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TURKISH HAZEL (CORYLUS COLURNA L.) SEEDLING CHARACTERISTICS AS ROOTSTOCK FOR HAZELNUT CULTIVAR GRAFTING

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SUMMARY: In the Faculty of Agriculture plant nursery at the University of Novi Sad, Serbia, Common hazel (Corylus avellana L.) cultivars were grafted on the Turkish hazel (Corylus colurna L.) rootstock. To produce high-quality planting material, seeding success, growth and development of one-year-old seedling was followed. This paper presents results of Turkish hazel A_1, B_1, B_4, B_7 and C_3 genotype nut germination from sowing performed in 2009. The results indicate high percentage of germinated nuts and a high plant survival rate. One-year-old seedlings measured during a vegetation rest period in 2010 and two-year-old seedlings measured in 2011 were better developed compared to the seedlings examined in the previous years, indicating that the application of the drip irrigation system in seedling development yields positive results.

Key words: *Turkish hazel, Corylus colurna L., field germination, one-year old seedlings, two-year old seedlings.*

INTRODUCTION

In nursery production, biological growth properties of the root and trunk are mostly manifested during the first year of plant development. Consequently, most studies in this field focus on the evaluation of the growth indicators in one-year and two-year-old Turkish hazel (*Corylus colurna* L.) seedlings. For example, Harris et al. (2005) examined the root length and the above-ground part of the Turkish hazel, Green Ash and Lilac seedlings. The authors found the correlation between the measured parameters and the total length of the root system, which was measured with rhizotron.

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In an earlier study, Harris et al. (2001) investigated one-year-old scions of Turkish hazel. Their findings indicate that the root growth in plants taken out in the fall is favorable when compared to those that have been kept in cold storage and planted in the spring. Based on these results, the authors recommend autumn planting for rootstocks without any irrigation.

In the nursery at Rimski Šančevi, autumn sowing of seeds for the production of rootstocks of different fruit species, including Turkish hazel (Ninić-Todorović, 1990), is performed annually, as the nursery has a cold chamber for storing graft branches as well as suitable storage of stratified seeds.

With application of optimal agrotechnical measures, in 2010 and 2011, we established remarkable growth of seedlings of specific genotypes, which surpassed those used in earlier studies (Ninić-Todorović et al., 1994; 2003; 2006; 2007).

MATERIAL AND METHODS

Turkish hazel fruits were collected at the time of physiological independence of cup stems from the mother tree. The key fruit maturity indicators are yellow-green cup and light brown nut color (Ninić-Todorović, 1990). Nut sowing was performed in the middle of October 2009, using genotypes A_1, B_1, B_4, B_7 and C_3 collected in the nursery of JKP "Gradsko Zelenilo" in Novi Sad. The optimal spacing and seeding depth—7 cm for proper development of seedlings of Turkish hazel in the first two years—was ensured. Sampling for the purpose of growth indicator testing in the one-year-old seedlings was carried out at the end of the vegetation period in 2010. Height and diameter at the base of two-year-old seedlings were measured *in situ* during the period of vegetative rest in 2011.

Measurements of the seedling root crown diameter and tree diameter at the base of two-year-old seedlings were conducted using a micrometer of 0.01 mm precision, while tree height was measured using a standard metric ruler. To determine the seedling root system morphological characteristics, we used a software package for image analysis "ImageJ''.

Data processing was performed using the statistical package STATISTICA 10 (StatSoft,Inc., Tulsa, OK, USA).

RESULTS AND DISCUSSION

The best nursery production results were obtained from the October seed sowing, as indicated by high field germination. According to long-term meteorological data related to the area where the nursery at Rimski Šančevi is located, low temperatures and frosts typically occur in November. Consequently, seeds sown in October have ample time to go through the period of warm stratification before the first appearance of frost. In November, once frost appears, physiological drought period and subsequent ripening stages of the embryo commence. The period from October, when the nuts are sown, until May, when the seedlings emerge, is optimized to overcome the prolonged dormancy of Turkish hazel seeds.

Nut classification is performed by collecting of cup from each tree separately. The seed material is carefully handled during processing and storage. Based on the indica-

tors of morphological characters (Ninić-Todorovic, 1990; 2009), the nut size is uniform within each sample.

The results (Table 1) indicate a high percentage of field germination and high plant survival rate. The values ranged from 76.62% for germination and 91.30% for survival (genotype A_1) to 88.20% and 95.40% (genotype C_3), respectively, after the first growing season. Thus, these results indicate that favorable plant selection and management enables successful development of seedlings in the first and second year of growth *in situ*.

Table 1. Field germination and survival of plants moment

Genotype	Field germination (%)	Survival percentage (%)
A_1	76.62	91.30
B_1	78.19	85.60
B_4	80.30	93.70
B_7	84.50	95.30
C_3	88.20	95.40

In the conditions of higher field germination and plant density in the first vegetative cycle, the number of surviving seedlings was higher than in the set with fewer plants, characterized by lower germination energy. Lower germination causes development of unfavorable physiological, morphological and technological properties in nuts. In the year when field germination analysis was performed, protection from rodents was also successful.

Table 2 presents mean values of parameters examined for one-year seedlings of Turkish hazel, errors in arithmetic means and standard deviation. Average tree height values of one-year-old Turkish hazel seedlings ranged from 28.60 cm for genotype A_1 to 42.93 cm for genotype C_3. Genotype A_1 was characterized by the lowest mean root length (29.13 cm), the lowest root crown diameter (5.76 mm) and the lowest number of the first line roots (22.60). Maximum average values of the root length and the root crown diameter were observed in genotype C_3, while the maximum number of the first line roots (31.93) was observed in genotype B_7. Trunk and root weight, two very important parameters for the examination of one-year-old seedling growth, proved to be highly variable compared to other examined parameters. The highest values of the trunk and root weight were measured for genotype C_3 (15.04 g and 17.03 g), whilst the lowest trunk weight was found in genotype A_1 (7.22 g), and the lowest mean root weight was observed in genotype B_4 (10.17 g).

Table 2. Morphometric characteristics of the one-year old seedlings of Turkish hazel (*Corylus colurna* L.) in 2010. year

Genotype	Tree hight (cm)	Root lenght (cm)	Root crown diameter (mm)	Number of first line roots	Trunk weight (g)/	Root weight (g)
	x±Sx	x±Sx	x±Sx	x±Sx	x±Sx	x±Sx
A1	28.60±1.67*	29.13±0.74*	5.76±0.37	22.60±0.89	7.22±1.01	12.01±1.34
B1	28.66±1.66*	29.26±0.80*	7.34±0.48	28.36±0.82	8.70±1.13*	10.48±1.12
B4	36.37±2.38	31.41±0.81	8.81±0.44	24.86±1.08	8.67±1.17*	10.17±1.12
B7	40.48±1.47	32.09±1.01	9.46±0.29	31.93±1.05	13.22±0.90	14.75±1.02
C3	42.93±1.54	38.70±0.96	10.29±0.33	31.46±1.13	15.04±1.32	17.03±1.42
x±Sx	35.60 ± 0.92	32.12 ± 0.48	8.33 ± 0.21	27.89 ± 0.53	10.60 ± 0.55	12.92 ± 0.57
SD	11.30	5.89	2.66	6.55	6.74	7.08

*Marked effects are significant at $p<0.050$.

According to previous studies (Ninić-Todorović et al., 1994), the height of one-year-old seedlings ranged from 17 to 20 cm, root length ranged from 34 to 38 cm, the root crown thickness ranged from 5 to 7 mm, number of first line roots ranged from 40 to 50, trunk weight ranged from 1.6 to 2.6 g and root weight ranged from 2.6 to 3.2 g. Seedlings were developed without irrigation and with minimal care measures, which caused the root system to be longer and the above-ground part lower, i.e. such care regiment resulted in low development of all growth indicators. The root system of one-year-old seedlings is of taproot type with many thin first line roots. These findings suggest that stimulation of root development should be performed at the end of the growing season by cutting off half of the taproot length.

The examined growth indicators of one-year-old Turkish hazel seedlings, which were developing during the vegetation period in 2004, were published in Ninić-Todorovic et al., (2007). The seed material for this study was collected at the location Futoški Park, and the height of one-year-old seedlings ranged from 26.77 (B_4) to 49.93 cm (B_9), root length ranged from 29.13 (B_5) to 38.70 cm (B9), root crown diameter ranged from 7.34 (B_1) to 12.22 mm (B_8), number of first line roots ranged from 22.60 (B_5) to 31.93 (B_7), trunk weight ranged from 7.24 g (B_5) to 19.89 g (B_8), and root weight ranged from 10.48 g (B_1) to 21.85 g (B_8).

The examination of the growth parameters was carried out in very dry years (Table 2), whereby drip irrigation system was applied and proved to be extremely effective for the development of Turkish hazel seedlings. According to the results published by Ninić-Todorovic et al., (1994), two-year-old seedlings were characterized by height of 45-60 cm, 50-60 cm root length, root crown thickness of 9-12 mm, 20-35 first line roots, 4-12 second line roots, 16-25 g tree mass, and root mass of 30-40 g. These growth indicators suggest that in conditions without irrigation, seedlings were much less developed compared to the specimens analyzed in 2011, for which two indicators were measured *in situ* and the results presented in Table 3.

Table 3. Morphometric characteristics of the two-year old seedlings Turkish hazel (*Corylus colurna* L.) in 2011

Genotype	Tree high (cm)	Diameter at the base of the tree (mm)
	$x \pm S_x$	$x \pm S_x$
A_1	80.78±2.16*	13.77±0.45*
B_1	92.01±4.26	15.50±0.47
B_4	102.14±5.93	15.55±0.60
B_7	86.52±5.85*	15.52±0.72
C_3	100.14±98	16.60±0.81
$x \pm S_x$	92.32±2.70	15.39±0.34
SD	10.46	1.31

*Marked effects are significant at p<0.050.

After examining the root crown height and diameter of two-year-old Turkish hazel (*Corylus colurna* L.) seedlings, significant differences between genotypes are evident. Tree height ranges from the minimal value in genotype A_1 (80.78 cm) to a maximum value in genotype B_4 (102.14 cm). The total average value for the tree height was 92.32 cm.

The average values for the root crown diameter in two-year-old seedlings were uniform for all genotypes, except genotype C_3, for which high values of this parameter were recorded (16.60 mm). At the level of all genotypes, low standard deviation (SD = 1.31) was observed. These results indicate that the seedlings of Turkish hazel genotypes B_4, B_7 and C_3 were developed in the first year as a rootstock for grafting hazelnut cultivars. Grafting was performed at the beginning of April 2012, using the English method of connecting to two-year-old seedlings in order to obtain highly grafted hazelnut seedlings.

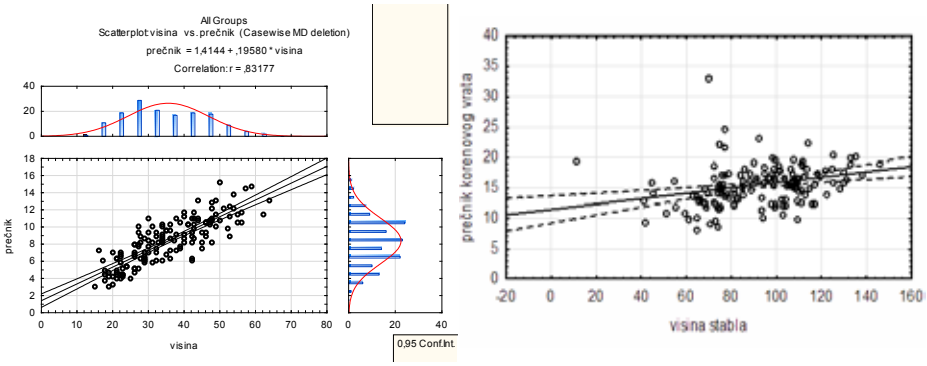

Fig. 1 and 2. Correlation between the height and diameter of root crown for a one-year old seedlings of Turkish hazel (*Corylus colurna* L.)

The correlation analysis of tree height and root crown diameter of one-year-old seedlings indicated high and positive correlation between the two characters. The ratio of tree height and root crown diameter of one-year-old and two-year-old Turkish hazel seedlings was r = 0.6078 r = 0.5492, respectively. The calculated correlations suggest that the growth of the above ground parts of seedlings followed the growth and development of the root system.

Grafting of hazelnut cultivars on Turkish hazel rootstock has been successfully performed in Serbia since 1989, with the key results published by Ninić-Todorović (1990; 2000), Ninić-Todorović et al. (1994; 2003; 2006), Korać at al. (1995, 1996, 2000), Cerović et al. (2007) and others.

CONCLUSION

Morphological and physiological characteristics of the nut, primarily achieved through germination, have directed the technological processes towards achieving high productivity and economy of production of hazelnut seedlings grafted on Turkish hazel (*Corylus colurna* L.) as a rootstock.

In the study year, the evaluated nut samples have demonstrated a high percentage of germination and plant survival rate.

When the seedlings were irrigated by "drop by drop" irrigation method, good development and growth indicators were measured. Tree height of one-year-old plants was in the range of 28.60 (A_1) to 42.93 (C_3) cm, which is in accordance with the results obtained for field-germinated nuts and corresponding plant survival rates. Root length and root crown diameter were the lowest for genotype A_1 (29.13 and 5.76 mm), and the highest for genotype C_3 (38.70 and 10.29 mm). Maximum average number of first line roots was measured for genotype B_7 (31.93), whereas maximum trunk weight of 15.04 g and 17.03 g root weight corresponded to genotype C_3. Two-year-old seedlings were twice as tall as the plants evaluated in the test years without irrigation. The maximum tree height (100.14 cm) and the greatest thickness at the base (16.60 mm) were measured for genotype C_3.

Grafting of hazelnut cultivars on Turkish hazel rootstock has many advantages in raising orchards. As Turkish filbert does not form offshoots from the roots, the use of advanced breeding measures is facilitated, such as pest and disease protection and mechanized harvesting. Turkish hazel planting material is suitable for organic production.

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KARAKTERISTIKE SEJANACA MEČJE LESKE (CORYLUS COLURNA L.) KAO PODLOGA ZA KALEMLJENJE SORTI LESKE

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Izvod

U rasadniku Poljoprivrednog fakulteta u Novom Sadu, na Rimskim Šančevima razvijena je tehnologija kalemljenja kultivara leske na mečjoj leski (*Corylus colurna* L.) kao podlozi. Praćen je uspeh setve, rast i razvoj jednogodišnjih i dvogodišnjih sejanaca u cilju proizvodnje kvalitetnih podloga i sadnog materijala. U radu su prikazani rezultati klijavosti orašica genotipova A_1, B_1, B_4, B_7 i C_3 mečje leske iz setve obavljene 2009. godine. Orašice su pokazale visok procenat klijavosti i momenat preživljavanja biljaka. Jednogodišnji sejanci mereni u toku mirovanja vegetacije 2010. godine i dvogodišnji sejanci mereni 2011. bili su razvijeniji u odnosu na ispitivanja sejanaca ranijih godina. Primena sistema za navodnjavanje kap po kap, dala je dobre rezultate pri razvoju sejanaca u ispitivanim godinama.

Ključne reči: mečja leska, *Corylus colurna* L., terenska klijavost, jednogodišnji sejanci, dvogodišnji sejanci.

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