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EFFECT OF DRIP IRRIGATION AND CULTIVATION METHODS ON THE YIELD AND QUALITY OF PARSLEY ROOTS

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Abstract

In the years 2005–2007, research work on the influence of surface and subsurface drip irrigation on the yield and quality of roots of parsley grown on ridges and on flat ground was carried out. Irrigation water was supplied via drip lines, which in subsurface irrigation were placed at a depth of 50 mm below the surface of the ridges, along the centreline between two rows of plants. In the case of surface irrigation, the drip lines were placed on the surface of the ridges between two rows of plants. Irrigation started when soil water potential was between -30 and -40 kPa. Nitrogen fertilizers (100 $kg \cdot ha^{-1}$) were applied in two doses. The first dose was applied pre-plant, while the second one was delivered by fertigation. In the control treatment without irrigation, the second dose of nitrogen was applied by broadcasting. Both surface and subsurface irrigation used in the cultivation on ridges and on flat ground had a significant effect on the marketable yield of parsley roots. However, no significant differences in the yield between surface and subsurface drip irrigation were found. The yield of non-marketable parsley roots in flat cultivation was twice as high as that in ridge cultivation. Parsley plants cultivated on ridges produced significantly longer, better-shaped storage roots compared to those cultivated on flat ground. Surface and subsurface drip irrigation significantly decreased the total N and K content in parsley roots.

Key words: root parsley, cultivation method, drip irrigation, fertigation.

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WPŁYW NAWADNIANIA KROPLOWEGO I METODY UPRAWY NA PLON I JAKOŚĆ KORZENI PIETRUSZKI

Abstrakt

W latach 2005–2007 badano wpływ nawadniania kroplowego powierzchniowego i podpowierzchniowego na plonowanie korzeni pietruszki uprawianej na płaskim gruncie i na redlinach. Nawadnianie prowadzono z użyciem przewodów nawadniających, z wewnętrznie wtopionymi co 35 cm emiterami z kompensacją ciśnienia, które przy nawadnianiu podpowierzchniowym umieszczono na głębokości 50 mm, pośrodku dwóch rzędów roślin. Nawadnianie rozpoczynano, gdy potencjał wodny gleby wynosił od -30 kPa do -40 kPa. Nawozy azotowe (100 kg $N \cdot ha^{-1}$) wprowadzano w dwóch dawkach: pierwszą zastosowano przedwegetacyjnie, drugą podano przez fertygację. W kontroli drugą dawkę wniesiono w nawożeniu posypowym. Nawadnianie kroplowe powierzchniowe i podpowierzchniowe zastosowane zarówno na redlinach, jak i na płaskim gruncie powodowało istotny wzrost plonu handlowego korzeni pietruszki. Natomiast nie stwierdzono różnic w plonie pietruszki po zastosowaniu powierzchniowego i podpowierzchniowego sposobu nawadniania kroplowego. W uprawie pietruszki na redlinach udział korzeni niekształtnych w plonie był o 100% mniejszy w porównaniu z uprawą na płaskim gruncie. Pietruszka uprawiana na redlinach wytwarzała dłuższe korzenie spichrzowe, o lepszym kształcie w porównaniu z uprawą na płaskim gruncie. Nawadnianie powierzchniowe i wgłębne powodowało istotny spadek zawartości azotu ogólnego i potasu w korzeniach pietruszki.

Słowa kluczowe: pietruszka korzeniowa, metody uprawy, nawadnianie kroplowe, fertygacja.

INTRODUCTION

Root parsley (*Petroselinum hortense* ssp. *microcarpum* Hoffm.) is one of the basic spice vegetables in Poland. The total area under its cultivation is around 7 000 ha, which is around 3% of the total land area under vegetable crops. Yields of root parsley are relatively low and on average amount to 15 $t \cdot ha^{-1}$. The reasons for the low yields include poor germination rate caused by unfavourable weather patterns, particularly the distribution of precipitation (infrequent rainfall during germination and field emergence) and lack of irrigation. Root parsley, like other small-seed root vegetables cultivated by direct sowing, requires the soil to have the optimal moisture content during germination and emergence. Lack or excess of precipitation at that time causes the top layer of the soil to dry up or become waterlogged, the soil surface becomes encrusted and more compact, which reduces the rate of germination or even, in extreme cases, halts it altogether (BŁAŻEWICZ-WOŹNIAK 1997). Dry weather or excess water at the time when the storage root is forming and growing (July, August) are also responsible for poor yields. The shape and size of parsley roots change considerably in response to the way parsley plants are cultivated (RUMPEL, KANISZEWSKI 1994). Cultivation on ridges or ploughing prior to sowing have a favourable effect on the yield and shape of parsley

roots (BŁAŻEWICZ-WOŹNIAK 1998, 2003). When the moisture content in the soil is not right while the main root mass is growing, the number of forked and deformed roots increases. According to KANISZEWSKI (2006), it is necessary to start irrigating parsley plants when soil moisture falls to 60 – 65% FWC.

The aim of the experiment was to compare the effects of surface and subsurface drip irrigation on the yield of root parsley plants grown on ridges and on flat ground.

MATERIALS AND METHODS

The work was carried out in the years 2005-2007, in an experimental field of the Institute of Vegetable Crops in Skierniewice, on a podsolic soil containing 15-17% of leachable components in the Ap layer (0-25 cm) and 1.15% of organic matter, with a pH of 6.8 in H_2O. The experiment was set up in a two-factorial design (cultivation method, irrigation system) in 4 replications. The size of each experimental plot was 10.8 m^2 (2.7 x 4 m).

Experimental treatments:

1) cultivation on ridges – subsurface drip irrigation,
2) cultivation on ridges – surface drip irrigation,
3) cultivation on ridges – no irrigation,
4) cultivation on flat ground – subsurface drip irrigation,
5) cultivation on flat ground – surface drip irrigation,
6) cultivation on flat ground – no irrigation,

Irrigation was set up with drip lines, which in subsurface irrigation were placed 50 mm below the surface of the ridge, along the centreline between two rows of plants. In surface irrigation, the drip lines were placed on the surface of the ridge between two rows of plants. The distance between the centrelines of the ridges was 67.5 cm. Seeds were sown on the ridges at a rate of 50 per 1 running meter, in 2 rows 10 cm apart. The same procedure was applied on flat ground. The irrigation system was equipped with a Dosatron proportional fertilizer feeder. Irrigation times were determined by means of a Watermark moisture meter made by Irrometer. Irrigation began when soil water potential was between -30 and -40 kPa. Potassium fertilizers (200 $kg \cdot ha^{-1}$ K_2O) were applied pre-plant on a one-off basis. Nitrogen fertilizers (100 kg $N \cdot ha^{-1}$) were delivered in two doses. The first dose of 50 $kg \cdot ha^{-1}$ was applied pre-plant, while the other half was applied in the form of a solution via the fertigation system. In the control combinations, without irrigation, the second dose of nitrogen was delivered by broadcasting. Fertigation with nitrogen finished at the end of August. Broadcasting of the second dose

of nitrogen was carried out in the second half of July. In the successive years of the experiment seeds of cv. Berliner parsley were sown on 16, 9 and 22 May, with harvest taking place on 18, 12 and 17 October, respectively. The basic information on soil moisture and watering rates is presented in Tables 1 and 2. Samples of roots for analyses were taken at harvest time. Concentrations of mineral elements (P, K, Mg, Ca) in parsley roots were determined by emission spectrometry using an ICP plasma spectrometer. Total nitrogen was determined by Kjeldhal's method. The results were evaluated statistically with an analysis of variance. Mean values were compared with Newman-Keuls test at P=0.05.

Table 1

Monthly sum of rainfall in the vegetation period of parsley in Skierniewice

Years	Rainfall (mm)							
	Apr	May	June	July	Aug	Sept	Oct	Apr-Oct
Long-period averages	40	48	60	92	79	43	35	397
2005	22.3	71.9	35.4	96.0	38.3	16.5	3.4	283.8
2006	45.9	44.0	35.5	16.7	141.4	22.9	18.8	325.2
2007	28.2	65.1	81.2	63.8	52.5	46.7	18.0	355.5
Mean of 3 years	32.1	60.3	50.7	58.8	77.4	28.7	13.4	320.5

Table 2

Seasonal irrigation rates applied for parsley (mm)

Specification	Years		
	2005	2006	2007
Surface trickle irrigation	242	118	125
Subsurface trickle irrigation	218	106	112

RESULTS AND DISCUSSION

The experimental results seem to indicate that the use of surface and subsurface drip irrigation in the cultivation of root parsley on ridges and on flat ground has a beneficial effect on the yield of parsley plants (Table 3). The average marketable yield of parsley storage roots in the cultivation on ridges was 15.47 $t \cdot ha^{-1}$ for the three years of the experiment, and was significantly higher in comparison with the cultivation on flat ground, for which the average marketable yield was 11.96 $t \cdot ha^{-1}$. However, the difference in the total yield of parsley roots between the two cultivation methods was not significant. This was caused by yield of non-marketable roots

Table 3

Influence of cultivation methods and drip irrigation on root yield of parsley (2005-2007)

Cultivation methods	Irrigation treatments	Yield of parsley roots ($t \cdot ha^{-1}$)		
		marketable	non marketable	total
Ridges	subsurface	17.77	5.50	23.27
	surface	19.47	4.77	24.23
	without irrigation	9.17	3.43	12.60
	mean	15.47	4.57	20.03
Flat ground	subsurface	12.23	10.13	22.37
	surface	15.73	10.33	26.07
	without irrigation	7.90	7.40	15.30
	mean	11.96	9.29	21.24
Mean for irrigation treatments				
surface		15.00	7.90	22.90
subsurface		17.60	7.60	25.20
without irrigation		8.60	5.50	14.00
$LSD_{\alpha=0.05}$ for:				
cultivation methods (A)		3.22	3.26	n.i.
irrigation (B)		4.91	n.i.	5.76
interaction A (B)		n.i.	n.i.	n.i.
B(A)		n.i.	n.i.	n.i.

(deformed, forked and small roots) in the cultivation on ridges being significantly lower than in flat cultivation. In the cultivation on flat ground there were twice as many misshapen roots as in the ridge cultivation. In both plant cultivation methods, surface and subsurface drip irrigation contributed to a significant increase in marketable and total yields of parsley roots in comparison with the non-irrigated treatment. No significant differences in yield were found between the surface-irrigated and the subsurface-irrigated parsley plants. In both flat and ridge cultivation there was a noticeable tendency towards achieving higher yields with surface drip irrigation than with subsurface irrigation. Drip irrigation did not have any effect on the size of non-marketable yield. DYŚKO and KANISZEWSKI (2007) found similar effects of the cultivation and irrigation methods on the yield of carrot plants. According to BŁAŻEWICZ-WOŹNIAK (1998), the total yield of parsley roots depends largely on the weather pattern during the vegetative period, especially on the moisture content of the soil. Compared to the cultivation on flat ground, parsley roots in the cultivation on ridges were found to be significantly longer. The average length of a parsley root was 21.38 cm in ridge cultivation and 17.26 cm in flat cultivation (Table 4).

Drip-irrigated parsley plants cultivated on ridges produced more slender roots than those cultivated without irrigation. There was a negative

Table 4

Influence of cultivation methods and drip irrigation on the length and dry matter content of parsley roots (2005–2007)

Cultivation methods	Irrigation treatments	Length of roots (cm)	Dry matter content of roots (%)
Ridges	subsurface	21.37	27.99
	surface	21.60	27.70
	without irrigation	21.17	26.99
	mean	21.38	27.56
Flat ground	subsurface	17.00	26.26
	surface	17.40	26.28
	without irrigation	17.37	27.31
	mean	17.26	26.62
$LSD_{\alpha=0.05}$ for:			
cultivation methods (A)		2.24	n.i.
irrigation (B)		n.i.	n.i.
interaction A(B)		n.i	n.i.
B(A)		n.i.	n.i.

correlation between root diameter and root length. As the length increased, there was a significant, linear decrease in the diameter of the roots of the plants that were irrigated and growing on ridges (Figure 1). On flat ground, however, irrigation contributed to a significant increase in the thickness of roots, which grew longer (Figure 2). In the cultivation

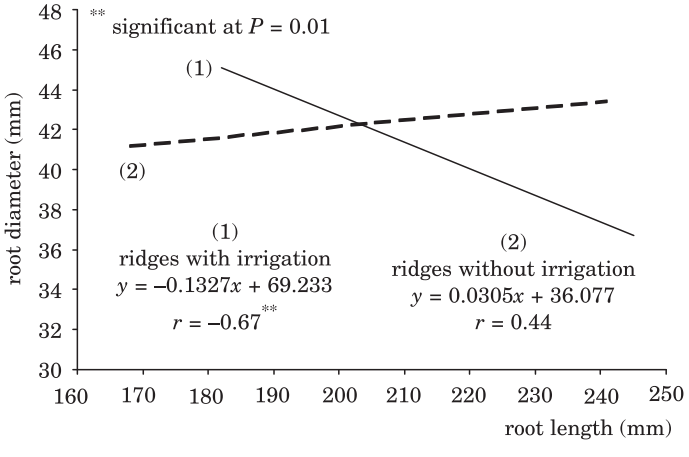

Fig. 1. Influence of drip irrigation of parsley cultivated on ridges on the root shape

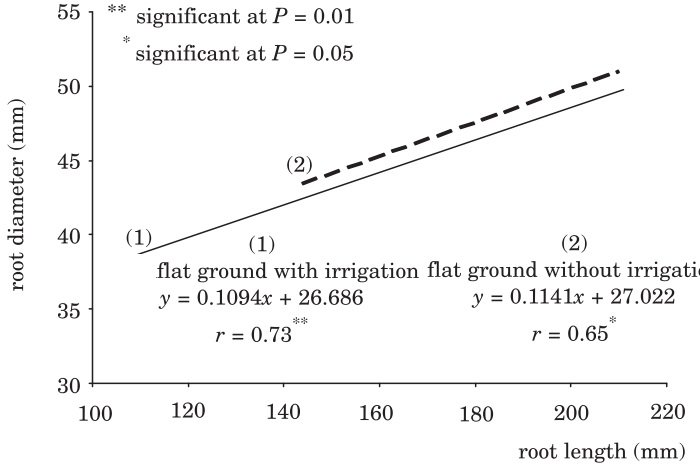

Fig. 2. Influence of drip irrigation of parsley cultivated on flat ground on the root shape

without irrigation, both on ridges (Figure 1) and on flat ground (Figure 2), as the length increased, the root diameter also increased significantly. This relationship was significant at $\alpha = 0.01$ for ridge cultivation, and at $P = 0.05$ for flat cultivation, and was rectilinear in character. In the estimation of BŁAŻEWICZ-WOŹNIAK (1998), the shape and length of parsley roots are greatly influenced by a soil tillage method prior to sowing, which changes soil density, porosity and compactness. Properly prepared ridges are able to maintain the same soil compactness across the entire profile, thus providing root vegetables with the right conditions to grow in (BABIK, DUDEK 2000). In experiments on carrot, it was found that carrot plants cultivated on ridges produced considerably longer roots than those cultivated traditionally on flat ground (DYŚKO, KANISZEWSKI 2007). The cultivation methods and the drip irrigation systems used in the experiment did not have a significant effect on dry matter content in parsley roots (Table 4). EVERS et al. (1997) found higher levels of dry matter in carrots cultivated on ridges compared to those grown on flat ground. In the experiment by ROLBIECKI and RZEKANOWSKI (1996), neither sprinkling nor drip irrigation reduced dry matter content in carrot roots. Different results, however, were obtained by DYŚKO and KANISZEWSKI (2007). Their experiment showed that dry matter content in carrot roots decreased significantly as a result of drip irrigation.

The plant cultivation methods used in this experiment did not have a significant effect on the concentration of minerals in parsley roots (Table 5). Drip irrigation, both surface and subsurface, brought about a decrease in the total nitrogen and potassium content, but did not affect the concentrations of phosphorus, magnesium or calcium in the roots. In the cultivation of carrot plants, drip irrigation was also found to reduce total nitrogen content in their storage roots (DYŚKO, KANISZEWSKI 2007).

Table 5

Influence of cultivation methods and irrigation on the content of macronutrients in parsley roots (2005–2007)

Cultivation methods	Irrigation treatments	Macronutrients ($g \cdot kg^{-1}$ d.m.)				
		N	P	K	Mg	Ca
Ridges	subsurface	12.8	2.74	26.09	2.42	2.95
	surface	13.6	2.78	24.39	2.64	2.98
	without irrigation	17.1	3.18	32.38	2.63	3.26
	mean	14.5	2.90	27.62	2.56	3.07
Flat ground	subsurface	13.6	2.97	24.93	2.43	2.86
	surface	13.2	3.03	25.81	2.49	3.17
	without irrigation	16.4	2.99	29.79	2.55	3.25
	mean	14.4	2.99	26.85	2.49	3.09
Mean for irrigation treatments						
subsurface		13.2	2.90	25.60	3.90	2.90
surface		13.4	2.90	25.10	2.60	3.10
without irrigation		16.8	3.10	31.10	2.60	3.30
$LSD_{\alpha=0.05}$ for:						
cultivation methods (A)		n.i.	n.i.	n.i.	n.i.	n.i.
irrigation (B)		2.4	n.i.	3.7	n.i.	n.i.
interaction A(B)		n.i.	n.i.	n.i.	n.i.	n.i.
B(A)		n.i.	n.i.	n.i.	n.i.	n.i.

CONCLUSIONS

1. Surface and subsurface drip irrigation used both on ridges and on flat ground caused a significant increase in the marketable yield of parsley roots.

2. In the cultivation of root parsley on ridges, the percentage of misshapen roots in the whole crop was half of that obtained in the cultivation on flat ground.

3. The method of laying irrigation drip lines (surface or subsurface) did not have a significant effect on the yield of parsley plants.

4. Longer roots of a better shape were obtained in the cultivation of parsley on ridges than on flat ground.

5. Surface and subsurface irrigation both resulted in a decrease in the total nitrogen content and potassium content in parsley roots.

REFERENCES

BABIK J., DUDEK J. 2000. *New, complex machine for ridge forming, and simultaneous sowing vegetable crops*. Veget. Crops Res. Bull., 53:103-110.

BŁAŻEWICZ-WOŹNIAK M. 1997. *Wpływ czynników agrotechnicznych na wschody, wzrost i plonowanie pietruszki korzeniowej, uprawianej na glebie zlewnej o nietrwałej strukturze.* Cz. I. *Wschody roślin.* Ann. UMCS, Sec. EEE, 5:117-127.

BŁAŻEWICZ-WOŹNIAK M. 1998. *Wpływ czynników agrotechnicznych na wschody, wzrost i plonowanie pietruszki korzeniowej, uprawianej na glebie zlewnej o nietrwałej strukturze.* Cz. III. *Plon korzeni i jego struktura*. Ann. UMCS, Sec. EEE, 6:73-87.

BŁAŻEWICZ-WOŹNIAK M. 2003. *Zmiany kształtu korzeni pietruszki pod wpływem uprawy zerowej i mulczów roślinnych*. Acta Agroph., 2(3):489-497.

DYŚKO J., KANISZEWSKI S. 2007. *Effect of drip irrigation, N- fertigation and cultivation methods on the yield and quality of carrot.* Veget. Crops Res. Bull., 67:25-33.

EVERS A. M., TUURI H., HÄGG M., PLAAMI S., HÄKKINEN U., TALVITIE H. 1997. *Soil forming and plant density effects on carrot yield and internal quality*. Plant Foods Human Nutrit., 51 (4): 283-294.

KANISZEWSKI S. 2006. *Nawadnianie warzyw*. W: *Nawadnianie roślin.* Red. S. KARCZMARCZYK, L. NOWAK, PWRiL, Warszawa, ss. 295-332.

ROLBIECKI S., RZEKANOWSKI CZ. 1996. *Wpływ nawadniania deszczownianego i kroplowego na niektóre cechy jakościowe plonu wybranych gatunków warzyw*. Zesz. Probl. Post. Nauk Rol., 438: 205-212.

RUMPEL J., KANISZEWSKI S. 1994: *Influence of nitrogen fertilization on yield and nitrate nitrogen content of turnip-rooted parsley.* Acta Hort., 371: 413-419.