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# PRODUCTIVITY AND QUALITY OF ROOT CROPS OF PARSNIP DEPENDING ON SCHEMES OF SOWING AND DENSITY OF PLANTS

**The purpose.** To determine the optimum scheme of sowing and density of plants of parsnip in conditions of Right-bank Forest-steppe for deriving high productivity of standard root crops. **Methods.** Field —for research of elements of technique of growing and weather environment on the object of researches; biochemical — for determination of quality of root crops; statistical — for verification of reliability of the gained data. **Results.** Results are brought of researches (2015-2017) on study of effect of schemes of sowing and density of plants of parsnip (*Pastinaca sativa* L.) of the grade Stimulant on productivity, marketability and biochemical content of root crops in conditions of Right-bank Forest-steppe. **Conclusions.** It is fixed that optimum schemes for growing parsnip are as follows: (70+10+10)×8, (70+10+10)×10, and (50+20) ×8 cm. The highest yield of commodity root crops was gained at sowing on rows (90-93%). Reduction of area of feed leads to increase of amount of plants at a unit of area and to decrease of average mass of root crop. At increase of feeding area the average mass of root crop is also increased.

**Key words:** parsnip, productivity, root crops, dry matter, a total sugar, vitamin C, nitrates.

Spicy and aromatic vegetables grown in Ukraine are valuable vegetable raw materials. Of the group of root crops, the most common in the population is parsley, parsnip and celery. The main characteristic of spicy vegetables is the presence in the chemical composition of a large number of biologically active substances. Of great interest is parsnip, which, according to the content of easily digestible carbohydrates, occupy the first place among the root crops. Its value for health is due to a significant amount of potassium (342 mg per 100 g). A typical 100–g parsnip contains 30 mg vitamin C; sugar 8,6–10,5 %; 1,8–3,1 g protein; 18,1–22,5 % dry matter and essential oil – 1,35 % [1, 2].

Dense soils cause branching of root crops. An important problem in growing this crop is the length of the root crop, since the widely distributed domestic Petryk

variety has a very long root (more than 40 cm), which complicates the harvesting both mechanized and manually digging in the private sector [3, 4].

**Analysis of recent researches and publications.** The optimum size of the area of nutrition depends on the habitat of the plants, the duration of cultivating the crop, the soil fertility, the intensity of the light and the features of the technology. The optimal area of plant nutrition by configuration is the circle or square [5].

According to literary sources, parsnips are grown mainly in broad–band and ribbon ways [6, 7, 8, 9]. Scientists I.V. Dydiv, O.Y.Dydiv, I.M. Yavdyk, it is recommended to grow parsnips on vegetable beds in order to increase the yield and quality of root crops in the conditions of the Carpathian region of Ukraine [10].

Thus, when determining the optimum area of plant nutrition under the different planting patterns and the density of the parsnip sowing, the following factors should be taken into account: vegetation period, varietal characteristics, fertility and soil moisture, illumination, commodity purpose of products. Soil–climatic conditions of Ukraine are rather favorable for growing various kinds of plant production, and in the first place, vegetables, in particular parsnip, and because of this the importance of determining the optimal scheme of sowing and plant density of parsnip.

**The objective –** determine the optimal sowing scheme and plant density of parsnip in conditions of righ–bank Ukrainian Lisostep in order to obtain high–quality roots.

**Materials and methods.** The research was conducted in 2015–2017 on the basis of experimental field at the Department of Vegetable–Growing in SRD "Plodoovochevyi Sad" of NULES of Ukraine on parsnip (Pastinaca sativa L.) (sort Stymul). The experiment was conducted according to standard methods. [11].

Experience one–factor, the investigated factor – the sowing scheme and plant density. The scheme of experiment is shown in table 1. Seeds were sown in second decade of April at soil temperature + 6 …+ 8 $^{o}$C. Sowing depth – 1,5–2 cm. Arrangement of plots – systematical, repeatability – four times. Discount area – 11,3 m$^2$. Cultivation technology was is common for right–bank Ukrainian forest–steppe.

Biochemical studies conducted for standardized methods, namely dry matter content is determined by drying the sample at a temperature of 105 °C (DSTU ISO 751:2004); measurement of soluble solids content by refractometric method (DSTU 8402:2015); total sugar – by Bertran (DSTU ISO 4954:2008); ascorbic acid (vitamin C) by I.K. Murri (DSTU 7803:2015); the amount of nitrate – ion metric method (DSTU ISO 6635:2004). Statistical analysis of the data was performed by a computer program «Statistica 6» i *MS Excel*. Methods: field method – in order to study the influence of growing technology and weather conditions on the object of research; biochemical method – in order to determine quality of roots; statistical method – in order to verify received data.

**Results of researches.** As can be seen from table 1, in 2015, the highest yield (51,6–49,4 tons/hectare) was obtained for growing parsnip seeding in ranges under sowing schemes (70+10+10)x8 cm, (70+10+10)x10 cm with plant density, respectively, 416,7 and 333,3 thousand pcs./ha, which is 7,4 and 5,1 tons/hectare more than control. The decrease in plant density to 222,2 thousand pcs./ha (70+10+10) x15 cm yields 47,8 tons/hectare and was within the experimental boundary. With an increase in the number of plants to 666,7 thousand pcs./ha (70+10+10)x5 cm, the yield was 42,1 tons/hectare and was at the control level.

**Table 1. Crop capacity and root quality of parsnip depending on sowing scheme and plant density**

| Sowing scheme | Plant density, thousands pcs./hectare | Crop capacity, t/ha | | | | +/– control | | Marketable roots, % (average 2015–2017) |
|---|---|---|---|---|---|---|---|---|
| | | 2015 | 2016 | 2017 | average | t/ha | % | |
| 45x15 | 148,1 | 40,9 | 42,6 | 41,6 | 41,7 | -3,7 | -8,1 | 83 |
| 45x10 (контроль) | 222,2 | 44,3 | 46,4 | 45,5 | 45,4 | - | - | 87 |
| 45x5 | 444,4 | 35,4 | 39,1 | 37,4 | 37,3 | -8,1 | -17,8 | 77 |
| (50+20)x15 | 190,5 | 43,0 | 44,6 | 43,3 | 43,6 | -1,7 | -3,8 | 83 |
| (50+20)x10 | 285,7 | 47,1 | 48,8 | 48,0 | 47,9 | 2,6 | 5,7 | 86 |
| (50+20)x8 | 357,1 | 48,9 | 50,7 | 49,9 | 49,8 | 4,5 | 9,8 | 85 |
| (70+10+10)x15 | 222,2 | 47,8 | 49,9 | 48,5 | 48,7 | 3,4 | 7,4 | 91 |
| (70+10+10)x10 | 333,3 | 49,4 | 52,0 | 50,8 | 50,7 | 5,4 | 11,8 | 93 |
| (70+10+10)x8 | 416,7 | 51,6 | 54,6 | 52,8 | 53,0 | 7,6 | 16,8 | 93 |
| (70+10+10)x5 | 666,7 | 42,1 | 44,9 | 44,0 | 43,7 | -1,7 | -3,8 | 90 |
| SSD $_{0,05}$ | | 3,56 | 4,15 | 4,03 | | | | |

Applying a ribbon scheme of sowing (50+20)x8 cm with a density of 357,1 thousand pcs./ha yielded 48,9 tons/hectare, which is significantly higher than control. The decrease in plant density to 190,5 thousand pcs./ha (50+20)x15 cm yields 43,0 tons/hectare, which does not differ significantly from the control.

Under a wide–spread scheme of sowing 45x10 cm (control) with a plant density 222,2 thousand pcs./ha yielded 44,3 tons/hectare. With an increase in plant density to 444,4 thousand pcs./ha under the scheme of sowing 45x5 cm and a decrease to 148,1 thousand pcs./ha in the scheme of sowing 45x15 cm we did not establish a significant increase in yield.

In 2016, the yield of root crops of parsnip was higher compared to 2015. Comparing the conditions of humidity over the years of research it should be noted that the more favorable for the growth and development of plants parsnip was 2016. In April–September 2016, rainfall dropped to 308,9 mm whereas in 2015 the amount of precipitation was 176,7 mm in the same period of time. In 2016, the highest yield (54,6–52,0 tons/hectare) was obtained for the cultivation of parsnip on ranges with the scheme of sowing (70+10+10)x8 cm and (70+10+10)x10 cm and density respectively 416,7 and 333,3 thousand pcs./ha, which is 8,2–5,7 tons/hectare more than control. The decrease in plant density to 222,2 thousand pcs./ha in the scheme (70+10+10) x15 cm yields 49,9 tons/hectare, which does not differ significantly from control. With the thickening of plants to 666,7 thousand pcs./ha (70+10+10)x8 cm, the yield was 44,9 tons/hectare, which is at the control level.

Under the sowing scheme (50+20)x8 cm with a density of 357,1 thousand pcs./ha in 2016 yielded 49,9 tons/hectare, which is substantially 4,4 tons/hectare higher than control. The decrease in plant density to 190,5 thousand pcs./ha in the scheme of sowing (50+20)x15 cm yields 46,6 tons/hectare, which is not significantly different from the control. Under a wide–spread scheme of sowing 45x10 cm (control) with plant density 222,2 thousand pcs./ha yielded 46,4 tons/hectare. An increase in plant density to 444,4 thousand pcs./ha in the scheme of sowing 45x5 cm

and a decrease to 148,1 thousand pcs./ha in the scheme of sowing 45x15 cm significant increase in productivity is not established.

The results of studies in 2017 show that the highest yield (52,8–50,8 tons/hectare) was observed in plants for growing in ranges under sowing schemes (70+10+10)x8 cm, (70+10+10)x10 cm with a density of 416,7 and 333,3 thousand pcs./ha respectively, which is 7,3 and 5,3 tons/hectare more than control. Also, a significant increase in yield (49,9 tons/hectare) was noted for the sowing scheme (50+20)x8 cm with a density of 357,1 thousand pcs./ha, which is 4,4 tons/hectare higher than control.

During 2015–2017, a significant increase in yield, compared with control, (50,3; 50,7; 49,8 tons/hectare) was established in variants according to sowing schemes (70+10+10)x8 cm, (70+10+10)x10 cm and (50+20)x8 cm, with plant density: 416,7; 333,3 and 357,1 thousand pcs./ha, which is by 16,8 %, 11,8 % and 9,8 %, respectively, above the control.

The highest yield of commodity root crops (93 %) on average in 2015–2017 years was obtained for sowing in the ranges with the scheme of placement of plants (70+10+10)x8, (70+10+10)x10 cm with a density of 416,7 and 333,3 thousand pcs./ha. For ribbon sowing, the highest marketable roots (86 %) was provided by a scheme of sowing (50+20)x8 cm with a density of plants of 357,1 thousand pcs./ha. For broad–sowing, the highest commerciality (87 %) of root crops was provided by a scheme of sowing 45x10 cm with a plant density of 222,2 thousand pcs./ha. Decreasing plant density to 148,1 thousand pcs./ha for wide–range seeding leads to the growth of root crops and their branches with the release of marketable root crops 83 %. Also, the thickening to 444,4 thousand pcs./ha leads to a decrease in marketability to 77 %.

The mass of commodity root crop in the average for the experiment for 2015–2017 was 67–285 g. Under a wide–ranging scheme with an intermediate row of 45 cm this indicator was 85–285 g, and for ribbon (50+20 cm) – 142–231 g. For sowing on vegetable beds ranges the average weight of root crops was 67–223 g (table 2).

**Table 2. Average weight root of parsnip depending on sowing scheme and plant density**

| Sowing scheme | Plant density, thousands pcs./hectare | Average weight root, g | | | | +/– control | |
|---|---|---|---|---|---|---|---|
| | | 2015 | 2016 | 2017 | average | g | % |
| 45x15 | 148,1 | 279 | 292 | 283 | 285 | 78 | 37,7 |
| 45x10 (контроль) | 222,2 | 202 | 211 | 207 | 207 | - | - |
| 45x5 | 444,4 | 80 | 89 | 85 | 85 | -122 | -59,0 |
| (50+20)x15 | 190,5 | 228 | 235 | 230 | 231 | 24 | 11,8 |
| (50+20)x10 | 285,7 | 166 | 172 | 169 | 169 | -38 | -18,2 |
| (50+20)x8 | 357,1 | 138 | 145 | 143 | 142 | -65 | -31,3 |
| (70+10+10)x15 | 222,2 | 218 | 229 | 221 | 223 | 16 | 7,7 |
| (70+10+10)x10 | 333,3 | 150 | 158 | 154 | 154 | -53 | -25,5 |
| (70+10+10)x8 | 416,7 | 127 | 134 | 129 | 130 | -77 | -37,1 |
| (70+10+10)x5 | 666,7 | 64 | 69 | 67 | 67 | -140 | -67,7 |
| SSD $_{0,05}$ | | 15,47 | 18,02 | 17,79 | | | |

Decreasing the area of nutrition leads to increasing the quantity of plants on unit area and decreasing average weight of roots. Increasing the area of nutrition leads to increasing average weight of root. Although both increasing and decreasing of nutrition area leads to shortage of marketable yield. In first variant because of underriping and in second variant because of overriping (degeneration, dehiscence etc.). Thus, in thickened crops of parsnip, small root crops are formed, and for increasing the area of nutrition – they overgrow and in some years (wet) mass crack, branch and rot.

On average, in the years 2015–2017, with the increase in the number of plants per unit area, the content of dry matter, vitamin C, total sugars decreased, while the content of nitrates increased. (table 3).

**Table 3. Biochemical indices of root of parsnip (average 2015–2017)**

| Sowing scheme | Plant density, thousands pcs./hectare | Dry substance, % | | Total sugar, % | Vitamin C, mg/% | Nitrates, mg/kg |
|---|---|---|---|---|---|---|
| | | all | inc. soluble | | | |
| 45x15 | 148,1 | 23,3 | 13,5 | 5,3 | 8,3 | 48 |
| 45x10 (контроль) | 222,2 | 24,7 | 14,4 | 5,6 | 8,7 | 57 |
| 45x5 | 444,4 | 21,9 | 12,3 | 4,5 | 6,6 | 84 |
| (50+20)x15 | 190,5 | 23,4 | 13,4 | 5,1 | 8,0 | 60 |

| | | | | | | |
|---|---|---|---|---|---|---|
| (50+20)x10 | 285,7 | 24,3 | 14,0 | 5,5 | 8,6 | 65 |
| (50+20)x8 | 357,1 | 23,8 | 13,7 | 5,3 | 8,2 | 70 |
| (70+10+10)x15 | 222,2 | 23,2 | 13,1 | 4,9 | 8,1 | 50 |
| (70+10+10)x10 | 333,3 | 24,5 | 14,3 | 5,6 | 8,7 | 62 |
| (70+10+10)x8 | 416,7 | 24,0 | 14,1 | 5,5 | 8,5 | 73 |
| (70+10+10)x5 | 666,7 | 22,2 | 12,6 | 4,7 | 6,9 | 89 |
| SSD $_{0,05}$ | | 0,78 | 0,46 | 0,18 | 0,26 | 7,6 |

It is established that the biochemical composition and mass of the root are closely interconnected. The highest content of dry substances (24,0–24,7 %), dry soluble substances (14,0–14,4), total sugars (5,5–5,6 %) and vitamin C (8,5–8,7 mg/%) were observed in the root crops weighing 130–207 g. It should be noted that this mass of root crop was formed according to the schemes of sowing 45x10 cm (control), (70+10+10)x15 cm, (70+10+10)x8 cm and (50+20)x8 cm, with plant density: 222,2 thousand pcs./ha, 333,3 thousand pcs./ha, 416,7 thousand pcs./ha and 357,1 thousand pcs./ha.

Reduction of the number of plants per unit area to 148.1 thousand pcs / ha (45x15 cm); 190,5 thousand pcs./ha ((50+20)x15 cm) and up to 222,2 thousand pcs./ha ((70+10+10)x15 cm) results in a significant decrease in the dry matter content by 1,4 %, 1,3 % and 1,5 %, dry soluble substances respectively 0,9 %, 1,0 % and 1,3 %, total sugars respectively of 0,3 %, 0,5 % and 0,7 %, respectively, and Vitamin C, respectively, at 0,4 mg/%, 0,7 mg/% and 0,6 mg/% in the root crops of the parsnip as regards control. Thickening of plants to 357,1 thousand pcs./ha ((50+20)x8 cm); 444,4 thousand pcs./ha (45x5 cm); 416,7 thousand pcs./ha ((70+10+10) cm) and up to 666,7 thousand pcs./ha (70+10+10)x5 cm) results in a significant decrease in the dry matter content, respectively, at 2,8 %, 0,9 % and 2,5 %, dry soluble substances respectively by 2,1 %, 0,7 % and 1,8 %, total sugars respectively by 1,1 %, 0,3 % and 0,9 % and vitamin C, respectively, at 2,1 mg/%, 0,5 mg/% and 1,8 mg/% in root parsnips compared with controls. The content of nitrates in roots was lower than maximum permissible dose (250mg/kg) and ranged from 48 to 89 mg/kg.

## Conclusions

It is determined that optimal scheme of parsnip growing on vegetable beds is (70+10+10)x8 cm, (70+10+10)x10 cm, plant density 416,7 and 333,3 thousands

pcs./hectare, was highest crop capacity (53,0–50,7 tons/hectare) with marketable value 93 %. The application of the ribbon scheme of sowing (50+20)x8 cm, with a density of plants 357.1 thousand pcs./ha, provides a significant increase in yields by 9,8 % compared with control. Marketability of roots at that was 85 %, which is at the control level. Reducing or increasing the plant density of parsnips from optimal leads to a decrease in the level of total yield and marketability of root crops.

It is established that the biochemical composition and mass of the root are closely interconnected. The highest content of dry substances (24,0–24,7 %), dry soluble substances (14,0–14,4), total sugars (5,5–5,6 %) and vitamin C (8,5–8,7 mg/%) is indicated for root crops weighing 130–207 g. If plant quantity on unit area increases content of dry matter and vitamin C and sugars decreases and content of nitrates increases. The content of nitrates in roots was lower than maximum permissible dose (250mg/kg) and ranged from 48 to 89 mg/kg.

**Bibliography**

*1. Holembovska N.V. Kharakterystyka priano–aromatychnykh koreneplodiv / N.V Holembovska, T.K. Lebska / Naukovi pratsi, – Odesa, Vypusk 46, tom 2. – 2014. – S. 59–63.*

*2. Bufler G. Changes in sugar and starch concentrations in parsnip (Pastinaca sativa L.) during root growth and development and in cold storage / G. Bufler, B. Horneburg / The Journal of Horticultural Science and Biotechnology Vol. 88, Iss. 6, 2013. – P. 756–761.*

*3. Korniienko S.I. Osoblyvosti tekhnolohii vyroshchuvannia maloposhyrenykh ovochevykh roslyn / Korniienko S.I., Khareba V.V., Khareba O.V., Pozniak O.V. – Vinnytsya: TOV «Nilan–LTD», 2015. – 133 s.*

*4. Bolotskykh A.S. Ovoshchy Ukraыnы / A.S. Bolotskykh. – Kharkov: Orbyta, 2001. – S. 1088.*

*5. Barabash O.Iu. Biolohichni osnovy ovochivnytstva / O.Iu. Barabash, L.K. Taranenko, Z.D. Sych. – Kyyiv: Aristei, 2005. – 354 s.*

*6. Yusupov M. Ovoschevodstvo Kazahstana. Tom 2 / M. Yusupov, B. Petrov, F. Ahmetova. – Almata: Resp. izdat. kab. Kaz. akad. obrazov. im. I. Altyinsarina, 2000. – 268 s.*

*7. Bunin M.S. Ovoschevodstvo TsChR / M.S. Bunin, S.Ya. Muhortov, V.K. Rodionov i dr. – Voronezh: FGOU VPO VGAU, 2008. – 311 s.*

*8. Holian V.P. Dovidnyk po ovochivnytstvu i bashtannytstvu / V.P. Holian. – Kyyiv: Urozhai, 1981. – 296 s.*

*9. Latiuk H.I. Dovidnyk ovochivnyka Stepu Ukrainy [4–te vyd.] / H.I. Latiuk, L.P. Popova, P.S. Tykhonov, B.S. Anhel, S.P. Maksymov, L.M. Sapozhnykova, Yu.Ie. Klechkovsky. – Odesa: VMV, 2010. – 437 s.*

*10. Dydiv I.V. Urozhainist i yakist pasternaku zalezhno vid sposobiv vyroshchuvannia v umovakh Peredkarpattia / I.V. Dydiv, O.I. Dydiv, I.M. Yavdyk // Ovochivnytstvo i bashtannytstvo: mizhvid. temat. nauk. zb. – Kharkiv, 2008. – S. 292–296.*

*11. Bondarenko Gh. L. Metodyka doslidnoji spravy v ovochivnyctvi i bashtannyctvi / Za red. Gh. L. Bondarenka, K. I. Jakovenka. – Kharkov: Osnova, 2001. – 369 s.*