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EFFECT OF SOIL ON NURSERY-GROWN WALNUT PLANTS

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SUMMARY: This experiment evaluates the effect of two soil types viz. an alluvial loamy deposit and a leached vertisol on survival, percentage of first-class plants, growth and diameter of nursery-grown grafted walnut. Plants grown on the alluvial loamy deposit showed higher rate of survival at the end of the first growing season and increase in percentage of first-class plants at the end of the second season compared to plants grown on leached vertisol. The average growth and diameter of plants on the alluvial loamy deposit increased at the end of the first and second growing season compared to plants grown on leached vertisol.

Key words: *plant, walnut, alluvial loamy deposit, leached vertisol.*

INTRODUCTION

Nursery production of walnut plans is a complex process dependent upon a range of factors. Apart from favourable environmental conditions, the production of high quality planting stock is also determined by adequate soil selection. Soils selected for walnut production should be permeable, deep, loose, rich in both humus and nutrients. Compact, stony, dry, strongly podzolic, too moist, salinated, strongly alkaline or rather acid soils are not suitable for walnut cultivation (Stanković and Jovanović, 1983). Walnut grows best on soils with medium to fine textures such as loam or sandy loam with good internal drainage, whereas soils that are poorly drained, droughty, and sandy should be avoided (Ponder, 2004). Permeable loose soils with favourable air and temperature regimes and a pH of 6.5-7.5 are ideal for the species (Šapa, 2002; Solar and Štampar, 2004). There is practically not a single study that deals with the effects of soil on the quality of walnut plants.

The objective of this study was to evaluate the effect of two soil types viz. an alluvial loamy deposit and a leached vertisol on survival and growth of nursery-grown walnut plants.

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MATERIAL AND METHOD

The experiment was conducted during 2010 and 2011 at two locations of the Fruit Research Institute, Čačak. Five walnut cultivars viz. Šeinovo (control), Šampion, Elit, G-286 and G-139 were used. Planting was performed in the second third of May, involving a sample of 30 grafted walnut plants per cultivar. The experiment was laid out in a randomised block design (5 cultivars x 2 soil types x 3 replications). In terms of their physicochemical properties, the soils used for the research are classified as an alluvial loamy deposit and a leached vertisol.

Plant survival and percentage of first-class plants were determined at the end of the first and second growing season, respectively. Upon shoot emergence, vegetative growth and plant diameter were measured.

The results obtained were statistically analysed using Fisher's model of analysis of variance - ANOVA. The significance of differences between the means of the control and those of the other test cultivars at $P \leq 0.01$ and $P \leq 0.05$ was defined using Dunnett's test (Dunnett, 1955). LSD test was performed at $P \leq 0.05$ to test the significance of differences between soils, as well as interaction means. The results are given in tabular form.

RESULTS AND DISCUSSION

The soil at location I is an alluvial soil in terms of morphology and origin, and an alluvial loamy deposit in terms of physicochemical properties. The soil is relatively coarse in texture, and slightly acid. In the 0-20 cm layer, the soil has a good content of humus and readily available phosphorus and potassium, and a medium nitrogen content (Table 1). Their contents decrease with increasing depth. In the 0-100 cm layer, the soil has 58.2% total sand and 42.5% total clay, on average. The other soil particles occur within the narrow range across profile depth: coarse sand 1.0-3.0%, fine sand 54.0-58.6%, silt 20.9-26.2% and clay 17.0-18.8% (Table 2). The soil at location II is a leached vertisol, according to its morpohological, textural, and agrochemical propertis. The soil is acid in reaction. In the 0-20 cm layer, the soil has a good supply of humus and readily available phosphorus and potassium, and a medium supply of nitrogen (Table 3). It is a medium-textured soil. In the 0-100 cm layer, there is 33.6 % total sand and 66.3% total clay, on average. The content of the other particles across profile depth is as follows: coarse sand 0.0-4.75%, fine sand 28.6-33.3%, silt 16.1-25.4% and clay 28.6-38.1% (Table 4). The leached vertisol contains much larger amounts of clay compared to the alluvial loamy deposit.

Table 1. Agrochemical properties of walnut nursery soil - location I

Tabela 1. Agrohemijske osobine zemljišta rastila oraha – lokalitet I

Depth/*Dubina* (cm)	pH in KCl/*pH u KCl*	K_2O mg/100g air-dry soil/ *K_2O mg/100g v.s.z.*	P_2O_5 mg/100g air-dry soil/ *P_2O_5 mg/100g v.s.z.*	Humus/ *Humus* (%)	N/*N* (%)
0-20	6.35	28.25	17.80	2.76	0.13
20-40	6.28	12.60	7.40	1.50	0.06
40-60	6.25	9.25	3.95	1.30	0.05
60-80	6.20	8.85	3.10	1.30	0.05
80-100	6.23	8.25	3.00	0.97	0.04

Table 2. Physical properties of walnut nursery soil – location I

Tabela 2. Fizičke osobine zemljišta rastila oraha – lokalitet I

Depth/ Dubina (cm)	Coarse sand/ Krupan pesak (%)	Fine sand/ Sitan pesak (%)	Silt/Prah (%)	Clay/ Glina (%)	Total sand/ Ukupan pesak (%)	Total clay/ Ukupna glina (%)
0-20	3.0	58.1	20.9	18.0	61.1	38.9
20-40	2.0	54.0	25.6	18.4	56.0	44.0
40-60	1.0	58.3	22.3	18.4	59.3	40.7
60-80	1.0	58.6	23.4	17.0	59.6	40.4
80-100	1.0	54.0	26.2	18.8	55.0	45.0

Table 3. Agrochemical properties of walnut nursery soil – location II

Tabela 3. Agrohemijske osobine zemljišta rastila oraha – lokalitet II

Depth/ *Dubina* (cm)	pH in KCl/ *pH u KCl*	K_2O mg/100g air-dry soil/*K_2O mg/100g v.s.z.*	P_2O_5mg/100g air-dry soil/ *P_2O_5mg/100g v.s.z.*	Humus/ *Humus*(%)	N/*N* (%)
0-20	4.44	25.74	17.31	2.78	0.13
20-40	4.26	25.16	3.60	1.56	0.07
40-60	4.28	25.19	1.31	1.11	0.05
60-80	6.65	25.40	2.95	1.06	0.05
80-100	7.05	22.40	6.30	0.85	0.04

Table 4. Physical properties of walnut nursery soil – location II

Tabela 4. Fizičke osobine zemljišta rastila oraha – lokalitet II

Depth/ *Dubina* (cm)	Coarse sand/ *Krupan pesak* (%)	Fine sand/ *Sitan pesak* (%)	Silt/*Prah* (%)	Clay/ Glina (%)	Total sand/ *Ukupan pesak* (%)	Total clay/ *Ukupna glina* (%)
0-20	2.75	33.3	21.7	40.2	38.1	61.9
20-40	4.75	28.6	19.8	46.8	33.3	66.6
40-60	3.25	32.4	16.1	47.9	35.6	64.4
60-80	1.00	31.6	25.4	42.0	32.6	67.4
80-100	00.0	28.6	31.0	40.4	28.6	71.4

Dunnett's test ($P \leq 0.01$ and $P \leq 0.05$) showed that cv. Šeinovo had a highly significantly higher rate of survival at the end of the first growing season, and a higher percentage of first-class plants at the end of the second growing season, as compared to the other cultivars tested. As regards plant height at the end of the first and second growing seasons, no difference was observed between the control and G-286 and Šampion, whereas the control exhibited highly significantly higher growth compared to cvs. Elit and G-139. Šeinovo gave plants that were highly significantly superior in terms of diameter at the end of both growing seasons, compared to the other cultivars. LSD-test ($P \leq 0.05$) revealed the survival rate, percentage of first-class plants, growth and diameter to be highly significantly higher in plants grown on alluvial loamy deposit than in plants on leached vertisol (Tables 5 and 6).

Table 5. Survival, growth and diameter of walnut plants in the first growing season

Tabela 5. Prijem, porast i prečnik sadnica oraha u toku prve godine gajenja

Treatment/*Tretman*	Cultivar /Soil/ *Sorta /Zemljište*	Plant survival at the end of the 1st growing season/ *Broj primljenih sadnica na kraju I vegetacije* (%)	Plant growth at the end of the 1st growing season/ *Porast sadnica na kraju I vegetacije* (cm)	Plant diameter at the end of the 1st growing season/ *Prečnik sadnica na kraju I vegetacije* (mm)
Cultivar/*Sorta* (A)	Šampion	78.3±0.90 **	18.5±0.52 ns	7.1±0.22 **
	Elit	74.5±0.66 **	17.2±0.52 **	7.0±0.29 **
	G-139	77.0 ±0.90 **	17.5±0.44 **	7.1±0.24 **
	G-286	78.0±0.62 **	18.3±0.59 ns	7.2±0.16 **
	Šeinovo	86.1±0.56	19.2±0.48	7.8±0.10
Soil/*Zemljište* (B)	Leached vertisol/ *Smonica u lesiviranju*	74.2±0.45 b	17.0±0.41 a	7.1±0.22 a
	Alluvial loamy deposit/ *Aluvijalno ilovasti nanos*	83.4±0.41 a	19.2±0.36 b	7.6±0.15 b
ANOVA				
Cultivar/*Sorta* (A)		**	**	**
Soil/*Zemljište* (B)		**	**	**
A x B		**	**	**

- A and B stand for treatments for cultivars and soil, respectively
- *A i B predstavljaju tretmane za sorte i zemljište*
- The asterisks in vertical columns indicate significant differences between the means at P≤0.05 and P≤0.01 according to Dunnett's test and ANOVA (F-test) results; ns- non-significant
- *Zvezde u vertikalnim kolonama obeležavaju značajne razlike između sredina za P≤0.05 i P≤0.01 na osnovu Dunnett testa i rezultata ANOVA (F-test); ns- nije značajno*
- The values designated with same small letters within columns for years and interaction means do not differ significantly at P≤0.05 according to LSD test
- *Vrednost u kolonama za godine i interakcijske sredine označene istim malim slovima značajno se ne razlikuju za P≤0.05 na osnovu LSD-testa*

Table 6. Growth, diameter and percentage of first-class walnut plants in the second growing season

Tabela 6. Porast, prečnik i broj sadnica oraha I klase u toku druge godine gajenja

Treatment */Tretman*	Cultivar /Soil/ *Sorta /Zemljište*	Percentage of first-class plants at the end of the 2nd growing season/ *Broj sadnica I klase na kraju II vegetacije* (%)	Plant height at the end of the 2nd growing season/ *Visina sadnica na kraju II vegetacije* (cm)	Plant diameter at the end of the 2nd growing season/ *Prečnik sadnica na kraju II vegetacije* (mm)
Cultivar/*Sorta* (A)	Šampion	62.7±0.91 **	194.5±5.72 ns	18.7±0.21 **
	Elit	56.3±0.67 **	185.5±5.82 **	19.4±0.26 **
	G-139	59.8 ±0.92 **	186.7±4.58 **	19.9±0.25 **
	G-286	64.5±0.57 **	193.8±7.52 ns	18.5±0.25 **
	Šeinovo	73.7±0.63	197.6±7.86	21.7±0.16
Soil/*Zemljište* (B)	Leached vertisol/ *Smonica u lesiviranju*	58.1±0.46 b	179.9±4.09 a	17.7±0.14 a
	Alluvial loamy deposit/ *Aluvijalno ilovasti nanos*	68.7±0.42 a	203.4±1.29 b	21.6±0.13 b
ANOVA				
Cultivar/*Sorta* (A)		**	**	**
Soil /*Zemljište* (B)		**	**	**
A x B		**	**	**

- A and B stand for treatments for cultivars and soil, respectively
- *A i B predstavljaju tretmane za sorte i zemljište*
- The asterisks in vertical columns indicate significant differences between the means at P≤0.05 and P≤0.01 according to Dunnett's test and ANOVA (F-test) results; ns- non-significant
- *Zvezde u vertikalnim kolonama obeležavaju značajne razlike između sredina za P≤0.05 i P≤0.01 na osnovu Dunnett testa i rezultata ANOVA (F-test); ns- nije značajno*
- The values designated with same small letters within columns for years and interaction means do not differ significantly at P≤0.05 according to LSD test.
- *Vrednost u kolonama za godine i interakcijske sredine označene istim malim slovima značajno se ne razlikuju za P≤0.05 na osnovu LSD-testa*

Bulatović (1985) found that the most suitable soils for walnut cultivation contain the following: 4.30-7.33% coarse sand, 59.26-65.70% fine sand, 14.53-15.26% clay, 66.60-72.75% total sand, 31.13-25.96% total clay, 5.05-11.56 mg phosphorus in 100 g air dry soil, 5.66-9.66 mg potassium in 100 g air dry soil, 0.69-1.48% humus, 0.05-0.10% nitrogen and pH 6.5-8.0 The same author reported higher growth of walnut plants when grown at pH7 than at pH 6 and pH 8. Korać et al. (1998) gave priority to soils having 3% humus, 250-300 ppm K_2O, 80-100 ppm P_2O_5 and pH 7-7.5, as confirmed by Solar and Stampar (2004). Šapa (2002) recommended soils containing 2.5-3% humus, 250-300

ppm K_2O and 100-120 ppm P_2O_5, whereas Šoškić (2007) suggested soils with 2.3-3% humus, 1.5-3% potassium, and 0.12-0.13% phosphorus as most suitable for walnut production.

There is practically not a single study that deals with the effects of soil properties on the quality of walnut plants. In an experiment on an alluvial loamy deposit, Paunović et al. (2010a) reported survival rates of 77.3% and 74.3%, and average vegetative growth of 14.3 cm and 171.6 cm at the end of the first and second growing season, respectively. These results are not in agreement with the findings from the present experiment on aluvial loamy deposit.

In the present study, mid-season cultivars (Šeinovo, Šampion and G-286) exhibited a higher survival rate, higher growth and a higher percentage of first-class plants, on average, compared to mid-late (G-139) and late-season (Elit) cultivars. These results are consistent with the reports of Paunović et al. (2010b) who suggested that survival and growth of walnut plants are significantly influenced by genetic traits of a cultivar, with cultivars having superior survival and growth during the first year in the nursery show improved survival and growth, and produce high quality plants in the second year.

Overall, the results obtained on the two soils are in agreement with those of other authors. Stanisavljević and Mitrović (1997) and Paunović et al. (2011) reported the following values, depending on cultivar, under Čačak conditions: survival rate 67.2–86.5% and growth 14.7-17.8 cm at the end of the first growing season; percentage of first-class plants 50.9-63.4% and growth 170-172.3 cm at the end of the second season. At the end of the second growing season, the survival rate of plants was 43.0%-73.0% in a study by Solar et al. (2001) and 69.9-95.5% as obtained by Erdogan (2006). In terms of plant growth, 40.0-50.0% first-class plants reaching a height of about 150 cm can realistically be obtained at the end of the second growing season (Korać et al., 1998). Plant growth in the second season was 168-172 cm and 179.7-244.5 cm, as reported by Achim and Botu (2001) in Romania and Ozkan and Gumus (2001) in Turkey, respectively.

CONCLUSIONS

Alluvial loamy deposits and leached vertisols can be used for the production of high quality walnut plants, under adequate fertilisation and regular cultivation conditions.

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UTICAJ ZEMLJIŠTA NA SADNICE ORAHA U RASTILU

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Izvod

U ogledu je praćen uticaj dva tipa zemljišta, aluvijalno-ilovasti nanos i smonica u lesiviranju na prijem, broj sadnica I klase, porast i prečnik okalemljenih sadnica oraha u rastilu. Na zemljištu tipa aluvijalno ilovasti nanos ostvaren je veći prijem sadnica i broj sadnica I klase, veći porast i prečnik sadnica na kraju prve i druge vegetacione sezone u odnosu na sadnice gajene na smonici u lesiviranju.

Ključne reči: sadnica, orah, aluvijalno ilovasti nanos,smonica u lesiviranju.

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