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EFFECT OF DIFFERENT PRE-SOWING TILLAGE ON QUANTITY AND QUALITY OF PARSNIP (*Pastinaca sativa* L.) ROOT YIELD IN RIDGE CULTIVATION

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Abstract

Parsnip is a very valuable vegetable due to its nutritional value and dietetic quality. It is moreover herbal raw material abundant in active substances. The yield quality of vegetables greatly depends on thorough pre-sowing soil tillage. The present study aimed at evaluating the influence of different pre-sowing soil tillage (medium-deep ploughing, cultivating) and plant growing methods, flat or ridge cultivation, on the yield of parsnip and some biometric traits of its roots. The field experiment was carried out in 1999, 2000 and 2002 on lessive soil with the granulometric composition corresponding to medium silty loam. The parsnip cultivar 'Półdługi Biały' was the experimental plant species. The cultivation of parsnip on ridges had a significant influence on increased total yield of roots and decreased yield of small roots, as compared to flat cultivation. A significant increase in unit weight of the root and its diameter in the top part was also recorded in the latter type of cultivation. Spring pre-sowing tillage had no significant effect on parsnip yields. An increasing trend was observed only for total and marketable root yield in the ploughed plots. When parsnip is grown on lessive soil (which has an unstable structure), plants cultivated on ridges after spring pre-sowing plough are the most beneficial treatment combination.

Key words: *Pastinaca sativa*, tillage, plant cultivation method, yield quality

INTRODUCTION

Parsnip is a vegetable with a high nutritional value and dietetic quality. The storage roots of parsnip contain considerable amounts of sugars, proteins and vitamin C, B_1, B_2 and B_6. The value of parsnip is also enhanced due to the content of fibre, minerals, including potassium, phosphorus, calcium, iron, as well as pectins (Orłowski and Kołota, 1999; Wolski et al. 1999; Kuskowska, 2000; Kołota et al. 2007). Parsnip is valuable as herbal raw material. Its herb, roots, and fruits contain many active substances such as essential oils, flavonoids, acetylene, and furanocoumarin compounds (Dyduch and Wolski, 1996).

The climatic and soil requirements of parsnip are not excessive; however, due to the fact that it is an oceanic climate species, it needs wet habitats (Skąpski and Dąbrowska, 1994). Water deficiency during its growing period strongly reduces plant growth and lowers yields, and moreover, it has a negative influence on the quality of harvested roots. Parsnip grows well on heavy and loamy soils, while higher yields can be achieved from habitats with good culture, humic ones, and non-crusting soils.

Root vegetables show a strong reaction to the way in which soil is prepared for sowing as well as to the plant cultivation method. Deep pre-sowing tillage determines the achievement of good quality yield of parsnip roots. Nevertheless, there are still attempts to introduce some tillage reduction consisting in the elimination of ploughing or making pre-sowing tillage more shallow (Włodek et al. 1999; Konopiński et al. 1999; Błażewicz-Woźniak et al. 2001; Kęsik et al. 2006; Konopiński and Błażewicz-Woźniak, 2008).

The aim of the present study was to evaluate the influence of spring pre-sowing ploughing and shallow tillage (cultivating) as well as of plant cultivation methods, with parsnip grown on ridges or on flat ground, on its root yield and selected biometric traits of roots.

MATERIALS AND METHODS

The field experiment was carried out in 1999, 2000, and 2002 in the Felin Experimental Farm belonging to the University of Life Sciences in Lublin.

The study was conducted on lessive soil developed from loess formations with the granulometric composition of medium silty loam. Parsnip (*Pastinaca sativa* L.), 'Półdługi Biały', was the experimental plant species. The experimental design included the following: two methods of pre-sowing tillage with cultivating (medium-deep ploughing – to 22 cm depth and cultivating – to 15 cm depth), as well as two methods of plant cultivation: ridge and flat cultivation. Mineral fertilization was applied at the following rates: 50 kg N×ha^{-1} prior to sowing and 50 kg N×ha^{-1} post-crop, 44 kg P, and 166 kg K×ha^{-1}. Seeds were sown at the end of April at an amount of 8 kg×ha^{-1} in rows with 50 cm spacing and to a depth of 2 cm. The harvest of parsnip roots was done at mid-October.

The experiment investigated the effect of deep and shallow spring pre-sowing tillage as well as ridge and flat cultivation on total root yield, marketable root yield (root length above 20 cm, root thickness in its top part above 14 mm), yield of small roots, and some biometric traits of roots (unit weight, length, diameter).

The results were studied by means of variance analysis and the significance of differences was determined using Tukey's test at the 0.05 probability level.

RESULTS AND DISCUSSION

Total root yield. Regardless of the studied experimental factors, parsnip root yield amounted to 29.1 t per 1 hectare (Table 1). Parsnip grown on ridges produced significantly higher total root yields (by 7.8 t×ha^{-1}) as compared to flat field cultivation. The positive influence of the cultivation of root vegetables on ridges was confirmed by other experiments carried out by Konopiński (2009) on purple salsify, which revealed significantly better yields on ridges than in flat field cultivation. Scorzonera also yielded better when grown on ridges (Konopiński, 2008). Carrot has been recommended for growing on ridges for many years (Taivalmaa and Talvitie, 1997; Saiful-Islam et al. 1998; Rumpel and Grudzień, 2000; Sady and Cebulak, 2000; Wierzbicka et al. 2004). Babik and Skierkowski (1998) reported that, despite poor emergence, chicory and carrot yields from ridge cultivation were higher than from flat cultivation.

Different pre-sowing tillage methods applied in spring (medium-deep ploughing and cultivating), along with complementary tillage, had no significant influence on parsnip total root yields. Regardless of the cultivation method, more roots were harvested from the treatments with spring ploughing (by 0.8 t×ha^{-1} on average) than from the plots in which cultivating was used. Experiments done by Kęsik et al. (1999) revealed that spring ploughing produced better effects on root yields than shallow pre-sowing soil tillage in experiments involving parsley and beetroot. Considering the interaction of tillage with the plant cultivation method, parsnip grown on ridges after spring medium-deep ploughing with cultivating appeared to be the most beneficial cultivating treatment combination. Total root yield in this treatment was higher by 7.8 t×ha^{-1} than in the least beneficial one - parsnip grown on flat ground after spring pre-sowing ploughing.

Marketable root yield. The yield of marketable roots amounted to 15.3 t per 1 hectare, on average (Table 2). Parsnip grown on ridges had no significant influence on marketable root yield. Regardless of spring pre-sowing soil tillage, 0.2 tons more roots were harvested from the treatments with ridges than from flat cultivation. Similar results were obtained in the study by Konopiński (2008) with scorzonera: higher marketable root yields were harvested on ridges. Diverse spring tillage in parsnip cultivation did not have any significant effects on marketable yield of its roots. However, slightly more roots (by 0.3 t×ha^{-1}) were harvested from the plots where ploughing was applied. In experiments with beetroot, Konopiński (1997) achieved the highest marketable root yield due to the application of cultivating in spring, while lower yields were recorded after spring ploughing. Parsley in the study carried out by Błażewicz-Woźniak (1998) reacted in a different way to pre-sowing tillage. Pre-sowing cultivation – as opposed to spring ploughing and the use of rotary tiller – had a negative influence on marketable yield of parsley roots. Among tillage and cultivation treatments applied for parsnip growing, ridges applied after pre-sowing plough tillage appeared to be the most beneficial for root yields. The marketable yield of parsnip roots in this treatment was the highest and amounted to 15.7 t×ha^{-1}.

Yield of small roots. Regardless of the studied factors, the yield of small parsnip roots was 2.3 t×ha^{-1} (Table 3). Harvested root yield was about 8.0% of total root yield. It was reported that the cultivation method had a considerable impact on the yield level of small roots. When plants grew on ridges, the amount of small roots was lower by 1.1 t ha^{-1} than in flat cultivation. The same correlation was reported by Babik and Skierkowski (1998), who found less bent and small roots in chicory and carrots cultivated on ridges compared to those from flat cultivation. A slightly lower yield of small parsnip roots (by 0.3 t×ha^{-1}) was harvested from the plots where cultivating was applied in spring. Among of the tested cultivation combinations, growing on ridges after spring cultivating of the soil was characterized by the lowest yields of small roots.

Single root weight. The studied plant cultivation methods had a significant effect on unit weight of the parsnip root (Table 4). It was found that ridge cultivation resulted in a significant increase in root weight, which was by 82 g higher than the unit weight of roots

harvested from the flat field. Pre-sowing tillage played a remarkable role – although not proved statistically – in determining the root weight. Reduced spring tillage, by applying shallow ploughing and cultivating, had a negative effect on the unit weight of the parsnip root. Regardless of the cultivation method, the unit weight of the roots harvested from the cultivated plots was lower than that of the roots from the ploughed plots. Parsley reacted in a different way to spring cultivating in the experiments performed by Błażewicz-Woźniak (1998). The roots of the plants from the treatments after pre-sowing soil cultivating were characterized by higher weight. Among the tillage treatments under investigation, parsnip cultivation on ridges after spring ploughing appeared to be the best in terms of root weight. The average unit root weight from this treatment was 247 g, while the lowest value of this trait was recorded for flat field cultivation after spring ploughing (124 g, on average).

Root length. Regardless of the studied experimental factors, the mean root length was 239 mm (Table 5). Ridge cultivation had more beneficial effects (but not proved statistically) on parsnip root development. Roots harvested from ridges were longer than those from flat soil. Similar results were reported by Rumpel and Grudzień (2000) when studying carrot cultivation. These authors found that when carrot was grown on ridges, higher and better-quality yields could be achieved. Roots were longer and with a better shape. The same conclusions were drawn by Dyśko and Kaniszewski (2007) from experiments with carrot. Significantly longer black salsify roots in ridge cultivation, as opposed to flat cultivation, were obtained by Konopiński (2003). Regardless of the parsnip cultivation method, a significantly better effect of spring ploughing on root growth was recorded. Plough tillage resulted in roots by 30 mm longer compared to those harvested from the cultivated plots. Also, the longest parsley roots were produced after spring ploughing in the experiments done by Błażewicz-Woźniak (1998). Both in ridge and flat cultivation of parsnip, spring ploughing had much better effects on the value of this parameter than cultivating.

Root diameter in the top part. The applied plant cultivation methods had a significant influence on parsnip root diameter in its top section (Table 6). It was found that ridge cultivation produced better conditions for root growth, which was manifested in a 10 mm larger root diameter compared to flat cultivation. A positive impact of ridge cultivation on root thickness was also reported for scorzonera (Konopiński, 2003). The experiments with parsnip also revealed that spring ploughing tended to have a positive effect on the root diameter. In the plough tillage treatments, the mean parsnip root diameter was larger by 4 mm than in the plots in which cultivating was used. A similar correlation was observed in the case of scorzonera cultivation (Konopiński, 2003). Considering the examined factors, it should be concluded that plant cultivation on ridges after pre-sowing plough tillage was the best combination for this trait, because the average root diameter in its top part was 61 mm.

Table 1.
Effect of tillage and plant cultivation method on total yield of parsnip roots in t×ha^{-1} (mean for 1999-2002)

Spring pre-sowing tillage	Plant cultivation method		Mean
	ridge cultivation	flat cultivation	
Ploughing	33.9	25.1	29.5
Cultivating	32.1	25.3	28.7
Mean	33.0	25.2	29.1
$LSD_{(0.05)}$ for plant cultivation method			6.0
$LSD_{(0.05)}$ for pre-sowing tillage			ns

Table 2.
Effect of tillage and plant cultivation method on the marketable yield of parsnip roots in t×ha^{-1} (mean for 1999-2002)

Spring pre-sowing tillage	Plant cultivation method		Mean
	ridge cultivation	flat cultivation	
Ploughing	15.7	15.2	15.4
Cultivating	15.1	15.2	15.2
Mean	15.4	15.2	15.3
$LSD_{(0.05)}$ for plant cultivation method			ns
$LSD_{(0.05)}$ for pre-sowing tillage			ns

Table 3.
Effect of tillage and plant cultivation method on the yield of small parsnip roots in t×ha^{-1} (mean for 1999-2002)

Spring pre-sowing tillage	Plant cultivation method		Mean
	ridge cultivation	flat cultivation	
Ploughing	1.8	3.2	2.5
Cultivating	1.7	2.6	2.2
Mean	1.8	2.9	2.3
$LSD_{(0.05)}$ for plant cultivation method			1.1
$LSD_{(0.05)}$ for pre-sowing tillage			ns

Table 4.
Effect of tillage and plant cultivation method on the weight of the parsnip root in g (mean for 1999-2002)

Spring pre-sowing tillage	Plant cultivation method		Mean
	ridge cultivation	flat cultivation	
Ploughing	247	124	186
Cultivating	167	126	147
Mean	207	125	166
$LSD_{(0.05)}$ for plant cultivation method			52.4
$LSD_{(0.05)}$ for pre-sowing tillage			ns

Table 5.
Effect of tillage and plant cultivation method on the length of the parsnip root in mm (mean for 1999-2002)

Spring pre-sowing tillage	Plant cultivation method		Mean
	ridge cultivation	flat cultivation	
Ploughing	262	245	254
Cultivating	221	227	224
Mean	242	236	239
$LSD_{(0.05)}$ for plant cultivation method			ns
$LSD_{(0.05)}$ for pre-sowing tillage			19.1

Table 6.
Effect of tillage and plant cultivation method on the diameter of the parsnip root in its top part in mm (mean for 1999-2002)

Spring pre-sowing tillage	Plant cultivation method		Mean
	ridge cultivation	flat cultivation	
Ploughing	61	46	54
Cultivating	53	47	50
Mean	57	47	52
$LSD_{(0.05)}$ for plant cultivation method			6.8
$LSD_{(0.05)}$ for pre-sowing tillage			ns

CONCLUSIONS

Parsnip cultivation on ridges had a significant influence on the increase in total root yields and the decrease in the yield of small roots as compared to flat cultivation. A significant increase in the unit weight of the root and the diameter in its top was recorded as well.

Spring pre-sowing tillage did not exert any significant effect on parsnip yield. An increasing tendency for total and marketable root yield was only observed in the treatments with plough tillage. Spring ploughing - as compared to cultivating - had a significant impact on parsnip root elongation.

The most beneficial method for parsnip grown on lessive soil with an unstable structure is ridge cultivation after spring pre-sowing ploughing.

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Wpływ zróżnicowanej przedsiewnej uprawy roli na wielkość i jakość plonu korzeni pasternaku (*Pastinaca sativa* L.) w uprawie na redlinach

Streszczenie

Pasternak należy do bardzo cennych warzyw ze względu na wartość odżywczą i walory dietetyczne. Jest też bogatym w substancje czynne surowcem zielarskim. Jakość plonowania warzyw korzeniowych zależy w dużej mierze od starannej przedsiewnej uprawy roli. Celem przeprowadzonych badań było określenie wpływu zróżnicowanej przedsiewnej uprawy roli (orka średnia, kultywatorowanie) oraz uprawy roślin na redlinach i na płask, na plonowanie pasternaku i niektóre cechy biometryczne jego korzeni. Doświadczenia polowe przeprowadzono w latach 1999, 2000, 2002, na glebie płowej o składzie mechanicznym odpowiadającym glinom średnim pylastym. Rośliną doświadczalną był pasternak odmiany Półdługi Biały. Uprawa pasternaku na redlinach miała istotny wpływ na zwiększenie plonu korzeni ogółem oraz zmniejszenie plonu korzeni drobnych w porównaniu z uprawą na płask. W uprawie tej zanotowano istotny wzrost masy jednostkowej korzenia oraz jego średnicy w części głowowej. Wiosenna przedsiewna uprawa roli nie wywierała istotnego wpływu na plonowanie pasternaku. Zaobserwowano jedynie tendencję wzrostową plonu korzeni ogółem i handlowych w obiektach z uprawą płużną. Orka wiosenna, w porównaniu z kultywatorowaniem, miała natomiast istotny wpływ na zwiększenie długości korzeni. Na glebie płowej o nietrwałej strukturze, najkorzystniejszą kombinacją uprawową jest uprawa pasternaku na redlinach, po wiosennej orce przedsiewnej.