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AGRO-PHYSICAL CHARACTERISTICS OF CARROT ROOTS PRODUCED IN MINI-BEDS

AGROFIZIČKE OSOBINE KORENA MRKVE PROIZVEDENE NA MINI GREDICAMA

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SUMMARY

The quality of soil tillage was evaluated by measuring the physical and mechanical properties of the soil, (structure coefficient, volumetric bulk density and penetrometric resistance of soil), on flat surface and after the mini-beds were formed, at various depths. Samples were taken according to standard ISO 10381-6. The evaluation showed a significant statistical difference at 0.95 confidence interval in the 10–25 cm layer.

During the vegetation period, agro-physical properties of carrot root were monitored. In the mini-beds, carrot root length was 188.5, while on the flat soil it was 141.7 mm. Maximal root diameter in mini-bed was 26.8, while on the flat soil it was 30.7 mm. Average mass of carrot root in mini-bed was 89.2 and on the flat soil 76.8 g. Statistically significant differences on the 0.95 interval in carrot yield were recorded twelve weeks after sowing. Maximum difference in the yield was recorded after eighteen weeks, before harvest. Mini-beds yielded 89.2 t/ha of carrot while the flat soil yielded 63.6 t/ha.

Key words: *dimensions and yield of carrot root, mini-bed former machine.*

REZIME

Kvalitet obrade zemljišta ocenjen je merenjem fizičkih i mehaničkih osobina zemljišta (koeficijent strukturnosti, zapreminska specifična masa i otpor zemljišta), na ravnoj površini i nakon formiranja mini gredica, kao i sa promenom dubine. Uzimanje uzoraka zemljišta izvedeno je po standardu ISO 10381-6. Rezultati su pokazli statistički značajne razlike za interval poverenja 0,95 u sloju 10–25 cm.

U toku vegetacionog perioda praćene su agrofizičke osobine korena mrkve (EU No 730/99). Na mini gredicama formiran je koren dužine 188,5 mm, a na ravnom zemljištu 141,7 mm. Maksimalni prečnik na mini gredicama imao je vrednost 26,8, a na ravnom zemljištu 30,7 mm. Prosečna masa jednog korena mrkve na mini gredicama bila je 89,2, a na ravnom zemljištu 76,8 g. Statistički značajne razlike u prinosu mrkve pojavile su se nakon dvanaeste nedelje vegetacije, a maksimalna razlika u prinosu izmerena je u osamnaestoj nedelji vegetacije, pred ubiranje. Na mini gredicama ostvaren je prinos korena mrkve 89,2 t/ha, a na ravnom zemljištu 63,6 t/ha.

Ključne reči*: dimenzije i prinos korena mrkve, mašina za formiranje mini gredica.*

INTRODUCTION

The carrot is a vegetable with high requirements towards soil, especially to the physical properties. The highest yield is realised on fertile, structural, medium-light and light soil with fine water penetration (Lazić i sar, 2001).

Contemporary production of root vegetables is conducted at normal or mini-beds (Ponjičan et al, 2008b, 2009). Using mini-beds, the optimal physical and mechanical properties of different types of soil were achieved (Ponjičan et al, 2008a, 2008c, 2008d). In producing conditions the machine for making mini-beds has the speed between 0.294 to 0.53 m/s depending on soil condition and type (Ponjičan et al, 2006, Radomirović et al, 2008).

The advantage of vegetable production on mini-beds is that it enables the even growth and steady ripening of the plants. During the agrotechnical operations in vegetation (seeding, planting, interrow tillage, soil rushing, chemical treatment etc.), the tractor wheels, aggregated machines, harvesters and transporters steam in the channels between the beds. This makes correct machine managing possible, thus there can be no trample of the beds surface or the plant damage (Bajkin et al, 1994, 2005).

During the examination of physical and mechanical properties of soil, working with reverse rotation rotary tiller, better work quality was achieved than with the conventional rotary tiller (Salokhe and Ramalingam, 2001).

MATERIAL AND METHODS

The quality of presowing soil preparation was examined in May 2008, in Begeč, Vojvodina, the Republic of Serbia, located at 45° 15´ N latitude and 19° 34´ E longitude. The ploughing was done at 35 cm depth, the additional tillage with heavy disc harrow and conventional rotary tiller. The mini-bed former machine (with shape and dimension at Fig. 1) was aggregated with 139 kW powered tractor and 1.6 km/h working speed. The basic tool for soil tillage on mini-bed former is the reverse rotary tiller. The diameter of rotary tiller was D = 0.45 m and rotation number n = 230 min^{-1}. The examination was done at alluvial drifts of chernozem type soil (Najgebauer et al, 1971).

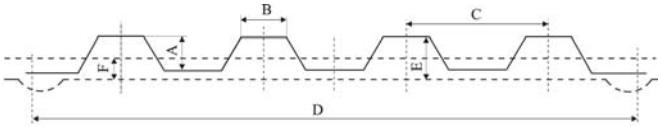

Fig. 1. The shape and dimensions of mini-beds:
Sl. 1. Oblik i dimenzije mini gredica:
A = 18.1 cm; B = 23.3 cm; C = 75 cm; D = 305 cm; E = 22.6 cm; F = 12.6 cm

The evaluation of quality of presowing soil preparation was done by measuring the physical and mechanical properties of flat soil, prepared with active and passive working tools (variant 1), and then also after the mini-bed former machine was done (variant 2). The experiment was conducted according to the split-plot system, and soil samples were taken according to ISO 10381-6.

The analysis of soil structure was conducted by the *field method* (Vučić, 1987) with 25, 19, 16, 10, 5, 3, 1, 0.5 and 0.25 mm openings on sieves by *Savinov method* (Hadžić et al, 2004). The structure was expressed with soil structure coefficient „k" (Šein et al, 2001). The moisture and specific volumetric mass of soil were determined by taking samples with *Kopecky cylinder* (Hadžić et al, 2004). For determining the soil compression, the electronic penetrometer was used (Savin et al, 2008).

The carrot sowing was conducted on 15 May 2008. The sowing quality was determined a month later by measuring the distance between plants according to ISO 7256/1 (Findura et al, 2007). The number of plants per square meter was determined at the beginning and at the end of the vegetation period. The dynamic of carrot root agrophysical properties was monitored by taking samples every two weeks during the whole period of intensive carrot root forming. There were 6 analyses from 6 July to 22 September.

Market standards evaluation for freshly consumed carrot (EU No 730/99) was done using the following agrophysical properties (Poničan et al, 2004):

- root mass, m_k,
- root length, l_k,
- maximal diameter of roots, d_1,
- minimal diameter of carrot roots at 1 cm from the bottom, d_2 and
- diameter of phloem at position of maximal diameter, d_3.

Based on the measured agro-physical properties of carrot the coefficient of elongation (λ) was determined:

$$\lambda = \frac{l_k}{d_1},$$

form (λ_1);

$$\lambda_1 = \frac{d_1}{d_2},$$

and the representation of phloem, measured at the position of maximal diameter (λ_2):

$$\lambda_2 = \frac{{d_3}^2}{{d_1}^2} \cdot 100, \ \%.$$

The measured data was tested using licenced programs Excel 2003 and Statistica 8. The testing was done at 0.95 interval of confidence with F-test for variance analysis and Duncan's-test.

RESULTS AND DISCUSSION

Quality of presowing preparation of soil

The testing of mini-bed former machine was conducted on the soil of following composition: 19,8% sturdy sand, 31,5% potty sand, 31,3% dust and 17,4% clay (classification of ISSS-International Society of Soil Science). From agricultural point of view, the best quality soil has: 40% sand, 40% dust and 20% clay (Vučić, 1987).

The quality determination of presowing preparation of soil was done by measuring the physical and mechanical properties before and after the mini-bed former machine passed (factor 1), with depth changing (factor 2). The structure coefficient at 10-25 cm depth on flat field has the value 0.36-0.07 but after the mini-bed was formed it was 1.03-0.51. The specific volumetric mass at 10-20 cm depth on the flat field was 1.39 g/cm^{3,} but after the mini-bed was formed it was 1.16 g/cm^3. The impaction at 14-25 cm depth on the flat field was 5.31-9.58 daN/cm^2 and on mini-beds 2.78-4.99 daN/cm^2. By variance analysis it was determined that there were significant statistical differences on the flat field and on the mini-beds after the mini-bed former machine passed (factor 1), with the depth changing (factor 2). The interaction between the factors is also significant (1*2). Based on F-test and Duncan's test these significant differences of 5% were at 10-20(25) cm depth (Ponjičan i sar, 2009).

The quality of sowing

The sowing was done by pneumatic sowing machine set for making 19 mm distance between seeds in the row. Therefore, on one mini-bed there were two rows 9 cm apart. Theoretically, the number of plants per square meter was 88.1 on the flat area and 104.96 on the mini-beds. At the end of vegetation period there were 82.75 plants/m^2 on the flat area and 100.00 on mini-beds because of the better presowing preparation.

Dynamic of agro-physical properties of carrot root

The dynamic of agro-physical properties was measured during root forming every 14 days. So, in the vegetation period there were 6 analyses (fig. 2). The measured agro-physical characteristics were then tested with F-test of variance analysis and Duncan's-test at 5% of significance (Ponjičan et al, 2009).

The average mass of a carrot roots at mini-beds was 94.2 g and at a flat soil 76.8 g. The bigger mass for the plants from mini-beds was the consequence of much longer roots despite smaller maximal and minimal diameters. Yield of carrot roots per unit of area was calculated based on the number of plants and average of roots mass. There were statistically significant differences in the yield of roots after 12 weeks in vegetation and the maximal difference was before harvesting, in 18th vegetation week. The yield at mini-beds was 89.2 t/ha and at the flat soil it was 63.6.

Based on the measured dimensions of carrot roots the coefficients were determined (tab. 1) and they objectively show the shape of carrot roots produced at the mini-beds or flat soil.

Table 1. Root form coefficients
Tabela 1. Koeficijenti oblika korena

	Date of analysis Datum analize	Ratio of root slenderness, λ Koeficijent izduženosti korena, λ	Coefficient of root shape, λ_1 Koeficijent oblika korena, λ_1	Percentual share of phloem, λ_2, % Procentualna zastupljenost phloema, λ_2, %
On flat soil (A) Na ravnom zemljištu (A)	14/07/2008.	7.35	1.91	-
	28/07/2008.	8.49	2.07	-
	11/08/2008.	5.25	1.74	-
	25/08/2008.	4.97	1.78	19.21
	08/09/2008.	4.95	1.66	29.34
	22/09/2008.	4.62	1.66	26.32
In mini-beds (B) Na mini gredicama (B)	14/07/2008.	8.37	2.25	-
	28/07/2008.	8.53	2.23	-
	11/08/2008.	7.91	1.77	-
	25/08/2008.	7.42	1.72	16.23
	08/09/2008.	7.23	1.67	24.90
	22/09/2008.	7.10	1.60	24.39

The biggest difference was noted for coefficient of roots slenderness (λ). At the end of the vegetation period the coefficient of slenderness at mini-beds have average value 7.1 and at

the flat soil 4.62. The equal values were measured for coefficient of the root shape (λ_1): at the flat soil 1.66 and at mini-beds 1.6 with cylindrical roots. In the carrot roots produced at mini-beds the ratio of phloem was 24.39% but at the flat soil it was 26.32%. If the ratio of phloem is smaller in the structure of carrot root it means better quality of carrot (Lazić et al, 2001).

The carrot produced at mini-beds in the same time have bigger yield, smaller content of phloem and have higher quality compared with those from a flat soil.

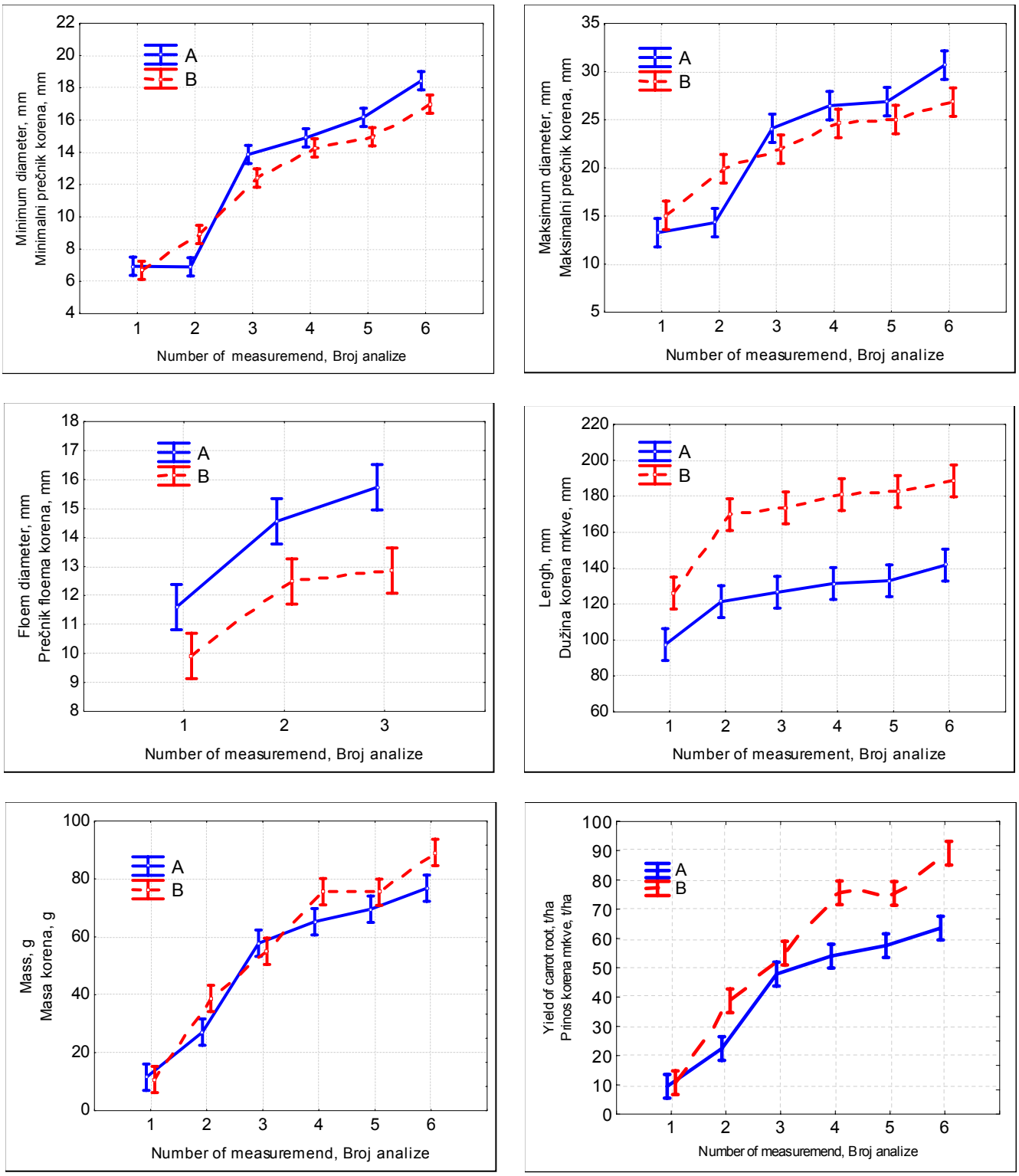

Fig. 2. Agro-physical properties and yield of carrot roots:
A–on flat soil, B–on mini-beds
Sl. 2. Agrofizičke osobine i prinos korena mrkve:
A–na ravnom zemljištu, B–na mini gredicama

CONCLUSION

The presowing prepare of soil was evaluated by measuring the physical and mechanical properties of soil, depending on depth. The experiment was situated at flat soil and mini-beds. Based on F-test for variance analysis and Duncan's-test for 5% significance, the significant statistic differences of 10 to 25 cm of layer was determined. Therefore, the carrot roots have optimal conditions for growing at the mini-beds.

At the flat soil the yield of carrot roots was 63.57 t/ha and at mini-beds 89.15. The average length of roots at flat soil was 11.7 mm and at mini-beds it was 188.5 with smaller content of phloem (22.97%). This means nicer form of roots and better quality for fresh consuming.

Using mini-beds in carrot production technology has adequacy in statistically significant higher yield and in getting the best quality of the carrot shape.

Note: This paper is a part of research project: „Izučavanje novog proizvodnog koncepta u cilju dobijanja zdravstveno bezbednog povrća za svežu potrošnju i čuvanje uz uštedu energije", evidence number: 20147, subsidized from Ministri of Science and Technological Development, Republic of Serbia.

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