it showed contraction and expansion in the canes of 140 Ru. 140 Ru generally had wider pith compared to 5 BB.

Bark+phloem values also showed a decrease as the cane became thinner in both of the rootstocks.

Cane width/pith ratio was significantly different in nodal sections of the both rootstocks from basal to tip. Nodes between 1 and 12 in the canes of 5 BB almost had cane widths three times wider than the pith. However, only the cane sections between 1 and 8 nodes in the 140 Ru canes had cane widths three times wider than the pith.

The ratio of thinnest and thickest point of pith (P1:P2) showed that piths of the 5 BB canes were more rounded. The most round part was between 13th and 16th nodes. Piths of the 140 Ru canes however, showed differences. The most flattened pith was between 9th and 12th nodes, and the roundest was between 5thand 8th, resp. 13th and 16th nodes.

The ratio of the thinnest bark+phloem to the thickest bark+phloem (BP1:BP2) indicated the differences between the stocks. There were no nodal differences in the 5 BB canes, indicating that bark or phloem did not significantly changed along the canes. 140 Ru canes, however, had statistically important differences in the bark+phloem.

CW1:CW2 values approximating unity (1) indicated that flattening seen in the basal internodes disappeared towards the tip and canes became rounder. This was more apparent for 140 Ru. Xylem/pith ratios were similar for both of the rootstocks, diminishing along the length of the canes from 1.09 to 0.52 in 5 BB and from 1.01 to 0.51 in 140 Ru. CW_1:CW_2/P_1:P_2 ratio indicated that flattening of the pith was more apparent than that of the cane itself. Rootstocks differed in this characteristic.

Bark+phloem/pith, xylem+(bark+phloem)/pith, and xylem/(bark+phloem) values showed a steady decrease from basal to upper nodes in the rootstocks. Cane width/(bark + phloem) was higher in the basal and apical parts of the canes of the rootstocks.

Table 1. Measurements taken on transverse cuts of 5 BB and 140 Ru.

Rootstock	Nodal section	Cane width (mm)	Xylem (mm)	Pith (mm)	Bark+ Phloem (mm)	CW1:CW2	P1:P2	BP1:BP2	Cane width /Pith
5 BB	1 – 4	10.34 a	2.91 a	2.72 d	1.078 a	0.859 b	0.827 c	0.847	3.80 a
	5 – 8	9.48 b	2.50 b	2.82 c	1.021 b	0.860 b	0.840 bc	0.856	3.36 b
	9 – 12	8.78 c	2.11 c	3.00 b	0.957 c	0.864 b	0.849 ab	0.856	2.93 c
	13 – 16	8.15 d	1.83 d	3.11 a	0.883 d	0.864 b	0.860 a	0.848	2.62 d
	17 – 20	7.69 e	1.65 e	3.15 a	0.797 e	0.874 a	0.851 ab	0.837	2.44 e
	Significance	**	**	**	**	**	**	NS	**
140 Ru	1 – 4	11.59 a	3.26 a	3.32 ab	1.005 a	0.841 d	0.838 ab	0.854 a	3.49 a
	5 – 8	9.89 b	2.51 b	3.41 a	0.883 b	0.871 c	0.844 a	0.838 ab	2.90 b
	9 – 12	8.72 c	2.02 c	3.39 a	0.799 c	0.887 b	0.826 b	0.838 ab	2.57 c
	13 – 16	7.91 d	1.77 d	3.30 b	0.726 d	0.899 a	0.841 a	0.822 bc	2.40 d
	17 – 20	7.37 e	1.60 e	3.16 c	0.670 e	0.908 a	0.832 ab	0.806 c	2.33 d
	Significance	**	**	**	**	**	**	**	**

Rootstock	Nodal section	Xylem /Pith	Bark+ Phloem /Pith	Xylem+ (Bark+ Phloem) /Pith)	Cane Width /Bark+ Phloem	Xylem /Bark+ Phloem	CW1:CW2 /P1:P 2	Cane moisture (%)	Internode length (mm)
5 BB	1 – 4	1.070 a	0.396 a	1.466 a	9.59 a	2.70 a	1.039 a	45.10 c	125.7 d
	5 – 8	0.887 b	0.362 b	1.249 b	9.29 b	2.45 b	1.024 ab	52.33 b	168.8 a
	9 – 12	0.703 c	0.319 c	1.022 c	9.17 b	2.20 c	1.018 bc	55.72 ab	167.8 a
	13 – 16	0.588 d	0.284 d	0.872 d	9.23 b	2.07 d	1.005 c	57.02 ab	158.5 b
	17 – 20	0.524 e	0.253 e	0.777 e	9.65 a	2.07 d	1.027 ab	60.27 a	149.7 c
	Significance	**	**	**	**	**	**	**	**
140 Ru	1 – 4	0.982 a	0.303 a	1.285 a	11.53 a	3.24 a	1.004 c	49.84 b	128.0 d
	5 – 8	0.736 b	0.259 b	0.995 b	11.20 b	2.84 b	1.032 b	51.76 ab	161.1 a
	9 – 12	0.596 c	0.236 c	0.832 c	10.91 b	2.53 c	1.074 a	53.14 a	151.4 b
	13 – 16	0.536 d	0.220 d	0.756 d	10.90 b	2.44 cd	1.069 a	53.49 a	143.6 c
	17 – 20	0.506 d	0.212 d	0.718 d	11.00 b	2.39 d	1.091 a	53.79 a	144.1 c
	Significance	**	**	**	**	**	**	**	**

CW_1 = thinnest and CW_2 = thickest points of the cane; P_1 = thinnest and P_2 = thickest points of the pith; BP_1 = thinnest and BP_2 = thickest points of the bark+ploem width.;
**, significant at 1 %; NS, not significant.

The upper ends of the canes contained more water in the rootstocks. 5 BB canes had comparatively higher water in the canes than those of 140 Ru. Internode lengths of the rootstocks were the longest between 5th and 12th nodes and the shortest between 1st and 4th nodes.

Growth Performance

In the second part of the study, in which the cuttings were forced to grow out, the lowest viable plant ratio was obtained from 1–4 and 17–20th nodal portions in the rootstocks (Table 2). In 140 Ru, the highest rooting was about 90 % between 5th and 12th nodes. Rooting was higher in 5 BB cuttings made from the middle section (5 to 16th). Root fresh weight was also comparatively higher in the middle section of the canes. Shoot growth was not significantly different in nodal parts.

Discussion

The aim of this research was to put forward the morphological changes along the canes of 5 BB and 140 Ru rootstocks, force them to grow out, and relate the changes with the root and shoot growth characteristics.

Table 2. Growth performance of the cuttings of 5 BB and 140 Ru.

Rootstock	Nodal section	No of cutting (n)	Whole plant (%)	Rooting (%)	Root fresh weight (g)	Shoot growth (%)	Shoot fresh weight (g)	Shoot number (n plant^{-1})	Shoot length (cm)	Node number (n plant^{-1})	Cutting weight (g)
5 BB	1 – 4	240	56.98 b	60.73 b	0.49 c	93.23	1.57abc	1.70	18.40 ab	7.64 a	13.41 ab
	5 – 8	240	80.00 a	86.31 a	0.72 ab	96.99	1.94 a	1.74	21.88 a	7.50 a	13.77 a
	9 – 12	240	80.15 a	90.80 a	0.88 a	93.60	1.69 ab	1.65	17.75 b	6.91 ab	12.19 bc
	13 – 16	240	73.33 a	92.50 a	0.89 a	95.42	1.49 bc	1.61	15.12 bc	6.08 b	11.71 c
	17 – 20	240	53.60 b	82.72 a	0.64 bc	95.26	1.28 c	1.53	12.55 c	5.84 b	11.05 c
	Significance		**	**	**	NS	**	NS	**	**	**
140 Ru	1 – 4	240	77.50 ab	80.42 ab	1.17 b	96.67	1.53 a	1.61 ab	15.90 a	6.79	16.30 a
	5 – 8	240	87.92 a	91.67 a	1.51 ab	94.17	1.41 ab	1.65 a	14.34 ab	6.65	13.32 b
	9 – 12	240	87.50 a	92.08 a	1.74 a	95.83	1.33 ab	1.63 a	14.40 ab	6.60	12.07 b
	13 – 16	240	83.24 a	86.58 ab	1.81 a	95.24	1.17 b	1.45 ab	11.53 b	5.71	10.23 c
	17 – 20	240	68.34 b	73.60 b	1.24 b	96.88	1.07 b	1.41 b	11.45 b	5.88	8.67 c
	Significance		**	**	**	NS	**	**	**	NS	**

**, Significant at 1 %; NS, Not significant.

In practical grapevine propagation it is generally accepted as the norm that cuttings should not be less than 7 mm in diameter and their length should also be 30–40 cm (Winkler et al. 1974; Nicholas et al. 1992). The cuttings of 5 BB and 140 Ru in this study were found to be suitable to the norms. All parts taken could be used. However, another good indicator of cane suitability for propagation is that surface area of the pith should not be more than a quarter of the surface area of the diameter of the cane in winter (Hunter et al. 2004). 5 BB canes had the desired ratio between 1st and 16th nodes. 140 Ru, on the other hand, had it only between 1st and 12th nodes. It is clear from the results that best sections to use in propagating differ by the rootstock genotype.

Flat canes are not used in propagating grapes (Winkler et al. 1974; Nicholas et al. 1992). 5 BB and 140 Ru canes did not have flatness along their length. Round canes are better in formation of graft union by enhanced adhesion of the rootstock and scion.

Cane width/bark+phloem ratio showed irregularities, being highest in the most basal and most superior portion of the canes. Çelik (1998) reported that cane quality was higher when bark+phloem developed better than the cane. Bark+phloem/pith and xylem+(bark+phloem)/pith values agreed with cane width/pith and xylem/pith ratios, showing lower quality as the canes elongated. Accordingly, 5 BB generally had better quality in the internodes. Decreases in the xylem might mean that the upper section of the canes had less reserve, because xylem tissue is the storage places for reserve food.

Cane width/pith and phloem+xylem/pith suggested by Dardeniz et al. (2007), were also proven to be useful in this research to determine cane quality, in addition to the bark+phloem/pith, cane width/bark+phloem and xylem/bark+phloem ratios.

Root and shoot growth characteristics were in compliance with the morphological changes, supporting the obligation to make use of middle sections of the rootstock canes. Basal (1–4) and apical (17–20) nodes produced less viable plants with less than healthy roots and shoots. Their rooting percentages were also at the least level compare to the other nodal portions.

Results support that it is best to prepare cuttings for grafting from the middle section of the canes (Subbotovich and Perstnev 1971; Winkler 1974; Nicholas et al. 1992) and canes with low cane width/pith or wood/pith ratios decrease graft take success (Samson and Casteran 1971; Dardeniz 2001). All the parameters considered, grafting materials should be prepared bearing in mind that 5 BB cuttings are the best between 5–16, whereas 140 Ru provides best cuttings from the nodal sections of 5 through 12, because of better quality and well balanced root-shoot growth. When there is shortness in the amount of cuttings needed for propagation, basal and uppermost sections of canes of 140 Ru and 5 BB, respectively, could be used.

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