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EFFECT OF WINTER HARDINESS ON HAMBURG PARSLEY (*Petroselinum crispum* (Mill.) Nyman ex A. W. Hill var. *tuberosum* (Bernh.) Mart. Crov.) YIELD QUALITY

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Abstract. Hamburg parsley is a vegetable that can overwinter in the field. One of the factors influencing surviving winter by plants is the selection of cultivar. In the experiment the relationship between winter hardiness of plants and the changes taking place in the structure of the yield obtained in spring was examined, in comparison to the crop harvested before winter, and Hamburg parsley cultivar. From among the plants of examined cultivars the winter conditions were best survived by 'Bubka', 'Ołomuńcka' and 'Vistula'. The yield harvested in spring, as compared to that obtained in autumn, did not depend of the plants' winter hardiness. Postponing the harvest term to spring decreased the quantities of obtained yields. From among the examined cultivars, only 'Vistula', 'Eagle' and 'Ołomuńcka' plants formed larger marketable yields of roots in spring. In the yield collected in spring there were more I class marketable roots (Ø 30–60 mm), and less small ones (Ø < 20 mm). The participation of bifurcated and rotted roots was also greater. Overwintering of plants caused the decrease of leaf yield quantity, with simultaneous improvement of marketable quality.

Key words: Cultivar, roots, leaves, yield structure, bifurcated roots, rotted roots

INTRODUCTION

Hamburg parsley is one of the most popular vegetables used as a condiment, garnish and flavoring ingredient [Freeman et al. 1975, Simon and Quinn 1988, Jabłońska-Ryś 2004]. However, parsley is characterized by worse storability than carrot, even in good storage conditions [Robak and Adamicki 2007, Gruszecki 2007a]. In the climatic conditions of Poland parsley can overwinter in the field. This facts is taken advantage of mainly in producing the seeds of this plant [Jędras 1989, 1991, Gruszecki 2000]. In this way Hamburg parsley can also be grown for an early harvest [Rumpel et al. 1995, Biesiada and Kołota 1996]. Overwintering of parsley plants depends first of all on the

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course of weather conditions [Jędras 1989, 1991, Gruszecki 2004]. One of the factors that determine the success of growing with overwintering of plants in the field is also the selection of appropriate cultivar [Michalik and Kabłak 1973, Tucker and Cox 1978, Kołota and Orłowski 1982, Kołota and Biesiada 1998, Gruszecki 2004]. The hitherto studies on winter hardiness of Hamburg parsley plants, which achieved the marketable size before winter, comprised a small number of cultivars [Jędras 1989, 1991, Gruszecki 2000]. The quantity of yield obtained from overwintering plants may depend on the applied cover and fertilization [Rumpel et al. 1995, Biesiada and Kołota 1996]. The relationship between root and leaf yield quantity and the cultivar in growing with overwintering of plants was presented by Rumpel et al. [1995], but only for two cultivars and one growing season. In the published works no characterization of obtained yield was encountered, which would comprise the structure of its both marketable and non-marketable parts, as well as changes caused by delayed harvest and overwintering of plants.

The aim of the presented studies was to determine the winter hardiness, as well as marketable quantity and quality of the yield harvested in spring, in relation to that obtained before winter.

MATERIAL AND METHODS

The experiment was conducted in the years 2004–2007 in the Agricultural Experimental Farm of the University of Natural Sciences in Lublin – Felin, on fallow soil of mechanical composition of light soil, comprising 1.5% organic matter. The plants were fertilized on the basis of chemical analysis of the soil to the level (in $mg \cdot dm^3$ of soil): N 80, P 100, K 250, applying ammonium nitrate, triple superphosphat and potassium sulfate. Nitrogen fertilization (50 kg $N \cdot ha^{-1}$ – calcium nitrate) was performed after vegetation started in spring. In the studies fifteen (in the 2004/2005 season – eleven) Hamburg parsley cultivars were studied: 'Alba', 'Aroma', 'Berlińska PNE', 'Brandenburska', 'Bubka', 'Cukrowa', 'Eagle', 'Gazela', 'Hamburska', 'Kaśka', 'Kinga', 'Lenka', 'Ołomuńcka', 'Omega', 'Vistula'. The studies were carried out in a randomised block design in four replications. The seeds, 2 $kg \cdot ha^{-1}$, were sown in the third decade of April (20^{th} April 2004, 29^{th} April 2005, 28^{th} April 2006), the spaces between rows of plants were 0.3 m, plot surface – 4.2 m^2. Parsley was cultivated in accordance to commonly accepted recommendations. Autumn harvest was performed in the second half of October (16^{th} of October 2004, 22^{nd} October 2005, 20^{th} October 2006), spring harvest was performed in the beginning of May (4^{th} May 2005, 5^{th} May 2006, 4^{th} May 2007). In autumn, after the soil froze and in spring, when vegetation started, the plants were counted. On the basis of differences in the number of plants before and after winter, the share of plants which had overwintered were counted. Immediately after harvest the obtained yield was assessed in accordance with the Polish Standard PN-R-75370 (1996). The regression equation and determination coefficients were calculated with the use of Excel '97 Microsoft Corp. computer program. The statistical analysis for growing seasons was performed with the removal of lacking data with cases. Results ob-

tained were statistically processed by calculating the confidence intervals according to Tukey's test at the level $\alpha = 0.05$.

RESULTS AND DISCUSSION

The examined growing seasons differed as to weather conditions. The lowest temperatures were reported in winter, in 2005/06 season, but the effect of these temperatures upon the plants was limited by snow precipitations. The highest temperatures in winter period were found in the 2006/07 season (fig. 1).

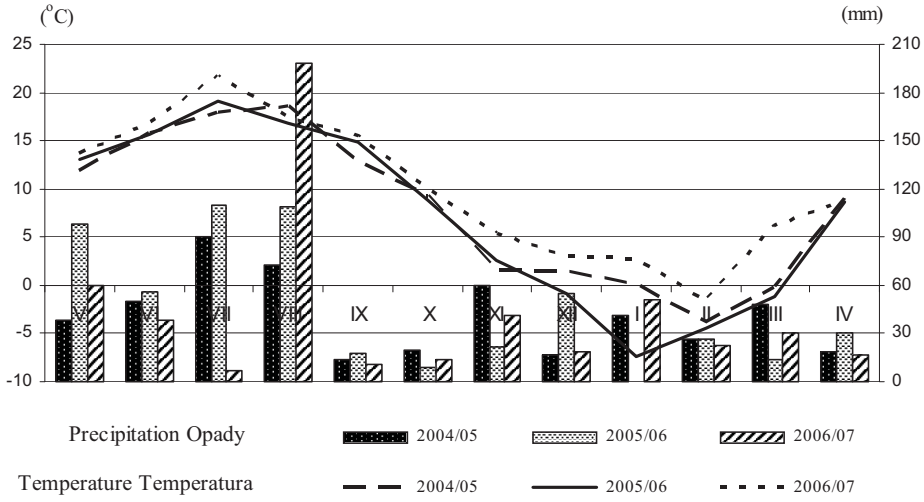

Fig. 1. Mean air temperature and precipitation for 2004–2007
Rys. 1. Przebieg warunków pogodowych w czasie doświadczenia

During the three study seasons the effect of weather conditions upon plant winter hardiness was found. It ranged from 77.1 (2004/05) to 85.0% (2006/07). These results confirm those obtained by Jędras [1989, 1991] and Gruszecki [2000, 2004]. They reported that winter hardiness of plants in particular growing seasons can be very differentiated. From among the plants of cultivars examined in the experiment the winter conditions were best survived by 'Bubka' (89.0%), 'Ołomuńcka' (86.0%) and 'Vistula' (85.6%), and the worst – by 'Lenka' (76.4%). However, these differences have not been significant (tab. 1). Jędras [1989, 1991] demonstrated that the effect of the cultivar upon winter hardiness of parsley plants is significant only in certain years. Gruszecki [2004] found the relationship between a cultivar and winter hardiness of parsley plants in younger growth phases.

Table 1. Effect of cultivar on winter hardiness of Hamburg parsley plants (%)
Tabela 1. Przezimowanie roślin pietruszki korzeniowej w zależności od odmiany (%)

Cultivar Odmiana	Growing season – Sezon uprawy			
	2004/2005	2005/2006	2006/2007	mean – średnio
'Alba'	80.5	77.5	76.7	78.2
'Aroma'		69.6	93.5	81.5
'Berlińska PNE'	67.8	89.9	77.6	78.4
'Brandenburska'	92.5	72.2	81.3	82.0
'Bubka'		88.2	89.8	89.0
'Cukrowa'	87.1	90.9	75.7	84.6
'Eagle'	75.5	83.5	79.2	79.4
'Gazela'		79.2	87.9	83.6
'Hamburska'	76.3	90.9	85.1	84.1
'Kaśka'		91.9	71.4	81.7
'Kinga'	63.6	80.8	93.1	79.2
'Lenka'	74.0	71.2	84.0	76.4
'Ołomuńcka'	81.0	83.0	94.0	86.0
'Omega'	71.6	85.4	94.0	83.7
'Vistula'	77.6	88.0	91.2	85.6
Mean – Średnio	77.0 A	82.8 B	85.0 B	

Table 2. Effect of cultivar on total yield of Hamburg parsley roots
Tabela 2. Plon ogólny korzeni pietruszki w zależności od odmiany

Cultivar Odmiana	Total yield – Plon ogólny ($t \cdot ha^{-1}$)				Compared to autumn harvest W porównaniu ze zbiorem jesiennym (%)			
	2004/05	2005/06	2006/07	mean średnio	2004/05	2005/06	2006/07	mean średnio
'Alba'	18.9 a-d	14.4 a-d	10.7 ab	14.7 bcd	73.7	75.7	64.9	71.4
'Aroma'		12.6 a-d	9.3 a	11.0 ab		68.6	54.5	61.6
'Berlińska PNE'	17.0 abc	15.9 cd	15.6 abc	16.2 cde	71.7	68.5	98.7	79.6
'Brandenburska'	26.5 d	9.5 a	13.7 ab	16.6 cde	97.1	57.5	107.9	87.5
'Bubka'		9.9 a	12.7 ab	11.3 ab		70.0	79.0	74.5
'Cukrowa'	18.2 abc	13.1 a-d	16.2 bc	15.9 cde	77.3	82.7	86.9	82.3
'Eagle'	19.0 bcd	16.9 d	13.3 ab	16.4 cde	110.1	97.3	87.3	98.3
'Gazela'		10.1 ab	17.3 bcd	13.7 abc		61.5	93.9	77.7
'Hamburska'	11.3 a	11.8 a-d	8.8 a	10.6 a	68.4	72.3	72.0	70.9
'Kaśka'		13.9 a-d	14.5 ab	14.2 a-d		78.2	87.3	82.8
'Kinga'	19.9 bcd	12.9 a-d	22.4 cd	18.4 e	98.8	91.3	127.4	105.8
'Lenka'	24.2 cd	15.3 bcd	11.4 ab	17.0 cde	110.2	76.5	73.6	86.8
'Ołomuńcka'	19.6 bcd	13.0 a-d	17.4 bcd	16.7 cde	106.9	96.9	137.0	113.6
'Omega'	13.3 bc	11.4 abc	10.6 ab	11.8 ab	72.2	85.1	85.7	81.0
'Vistula'	20.8 bcd	9.8 a	23.5 d	18.0 de	119.3	71.9	123.0	104.8
Mean – Średnio	19.0 C	12.7 A	14.5 B		91.4	76.9	91.9	

Biesiada and Kołota [2000, 2001] found a highest total yield of parsnip in spring, after overwintering than in autumn. In the analyzed studies the total yield of parsley roots, obtained in spring, was lower than that obtained in autumn, and its size depended on growing season. Lower, winter temperatures, of 2005/06 influenced larger yield decrease, as compared to the remaining growing seasons (2004/05 and 2006/07) (tab. 2).

The total yield depended on the cultivar. The highest total yield in spring was obtained from plants of 'Kinga' (18.4 t·ha^{-1}) and 'Vistula' (18.0 t·ha^{-1}) cultivars, and the lowest – from 'Hamburska' (10.6 t·ha^{-1}) and 'Aroma' (11.0 t·ha^{-1}) cultivars. The plants of the examined cultivars most often gave lower yield in spring. However, mean total yield of 'Ołomuńcka' (113.6%), 'Kinga' (105.8%) and 'Vistula' (104.8%) cultivars was higher than that harvested in autumn (tab. 2).

No dependence was found between winter hardiness of parsley plants and the quantity of total root yield obtained in spring, as compared to that harvested in autumn (fig. 2).

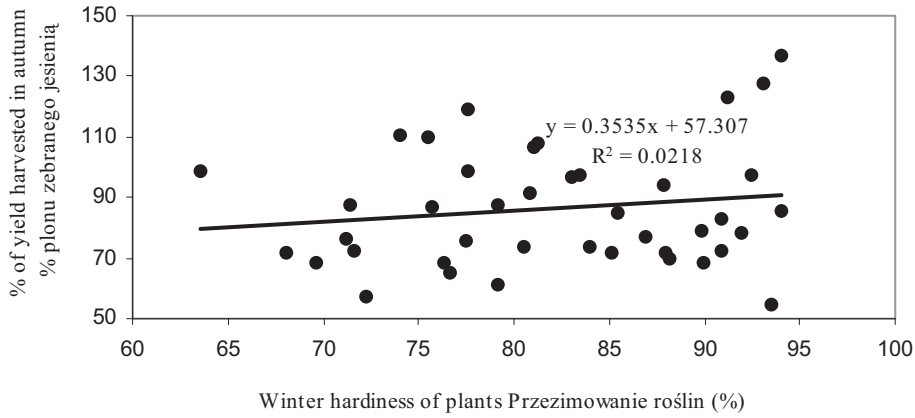

Fig. 2. Effect of winter hardiness on yield of 'Hamburg' parsley roots
Rys. 2. Plon pietruszki korzeniowej w zależności od przezimowania roślin

In the hitherto conducted studies the marketable Hamburg parsley root yield harvested in spring after overwintering ranged from 4.8 to 6.0 t·ha^{-1} in the region of central Poland [Rumpel et al. 1995] to 12.1–22.7 t·ha^{-1} in the south-eastern Poland [Biesiada and Kołota, 1996]. In this paper, depending on cultivar and growing season, from 4.0 t·ha^{-1} (Hamburska 2006/07) to 17.5 t·ha^{-1} ('Kinga' 2006/07) marketable roots were harvested. The highest marketable yield was collected in 2004/05 season (11.5 t·ha^{-1}), and the lowest –in the season with the most severe winter – 2005/06 (8.0 t·ha^{-1}). From among the examined plants the highest marketable yield was obtained from 'Kinga' (12.4 t·ha^{-1}), 'Vistula' (11.2 t·ha^{-1}), 'Lenka' (11.0 t·ha^{-1}) and 'Eagle' (10.7 t·ha^{-1}) cultivars. Mean marketable yield collected in spring was lower than that obtained in autumn, only in season 2004/05 most of the examined cultivars gave higher yields in spring. On average, from three growing seasons, higher marketable yield, as compared to harvests performed in autumn, was obtained only from plants of 'Vistula' (124.3%), 'Eagle' (108.2%) and 'Ołomuńcka' (106.5%) cultivars (tab. 3).

Table 3. Effect of cultivar on marketable yield of Hamburg parsley roots
Tabela 3. Plon handlowy pietruszki korzeniowej w zależności od odmiany

Cultivar Odmiana	Marketable yield – Plon handlowy (t·ha^{-1})				Compared to autumn harvest W porównaniu do zebranego jesienią (%)			
	2004/05	2005/06	200 6/07	mean średnio	2004/05	2005/06	2006/07	mean średnio
'Alba'	10.4 a-d	9.6 bc	6.4 abc	8.8 bc	98.1	66.5	56.3	73.6
'Aroma'		8.2 abc	5.6 abc	6.9 ab		58.0	60.5	59.2
'Berlińska PNE'	10.3 a-d	7.7 abc	9.3 cde	9.1 bc	98.8	42.5	67.2	69.5
'Brandenburska'	16.2 d	5.3 a	5.2 ab	8.9 bc	123.5	46.1	47.3	72.3
'Bubka'		6.6 ab	7.0 a-d	6.8 ab		64.9	57.0	61.0
'Cukrowa'	10.8 a-d	8.3 abc	10.4 def	9.8 c	102.8	70.9	94.4	89.4
'Eagle'	13.1 bcd	11.5 bc	7.6 a-e	10.7 cd	174.9	87.7	62.0	108.2
'Gazela'		5.8 ab	11.0 ef	8.4 abc		41.7	106.7	74.2
'Hamburska'	6.3 a	7.9 abc	4.0 a	6.0 a	122.5	58.7	51.4	77.6
'Kaśka'		9.1 abc	9.3 cde	9.2 bc		59.9	115.3	87.6
'Kinga'	10.1 abc	9.5 bc	17.5 g	12.4 d	72.6	82.2	134.9	96.6
'Lenka'	15.7 cd	9.3 bc	7.9 b-e	11.0 cd	147.3	58.6	76.6	94.2
'Ołomuńcka'	10.8 a-d	8.0 abc	10.8 def	9.9 cd	119.7	104.8	95.0	106.5
'Omega'	8.7 ab	6.4 ab	6.3 abc	7.1 ab	99.0	72.6	78.6	83.4
'Vistula'	13.6 bcd	6.1 ab	13.8 fg	11.2 cd	123.2	56.5	193.3	124.3
Mean – Średnio	11.5 C	8.0 A	8.8 B		116.6	64.8	86.4	

The share of marketable yield in the total yield did not depend on growing season.

Depending on cultivar, it ranged from 51.6% ('Brandenburska') to 67.7% ('Kinga'). It was found that the weather conditions and cultivar affect the share of marketable yield in the total yield harvested in spring, compared to that obtained in autumn (tab. 4).

Table 4. Effect of cultivar on share of marketable yield in total yield of Hamburg parsley roots (%)
Tabela 4. Udział plonu handlowego pietruszki korzeniowej w plonie ogólnym w zależności od odmiany (%)

Cultivar Odmiana	Share of marketable yield in total yield Udział plonu handlowego w plonie ogólnym				Compared to autumn harvest W porównaniu ze zbiorem jesiennym			
	2004/05	2005/06	2006/07	Mean Średnio	2004/05	2005/06	2006/07	Mean Średnio
'Alba'	55.3	66.5	60.4	60.7	14.4	-8.3	-9.4	-1.1
'Aroma'		65.1	60.2	62.7		-11.3	0.9	-5.2
'Berlińska PNE'	60.2	48.6	59.8	56.2	17.9	-30.5	-14.3	-9.0
'Brandenburska'	61.2	55.7	37.9	51.6	13.7	-12.4	-33.9	-10.9
'Bubka'		66.5	55.0	60.8		-6.4	-10.6	-8.5
'Cukrowa'	59.2	63.6	63.9	62.2	14.6	-10.7	-2.5	0.5
'Eagle'	68.9	67.9	57.5	64.8	25.6	-7.5	-13.1	1.7
'Gazela'		57.0	63.3	60.2		-27.7	-2.6	-15.1
'Hamburska'	55.8	66.5	45.2	55.8	11.8	-15.4	-16.6	-6.7
'Kaśka'		65.6	64.1	64.8		-20.3	-0.9	-10.6
'Kinga'	50.7	74.0	78.3	67.7	-4.6	-8.2	11.7	-0.4
'Lenka'	65.0	61.0	68.9	65.0	13.1	-18.7	8.8	1.0
'Ołomuńcka'	55.3	61.7	61.8	59.6	11.8	4.1	-9.7	2.0
'Omega'	65.0	56.5	59.5	60.3	17.9	-10.1	-7.6	0.1
'Vistula'	65.7	62.2	58.7	62.2	5.8	-16.8	0.3	-3.6
Mean – Średnio	60.2	62.6	59.6		12.9	-13.4	-6.6	

The yields of I class roots (Ø 30–60 mm), depending on growing season, amounted from 6.2 t·ha^{-1} (2005/06) to 9.7 t·ha^{-1} (2004/05). The highest yield of such roots was harvested from the plants of 'Kinga' (10.5 t·ha^{-1}) and 'Vistula' (9.8 t·ha^{-1}) cultivars, whereas the lowest – from Hamburska (4.7 t·ha^{-1}) and 'Aroma' (5.0 t·ha^{-1}). The quantity of I class yield after overwintering depended on the weather conditions course. The lowest yield (65.7%) was after winter during which the lowest temperatures were reported (2005/06). However, it was found that the I class marketable yield significantly increased in the season 2004/05, when the least plants survived winter (tab. 5).

Table 5. Effect of cultivar on I class yield of Hamburg parsley roots
Tabela 5. Plon korzeni I klasy pietruszki korzeniowej w zależności od odmiany

Cultivar Odmiana	I class yield – I class yield (t ha^{-1})				Compared to autumn harvest W porównaniu ze zbiorem jesiennym (%)			
	2004/05	2005/06	2006/07	mean średnio	2004/05	2005/06	2006/07	mean średnio
'Alba'	8.6 ab	7.2 abc	5.4 abc	7.1 bcd	257.7	67.4	66.7	130.6
'Aroma'		5.6 abc	4.3 ab	5.0 ab		57.4	78.9	68.1
'Berlińska PNE'	8.7 abc	7.0 abc	6.7 a-d	7.5 cd	163.7	44.0	67.8	91.8
'Brandenburska'	14.1 d	5.1 ab	4.5 ab	7.9 cde	183.2	47.6	58.3	96.4
'Bubka'		5.1 ab	5.7 a-d	5.4 abc		68.1	61.2	64.7
'Cukrowa'	9.4 bcd	7.2 abc	8.3 cd	8.3 def	141.0	74.9	106.1	107.3
'Eagle'	10.3 bcd	8.7 c	5.7 a-d	8.2 de	377.9	92.9	65.1	178.6
'Gazela'		4.5 ab	8.8 d	6.6 a-d		38.6	116.6	77.6
'Hamburska'	4.0 a	6.8 abc	3.5 a	4.7 a	156.5	56.6	75.7	96.3
'Kaśka'		7.3 abc	7.1 bcd	7.2 a-d		56.5	138.2	97.3
'Kinga'	8.7 abc	8.1 bc	14.6 e	10.5 f	101.7	91.4	220.1	137.7
'Lenka'	13.9 cd	6.0 abc	6.4 a-d	8.8 f	294.8	54.5	93.2	147.5
'Ołomuńcka'	7.9 ab	6.2 abc	8.1 cd	7.4 bcd	182.7	112.5	95.3	130.2
'Omega'	8.0 ab	4.3 a	4.3 ab	5.5 abc	199.3	69.6	61.4	110.1
'Vistula'	12.7 bcd	4.1 a	12.5 e	9.8 def	173.8	53.7	298.1	175.2
Mean – Średnio	9.7 C	6.2 A	7.1 B		202.9	65.7	106.9	

The share of rotted roots was on a similar level in all growing seasons and ranged from 12.4% (2006/07) to 13.8% of the total yield (2004/05 and 2005/06). Biesiada and Kołota [2000, 2001] did not demonstrate the effect of overwintering on parsnip rotted root yield. In the experiment it was found that there were big differences in the share of rotted roots, depending on cultivar (tab. 6). The highest share of such roots was in the yield of 'Brandenburska' (18.0%) and 'Hamburska (17.9%) cultivars, and the lowest – in 'Kinga' (9.7%), 'Kaśka' (10.1%) and 'Vistula' (10.3%). Only in the plants of 'Vistula' cultivar the lower share of such roots was found in the yield harvested in spring. Plants of the remaining cultivars were characterized by higher share of rotted roots in the yield harvested after overwintering (tab. 6). Many authors pay attention to differentiated susceptibility on root rotting of Hamburg parsley cultivars [Litka 1995, 1996, Nawrocki 1996, 2000, Nawrocki et al. 2001, Gruszecki 2007b].

Table 6. Effect of Hamburg parsley cultivar on share of rotted roots (% total yield)
Tabela 6. Udział korzeni z objawami chorobowymi w zależności od odmiany (% plonu ogółem)

Cultivar Odmiana	Rotted roots Korzenie z objawami chorobowymi				Compared to autumn harvest W porównaniu ze zbiorem jesiennym			
	2004/05	2005/06	2006/07	mean średnio	2004/05	2005/06	2006/07	mean średnio
'Alba'	13.1	12.8	9.1	11.7	3.0	10.1	3.0	5.3
'Aroma'		9.2	21.7	15.5		7.6	16.4	12.0
'Berlińska PNE'	11.2	17.8	5.8	11.6	-9.7	14.8	2.0	2.4
'Brandenburska'	12.7	21.7	19.5	18.0	-8.1	17.4	14.7	8.0
'Bubka'		14.2	15.8	15.0		3.0	12.9	7.9
'Cukrowa'	15.4	16.7	8.2	13.4	-3.7	13.1	7.4	5.6
'Eagle'	16.9	14.5	15.4	15.6	-5.6	7.7	15.0	5.7
'Gazela'		20.9	5.3	13.1		15.4	4.6	10.0
'Hamburska'	11.8	17.1	24.7	17.9	-6.9	10.8	20.9	8.3
'Kaśka'		11.5	8.8	10.1		8.7	0.0	4.4
'Kinga'	15.1	8.9	5.2	9.7	3.5	7.5	4.7	5.2
'Lenka'	11.7	9.1	11.7	10.8	-1.7	7.0	8.7	4.7
'Ołomuńcka'	22.1	12.2	13.7	16.0	-4.3	2.8	11.3	3.3
'Omega'	8.7	9.7	15.1	11.2	-2.8	0.3	13.4	3.6
'Vistula'	13.0	11.3	6.7	10.3	-6.2	8.5	-7.4	-1.7
Mean – Średnio	13.8	13.8	12.4		-3.9	9.0	8.5	

Bifurcation of parsley roots was the basic reason for the loss of their market value. The share of bifurcated roots in the total yield ranged, depending on growing season, from 16.8 (2005/06) to 21.7% (2004/05). Postponing the harvest term to spring affected the increase of the bifurcated roots' share in total yield. White and Strandberg [1979] proved that periodical of water saturated soil may increase the share of such roots. However, Biesiada and Kołota [2000, 2001] did not demonstrate the effect of parsnip plants winter hardiness upon the share of bifurcated roots. In the presented studies a relationship was found between cultivar and the share of bifurcated roots (tab. 7). The most of such roots there were in the yield of 'Brandenburska' plants (28.9%), the least – in 'Eagle' (10.6%). According to many authors, Hamburg parsley cultivars are characterized by differentiated aptness to forming bifurcated roots [Rumpel and Kaniszewski 1994, Litka 1995, 1996, Petropoulos et al. 2005, Gruszecki 2007b].

The share of small roots (Ø < 20 mm), depending on growing season, ranged from 4.3% to 6.8% of the total yield. The share of such roots was lower, on average by 4.0 (2005/06) to 18.6% (2004/05), depending on growing season, and by 4.7% ('Berlińska PNE') to 14.8% ('Alba'), depending on cultivar (tab. 8). In the yield harvested in spring, the highest share of small roots were found in the plants of 'Aroma' and 'Eagle' cultivars (9.0% each), and the smallest the yield of plants of 'Brandenburska' (1.6%). Biesiada and Kołota [2000, 2001] did not find a significant change in the small rots yield size after overwintering of parsnip plants.

The yield of Hamburg parsley leaves, harvested in autumn, most often ranges from 10.6 to 59.2 $t \cdot ha^{-1}$ [Błażewicz and Kęsik 1991, Kęsik et al. 1992, Konopiński and Kęsik 1992, Błażewicz-Woźniak 1997, Kmiecik and Lisiewska 1997, Gruszecki 2007c]. The yield of leaves from plants that had overwintered can be significantly lower. Rumpel et

Table 7. Effect of Hamburg parsley cultivar on share of bifurcated roots (% total yield)
Tabela 7. Udział korzeni rozwidlonych w zależności od odmiany (% plonu ogółem)

Cultivar Odmiana	Bifurcated roots Korzenie rozwidlone				Compared to autumn harvest W porównaniu ze zbiorem jesiennym			
	2004/05	2005/06	2006/07	mean średnio	2004/05	2005/06	2006/07	mean średnio
'Alba'	27.4	12.4	18.7	19.5	15.4	9.0	8.7	11.0
'Aroma'		14.8	10.9	12.8		8.1	-4.3	1.9
'Berlińska PNE'	25.6	32.9	22.4	27.0	5.0	17.6	12.2	11.6
'Brandenburska'	22.9	21.7	41.9	28.9	11.0	-2.4	28.9	12.5
'Bubka'		13.2	24.9	19.0		10.9	2.2	6.6
'Cukrowa'	22.5	15.1	20.5	19.4	2.1	5.8	3.8	3.9
'Eagle'	5.2	6.7	20.0	10.6	2.3	4.3	4.1	3.6
'Gazela'		21.5	26.5	24.0		13.1	9.5	11.3
'Hamburska'	22.9	13.1	27.3	21.1	19.1	4.0	9.5	10.9
'Kaśka'		17.8	20.6	19.2		12.0	12.8	12.4
'Kinga'	31.0	9.3	9.7	16.6	14.6	3.6	-3.8	4.8
'Lenka'	20.8	15.4	15.4	17.2	7.6	10.6	-5.8	4.1
'Ołomuńcka'	16.9	16.9	14.9	16.2	1.8	1.4	-4.9	-0.6
'Omega'	24.5	23.6	19.1	22.4	19.3	15.4	-12.9	7.3
'Vistula'	19.4	17.4	25.2	20.6	9.2	11.4	9.5	10.0
Mean – Średnio	21.7	16.8	21.2		9.8	8.3	4.6	

Table 8. Effect of Hamburg parsley cultivar on share of small roots (% total yield))
Tabela 8. Udział korzeni z małych w zależności od odmiany (% plonu ogólnego)

Cultivar Odmiana	Small roots – Korzenie małe				Compared to autumn harvest W porównaniu ze zbiorem jesiennym			
	2004/05	2005/06	2006/07	mean średnio	2004/05	2005/06	2006/07	mean średnio
'Alba'	4.2	8.3	11.8	8.1	-32.1	-9.8	-2.5	-14.8
'Aroma'		10.9	7.2	9.0		-3.8	-13.6	-8.7
'Berlińska PNE'	2.9	0.7	12.0	5.2	-11.8	-2.6	0.4	-4.7
'Brandenburska'	3.2	0.9	0.7	1.6	-16.0	-1.3	-9.4	-8.9
'Bubka'		6.1	4.3	5.2		-8.6	-3.7	-6.2
'Cukrowa'	2.9	4.6	7.4	5.0	-13.1	-8.3	-8.8	-10.0
'Eagle'	9.0	10.8	7.2	9.0	-22.3	-4.6	-6.4	-11.1
'Gazela'		0.7	4.9	2.8		-1.4	-11.1	-6.3
'Hamburska'	9.5	3.2	2.8	5.2	-23.3	0.7	-14.9	-12.5
'Kaśka'		5.1	6.5	5.8		-0.6	-11.6	-6.1
'Kinga'	3.2	7.8	6.8	6.0	-13.9	-3.0	-11.2	-9.4
'Lenka'	2.5	14.5	4.0	7.0	-18.1	1.0	-11.9	-9.6
'Ołomuńcka'	5.8	9.1	9.6	8.1	-11.5	-8.9	2.2	-6.1
'Omega'	1.8	10.2	6.3	6.1	-33.7	-6.1	3.1	-12.2
'Vistula'	1.9	9.2	9.4	6.8	-8.7	-3.0	-2.5	-4.7
Mean – Średnio	4.3	6.8	6.7		-18.6	-4.0	-6.8	

al. [1995] obtained in spring, from uncovered Hamburg parsley plants from 3.8 to 4.6 t·ha^{-1} of young tops, and Gruszecki [2004], obtained from late August sowing up to 7.8 t·ha^{-1} of leaves. In the experiment the yield of leaves harvested in spring ranged, depending on growing season, from 5.8 (2004/05) to 10.1 t·ha^{-1} (2006/07), which con-

stituted from 34.1 to 52.0% of the yield harvested in Autumn. Only the plants of 'Vistula' (11.3 t·ha^{-1}), 'Kaśka' and 'Ołomuńcka' cultivars (10.6 t·ha^{-1} each) gave the yield of leaves amounting, on average, more than 10 t·ha^{-1}, and were characterized by the lowest decrease of this yield after overwintering (tab. 9).

Table 9. Effect of cultivar on total yield of Hamburg parsley leaves
Tabela 9. Plon ogólny liści w zależności od odmiany

Cultivar Odmiana	Total yield – Plon ogólny (t·ha^{-1})				Compared to autumn harvest W porównaniu ze zbiorem jesiennym (%)			
	2004/05	2005/06	2006/07	mean średnio	2004/05	2005/06	2006/07	mean średnio
'Alba'	8.4 de	5.9 ab	7.5 ab	7.3 abc	35.2	25.5	45.0	35.2
'Aroma'		8.4 bcd	6.5 a	7.4 abc		39.1	26.6	32.8
'Berlińska PNE'	4.8 abc	6.3 abc	12.2 def	7.7 bc	21.3	29.6	68.7	39.9
'Brandenburska'	7.5 cde	4.8 bc	6.5 a	6.2 ab	36.4	33.9	51.4	40.6
'Bubka'		8.1 bcd	8.4 abc	8.2 bcd		51.2	52.4	51.8
'Cukrowa'	5.7 a-e	6.8 bcd	11.6 cde	8.0 bc	29.8	39.9	52.2	40.6
'Eagle'	2.6 a	6.8 bcd	8.5 a-d	6.0 ab	17.2	39.6	37.9	31.6
'Gazela'		2.4 a	12.1 c-f	7.2 abc		15.1	47.4	31.3
'Hamburska'	2.9 a	10.7 d	5.6 a	6.4 ab	22.7	70.0	35.7	42.8
'Kaśka'		10.4 cd	10.8 bcd	10.6 def		57.5	56.9	57.2
'Kinga'	5.4 a-d	5.7 ab	15.6 fg	8.9 cde	43.1	35.8	77.0	51.9
'Lenka'	6.8 b-e	8.6 bcd	7.4 ab	7.6 bc	42.3	39.7	48.4	43.5
'Ołomuńcka'	8.9 e	7.8 bcd	15.2 efg	10.6 ef	46.6	45.6	86.4	59.5
'Omega'	3.8 ab	7.1 bcd	5.1 a	5.3 a	28.2	39.4	26.9	31.5
'Vistula'	6.9 b-e	8.5 bcd	18.4 g	11.3 f	52.0	56.8	68.0	58.9
Mean – Średnio	5.8 A	7.2 B	10.1C		34.1	41.2	52.0	

Marketable yield of leaves, obtained in spring, was small, compared to that harvested in autumn – from 5.4 (2004/05) to 9.4 t·ha^{-1} (2006/07). The greatest marketable yield was harvested after winter with the highest mean temperatures (2006/07). The weather conditions as a factor influencing marketable yield of leaves are also emphasized by Gruszecki [2004]. He also demonstrated the relationship between marketable yield of leaves, after winter, and cultivar. The relationship between the quantity of marketable yield of leaves and cultivar was confirmed in the presented paper. Marketable yield, on average from three study seasons, in the plants of 'Vistula' cultivar, was 10.7 t·ha^{-1}, whereas from 'Omega' only 5.1 t·ha^{-1} leaves were harvested. On average, the spring-harvested marketable yield constituted from 40.4 (2004/05) to 59.8% (2006/07) of the yield obtained in autumn. In all the cultivars the spring-harvested marketable yield of leaves was smaller than in autumn. Change of harvest term affected the marketable yield of leaves of 'Vistula', 'Ołomuńcka' and 'Kaśka' the least (tab. 10). Other authors also found the relationship between yield of leaves and harvest term [Andruszczak 2007]

Table 10. Effect of cultivar on marketable yield of Hamburg parsley leaves
Tabela 10. Plon handlowy liści pietruszki korzeniowej w zależności od odmiany

Cultivar Odmiana	Marketable yield – Plon handlowy (t ha^{-1})				Compared to autumn harvest W porównaniu ze zbiorem jesiennym (%)			
	2004/05	2005/06	2006/07	mean średnio	2004/05	2005/06	2006/07	mean średnio
'Alba'	7.9 b	5.6 a-d	7.3 abc	7.0 abc	40.2	29.3	55.0	41.5
'Aroma'		8.1 bcd	5.8 a	7.0 abc		44.7	31.0	37.8
'Berlińska PNE'	4.4 ab	5.8 abc	11.3 def	7.2 abc	24.9	33.3	83.3	47.2
'Brandenburska'	6.6 ab	4.6 ab	6.2 a	5.8 ab	40.1	45.5	60.5	48.7
'Bubka'		7.8 bcd	7.8 a-d	7.8 b-e		66.9	57.7	62.3
'Cukrowa'	5.3 ab	6.5 bcd	11.0 c-f	7.6 bcd	34.3	46.7	61.6	47.5
'Eagle'	2.5 a	6.5 bcd	7.9 a-d	5.6 ab	20.0	56.1	41.6	39.2
'Gazela'		2.3 a	11.5 ef	6.9 abc		21.7	52.4	37.1
'Hamburska'	2.6 a	10.1 d	5.2 a	6.0 abc	27.0	79.3	40.3	48.9
'Kaśka'		9.7 cd	10.1 b-e	9.9 def		78.1	64.7	71.4
'Kinga'	5.1 ab	5.5 ab	13.5 ef	8.0 cde	53.1	45.3	76.7	58.4
'Lenka'	6.5 ab	8.4 bcd	6.9 ab	7.2 bc	52.2	55.9	54.1	54.1
'Ołomuńcka'	8.4 b	7.6 bcd	13.8 f	9.9 ef	54.8	63.3	101.9	73.4
'Omega'	3.6 a	6.8 bcd	4.8 a	5.1 a	33.2	58.4	33.2	41.6
'Vistula'	6.5 ab	8.1 bcd	17.5 g	10.7 f	64.3	82.2	82.8	76.4
Mean – Średnio	5.4 A	6.9B	9.4 C		40.4	53.8	59.8	

Table 11. Effect of cultivar on share of marketable yield in total yield of leaves (%)
Tabela 11. Udział plonu handlowego liści w plonie ogólnym w zależności od odmiany (%)

Cultivar Odmiana	Share of marketable yield in total yield Udział plonu handlowego w plonie ogólnym				Compared to autumn harvest W porównaniu ze zbiorem jesiennym			
	2004/05	2005/06	2006/07	mean średnio	2004/05	2005/06	2006/07	mean średnio
'Alba'	94.3	95.4	97.8	95.8	11.8	12.5	17.7	14.0
'Aroma'		96.5	90.4	93.5		12.2	12.7	12.4
'Berlińska PNE'	93.1	92.2	92.9	92.7	13.4	10.3	16.3	13.3
'Brandenburska'	88.7	96.6	95.0	93.5	8.0	24.5	14.4	15.6
'Bubka'		96.6	92.7	94.6		22.7	8.6	15.6
'Cukrowa'	93.3	95.1	94.5	94.3	12.4	13.9	14.4	13.6
'Eagle'	94.8	94.6	92.6	94.0	13.2	27.9	8.2	16.4
'Gazela'		93.8	95.7	94.8		28.6	9.1	18.8
'Hamburska'	90.2	94.8	92.4	92.4	14.4	11.1	10.5	12.0
'Kaśka'		94.1	93.5	93.8		24.8	11.3	18.1
'Kinga'	93.9	96.1	86.6	92.2	17.8	20.3	-0.4	12.6
'Lenka'	95.6	97.6	93.6	95.6	18.2	28.2	9.9	18.8
'Ołomuńcka'	93.7	96.7	91.3	93.9	14.0	27.1	13.9	18.4
'Omega'	94.6	95.6	94.8	95.0	14.3	31.2	17.8	21.1
'Vistula'	93.7	96.0	95.0	94.9	18.0	29.6	17.1	21.5
Mean – Średnio	93.3	95.4	93.2		14.1	21.7	12.1	

After overwintering, the yield of leaves was characterized by very good quality, irrespective of the course of weather conditions and cultivar. The share of marketable yield in total yield, depending on growing season, was greater by 12.1 to 21.7%, compared to

that harvested in autumn. Depending on cultivar, the share of marketable yield in the total yield of leaves increased by 12.0 (‘Hamburska’) – 21.5% (‘Vistula’) (tab. 11).

CONCLUSIONS

1. Winter hardiness of Hamburg parsley plants depended on the weather conditions course. No dependencies were found between cultivar and overwintering of Hamburg parsley plants.

2. Winter hardiness of plants did not affect the root yield quantity.

3. Total root yield harvested in spring was, in most cultivars, smaller, as compared to that obtained in autumn. Only the plants of ‘Ołomuńcka’, ‘Kinga’ and ‘Vistula’ cultivars gave larger root yield when harvesting was conducted in spring.

4. Marketable yield of parsley roots after overwintering was smaller than that collected in autumn. However, from plants of ‘Vistula’, ‘Eagle’ and ‘Ołomuńcka’ cultivars larger root yield was obtained in spring.

5. Most frequently larger yield of I class roots was found during spring harvests. However, after the most severe winter (2005/06) the yield of such roots was smaller than in autumn.

6. After overwintering of Hamburg parsley plants the share of small roots in the yield decreased, whereas the share of bifurcated and rotted roots increased.

7. After overwintering, smaller total yield of leaves was collected from Hamburg parsley plants, but the participation of marketable yield was greater.

REFERENCES

Andruszczak S., 2007. The effect of the method of plantation establishment and harvesting time on some morphological features of plants and essential oil content in lovage roots (*Levisticum officinale* Koch.). Acta Sci. Pol., Hortorum Cultus, 6(1), 21–27.

Biesiada A., Kołota E., 1996. Wpływ nawożenia mineralnego na plonowanie, trwałość w przechowywaniu oraz przezimowanie w polu pietruszki korzeniowej. Mat. Konf. nt. „Przechowywanie i obrót produktami ogrodniczymi”, Kraków, 56–60.

Biesiada A., Kołota E., 2000. Overwintering of parsnip (*Pastinaca sativa* L.) in relation to mineral fertilization and agrotextile cover. *Umbelliferae* Improv. Newslet.. Univ. Wisc., 10, 21–24.

Biesiada A., Kołota E., 2001. Wpływ dawki oraz sposobu nawożenia N i K na zimotrwałość pasternaku pod płaskim okryciem włókniną. Annales UMCS Sect. EEE, 9, Supl., 41–47.

Błażewicz M., Kęsik T., 1991. Wpływ głębokości siewu oraz zastosowania substancji zmniejszających zaskorupienie gleby na wschody, wzrost i plony pietruszki. Mat. Konf. Ogólnopol. Zjazdu Hod. Rośl. Warz., Kraków 5–6 lutego, 115–118.

Błażewicz-Woźniak M., 1997. Wpływ czynników agrotechnicznych na wschody, wzrost i plonowanie pietruszki korzeniowej, uprawianej na glebie zlewnej o nietrwałej strukturze. Część II. Wzrost i plon liści. Annales UMCS Sec. EEE, 5, 117–127.

Freeman G.G., Whenham R.J., Self R., Eagles J., 1975. Volatile flavour components of parsley leaves (*Petroselinum crispum* (Mill.) Nyman). J. Sci. Food Agric., 26, 465–470.

Gruszecki R., 2000. Wpływ terminu siewu na wielkość i jakość plonu nasion pietruszki korzeniowej uprawianej metodą bezwysadkową. Roczniki AR Pozn. Ogrodnictwo 31, 289–293.

Gruszecki R., 2004. Effect of cultivar on early yield of parsley grown from the late summer sowing. Folia Hort., 16, 2, 27–32.

Gruszecki R., 2005. Ocena wybranych odmian pietruszki korzeniowej uprawianych w warunkach Lubelszczyzny. W monografii „Zmienność genetyczna i jej wykorzystanie w hodowli roślin ogrodniczych". Wyd. ISK Skierniewice, 107–111.

Gruszecki R., 2007a. The effect of the method of leaves removing on storage ability of 'Hamburg' parsley. Veg. Crops Res. Bull., 66, 79–83.

Gruszecki R., 2007b. Wpływ odmiany na wielkość i jakość plonu pietruszki korzeniowej (*Petroselinum crispum* (Mill.) Nyman ex A.W. Hill var. *tuberosum* (Bernh) Mart. Crov.). Część I. Plon korzeni. Annales UMCS, Sec. EEE, 17, 27–34.

Gruszecki R., 2007c. Wpływ odmiany na wielkość i jakość plonu pietruszki korzeniowej (*Petroselinum crispum* (Mill.) Nyman ex A.W. Hill var. *tuberosum* (Bernh) Mart. Crov.). Część II. Plon liści. Annales UMCS, Sec. EEE, 17, 35–40.

Jabłońska-Ryś E., 2004. Wpływ blanszowania na zawartość związków terpenowych w wybranych odmianach pietruszki korzeniowej (*Petroselinum crispum*). Annales UMCS, Sec. E, Agricultura 59, 4, 2039–2044.

Jędras L., 1989. Termin siewu pietruszki nasiennej przy uprawie bezwysadkowej. Biul. Warz. Supl., II, 67–70.

Jędras L., 1991. Wpływ terminu siewu na wysokość i jakość plonu nasion trzech odmian pietruszki uprawianej systemem bezwysadkowym. Biul. Warz. 37, 109–118.

Kęsik T., Konopiński M., Błażewicz-Woźniak M., 1992. Wpływ niektórych zabiegów agrotechnicznych na plonowanie korzeniowych roślin warzywnych. Mat. Konf. II Ogólnopol. Zjazd Hodow. Rośl. Ogrod., Lublin, 137–140.

Kmiecik W., Lisiewska Z., 1997. Badania nad plonowaniem i jakością plonów liści pietruszki. Ogólnop. Konf. nt. „Produkcja warzyw do przetwórstwa", Skierniewice 13–14 listopada, 59–62.

Kołota E., Biesiada A., 1998. Wpływ zabiegów agrotechnicznych na plonowanie wybranych gatunków warzyw polowych w uprawie na zbiór wczesny w świetle wyników badań własnych. Zesz. Nauk. ATR Bydg. Rolnictwo 42, 11–18.

Kołota E., Orłowski M., 1982. Możliwości uprawy marchwi z siewu wrześniowego na zbiór wczesny. Biul. Warz., 26, 53–64.

Konopiński M., Kęsik T., 1992. Plonowanie czterech polskich odmian pietruszki korzeniowej na tle zróżnicowanej normy i głębokości wysiewu nasion. Mat. Konf. II Ogólnopol. Zjazd Hodow. Rośl. Ogrod., Lublin 1992, 133–136.

Litka M., 1995. Warzywa korzeniowe – marchew jadalna, burak ćwikłowy, pietruszka korzeniowa, seler korzeniowy. Synteza wyników doświadczeń odmianowych. COBORU Słupia Wielka, 1052.

Litka M., 1996. Warzywa korzeniowe – marchew jadalna, burak ćwikłowy, pietruszka korzeniowa, seler korzeniowy. Synteza wyników doświadczeń odmianowych. COBORU Słupia Wielka, 1085.

Michalik B., Kabłak J., 1973, Wstępne badania nad przyspieszeniem rozwoju generatywnego marchwi jadalnej. Hod. Rośl. Aklim. Nasien, 17, 4, 255–270.

Nawrocki J., 1996. Podatność odmianowa korzeni wysadkowych pietruszki na porażenie przez patogeny grzybowe. Mat. Konf. VI Ogólnopol. Zjazd Hodow. Rośl. Ogrod. nt. „Hodowla roślin o podwyższonej jakości, Kraków 15–16 lutego, 404–406.

Nawrocki J., 2000. Ocena zdrowotności kilku odmian pietruszki korzeniowej. Zesz. Nauk. AR Krak. Ogrod. 364, 349–352.

Nawrocki J., Mazur S., Kućmierz J., 2001. Nawożenie mineralne a zdrowotność korzeni wysadkowych pietruszki. Mat. Konf. nt. „Biologiczne i agrotechniczne kierunki rozwoju warzywnictwa". Skierniewice 21–22 czerwca, 162–163.

Petropoulos, S.A., Akoumianakis, C.A., Passam, H.C., 2005. Effect of sowing date and cultivar on yield and quality of turnip-rooted parsley (*Petroselinum crispum* ssp *tuberosum*). J. Food Agric. Environ. 3 (2), 205–207.

Polska Norma PN-R-75370. 1996. Pietruszka korzeniowa.

Robak J., Adamicki F., 2007. The effect of pre-harvest treatment with fungicide on the storage potential of root vegetables. Veg. Crop Res. Bull., 67, 187–196.

Rumpel J., Grudzień K., Borkowski J., 1995. Zimowanie warzyw pod osłoną z włókniny. Mat. Konf. nt. „Nauka Praktyce Ogrodniczej". Lublin 14–15 września, 687–690.

Rumpel J., Kaniszewski S., 1994. Influence of nitrogen fertilization on yield and nitrate nitrogen content of turnip-rooted parsley. Acta Hort., 371, 413–419.

Simon J.E., Quinn J., 1988. Characterization of essential oil of parsley. J. Agric. Food Chem. 36, 467–472.

Tucker W.G., Cox C.J., 1978. Studies on the overwinter losses of carrots stored in situ. J. Hort. Sci., 53, 4, 291–294.

White J.M., Strandberg J.O., 1979. Physical factors affecting carrot root growth: water saturation of soil. J. Am. Soc. Hort. Sci., 104, 3, 414–416.

WPŁYW ZIMOWANIA ROŚLIN NA JAKOŚĆ PLONU PIETRUSZKI KORZENIOWEJ (*Petroselinum crispum* (Mill.) Nyman ex A. W. Hill var. *tuberosum* (Bernh.) Mart. Crov.)

Streszczenie. Pietruszka korzeniowa należy do warzyw które mogą zimować w polu. Jednym z czynników wpływających na zimotrwałość roślin jest dobór odmiany. W doświadczeniu badano zależność pomiędzy przezimowaniem roślin i zmianami zachodzącymi w strukturze plonu uzyskanego wiosną, w porównaniu z zebranym przed nastaniem zimy, a odmianą pietruszki korzeniowej. Spośród roślin badanych odmian najlepiej warunki panujące zimą znosiły 'Bubka', 'Ołomuńcka' i 'Vistula'. Plon zebrany wiosną, w porównaniu z otrzymanym jesienią, nie był uzależniony od przezimowania roślin. Przesunięcie terminu zbioru na wiosnę wpływało na zmniejszenie wielkości uzyskiwanych plonów. Spośród badanych odmian jedynie rośliny 'Vistula', 'Eagle' i 'Ołomuńcka' wytwarzały wiosną większy plon handlowy korzeni. W plonie zebranym wiosną więcej było korzeni handlowych I klasy (Ø 30–60 mm), a mniej małych (Ø < 20 mm). Większy był też udział korzeni rozwidlonych i z objawami chorobowymi. Zimowanie roślin powodowało zmniejszenie wielkości plonu liści przy jednoczesnej poprawie jego jakości handlowej.

Słowa kluczowe: odmiana, korzenie, liście, struktura plonu, korzenie rozwidlone, korzenie z objawami chorobowymi

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