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EFFECT OF THE TERM OF HARVEST ON YIELD AND NUTRITIONAL VALUE OF SPINACH BEET

Kamila Czerniak, Eugeniusz Kołota

Chair of Horticulture
Wroclaw University of Environmental and Life Sciences

Abstract

In a field experiment conducted in 2004-2006, the influence of the harvest term on yield and crop quality of cv. Lukullus Spinach beet was examined. Seeds were sown to the field in the second decade of April and after thinning left at a spacing 45x25 cm. First harvest of leaves was conducted in mid-July and 2 subsequent harvests occurred in two week's intervals. The content of dry matter, vitamin C, phosphorus, potassium, calcium and magnesium were determined in samples of leaf blades and petioles.

The results proved that the yield of Spinach beet increased from 42.46 $t \cdot ha^{-1}$ in the first term of harvest to 72.04 $t \cdot ha^{-1}$ and 105.61 $t \cdot ha^{-1}$ in the subsequent terms. Delayed harvest date appeared to be beneficial for the content of dry matter and vitamin C, and resulted in the decrement of the amounts of potassium and magnesium as well as in the accumulation of nitrates in plants. Plants harvested later also contained a lower level of phosphorus in leaf blades.

Generally, higher amounts of dry matter, potassium and magnesium were observed in leaf blades, while petioles contained more phosphorus, calcium and nitrates.

Key words: Spinach beet, term of harvest, yield, nutritional value.

WPŁYW TERMINU ZBIORU NA PLON I WARTOŚĆ ODŻYWCZĄ BURAKA LIŚCIOWEGO

Abstrakt

W latach 2004-2006 badano wpływ terminu zbioru na wielkość i jakość plonu buraka liściowego odmiany Lukullus. Nasiona wysiewano w drugiej dekadzie kwietnia i po przerywce pozostawiono w rozstawie 45x25 cm. Pierwszy zbiór roślin przeprowadzono w drugiej dekadzie lipca,

mgr inż. Kamila Czerniak, Chair of Horticulture, Wroclaw University of Environmental and Life Sciences, pl. Grunwaldzki 24A, 50-363 Wrocław

a kolejne dwa w odstępach dwutygodniowych. Podczas zbioru pobierano oddzielnie próby liści i ogonków liściowych, w których oznaczano zawartość suchej masy, azotanów, witaminy C, P i Mg, K i Ca. Wyniki badań poddano analizie statystycznej za pomocą testu *t*-Duncana na poziomie istotności α=0,05.

Wykazano, że w miarę opóźniania terminu zbioru plon buraka liściowego wzrastał średnio z 42,46 $t \cdot ha^{-1}$ w pierwszym terminie do 72,04 $t \cdot ha^{-1}$ po dwóch tygodniach i do 105,61 $t \cdot ha^{-1}$ przy zbiorze najpóźniejszym. Zarówno w blaszkach, jak i ogonkach liściowych zawartość azotanów, potasu i magnezu oraz fosforu w blaszkach liściowych zmniejszała się w miarę opóźniania terminu zbioru. Przedłużenie okresu uprawy przyczyniło się do wzrostu zawartości suchej masy zarówno w blaszkach, jak i ogonkach liściowych, a także witaminy C w blaszkach liściowych.

W blaszkach liściowych buraka liściowego stwierdzono większe nagromadzenie suchej masy, K i Mg, natomiast w ogonkach liściowych – większą zawartość P, Ca i azotanów.

Słowa kluczowe: burak liściowy, termin zbioru, plon, wartość odżywcza.

INTRODUCTION

Many species of vegetables, including Spinach beet, can be harvested at various phases of maturity which depends on requirements of the selling market and consumer preferences. Delayed vegetable harvesting time usually entails higher crop yields as well as changes in chemical composition. This, however, does not always result in improved nutritional value. Some research conducted on this subject has demonstrated that as the harvest time was postponed, dry matter content increased in leek and kohlrabi but decreased with zucchini fruits (Biesiada et al. 2007). Earlier harvest time had a favourable effect on the level of vitamin C, as well phosphorus and potassium, but involved higher accumulation of nitrates (Bohner et al. 2005, Kozik 2006).

The goal of the research was to determine the effect of harvest time on crop yield and nutritious values of Spinach beet (*Beta vulgaris* L. var. *cicla* L.).

MATERIAL AND METHODS

Field experiments were carried out in 2004-2006 in the Vegetable and Ornamental Plants Research Station of the Department of Horticulture in Wrocław University of Environmental and Life Science, on soil containing 60 mg $P \cdot dm^{-3}$ and 200 mg $K \cdot dm^{-3}$. Pre-sowing fertilization with nitrogen at 150 kg $N \cdot ha^{-1}$ was applied. Seeds of cv. Lukullus were sown in the second decade of April at a spacing 45x25 cm. After emergence, at the phase of 2-4 true leaves, thinning was completed with one plant left in each spot. The first harvest of the plants was conducted in the second decade of July, and two subsequent harvests were conducted at two weeks' intervals.

Whole leaves (blades and petioles) were recognized as marketable yield of plants. During the harvest, samples of edible parts were taken for determinations of dry matter (drying at 105°C), nitrates (reflectometric method), vitamin C (Tillmans's method), P and Mg (colorimetric method), K and Ca (photometric method). Results of the study were evaluated statistically using the t-Duncan's test at the significance level α=0.05.

RESULTS AND DISCUSSION

Crops of Spinach beet in subsequent years of the experiments were considerably dependent on the harvesting time. As means for the 3 year period, the plants picked up in the earliest term yielded at the level of 42.46 t·ha^{-1}. Delaying the harvest by two and four weeks caused essential growth of the crop quantity up to 72.04 t·ha^{-1}, to 105.61 t·ha^{-1} (Table 1). Similar dependencies were found by DYDUCH and JANOWSKA (2004) in leafy parsley and by REKOWSKA and SŁODKOWSKI (2005) in corn salad.

Upon the data of chemical analysis for the three years of experiments, it can be concluded that average dry matter contents in leaf blades was much higher than in petioles (Table 1). Similar dependencies were indicated by DYDUCH and NAJDA (2005) as well as by KMIECIK et al. (2005) in their research on celery and dill. It was observed that along with a delay of harvesting time, the level of dry matter was increasing considerably both in blades and leaf petioles. In leaf blades its level was growing from 10.93% to 15.09%, and in leaf petioles from 7.42% to 9.61%. Significantly the highest dry matter contents appeared in leaf blades of plants picked up in 2006 in the second and third term of harvest (15.51% and 16.17% respectively), and the lowest one also in 2006 in plants collected in the first term (9.60%).

Evaluation of the nitrate level in leaf blades and petioles demonstrated considerable differences between the harvesting times (Table 1). Significantly the highest quantities of nitrates appeared in leaf blades of plants picked up the earliest term (869 mg·kg^{-1} fresh weight). In plants from the remaining two harvest times, no significant differentiation in contents of nitrates was observed, as they equalled 420 and 276 mg·kg^{-1} fresh matter respectively. On average, in 2004-2006, the lowest level of nitrates in leaf blades was determined in plants picked in 2005 in the third term (160 mg·kg^{-1} fresh weight), and the highest one in plants harvested in 2004 in the first term (1260 mg·kg^{-1}). Similarly to the blades, a significant effect of the harvest time on nitrate level was observed in leaf petioles. In plants picked in the earliest date, their level was the highest (4079 mg·kg^{-1} fresh weight), being much lower for the second term harvest (3348 mg·kg^{-1}), and the lowest in plants picked in the third term

Table 1

Yield of Spinach beet and content of dry matter and NO_3-N in relation to the term of harvest (mean for 2004-2006)

Year	Term of harvest	Yield ($t \cdot ha^{-1}$)	Dry matter (%)		NO_3-N ($mg \cdot kg^{-1}$ f.w.)		Vitamin C ($mg \cdot 100\ g^{-1}$ f.w.)
			blades	petioles	blades	petioles	blades petioles
2004	I	36.24	11.47	7.52	1260	3953	49.52
	II	62.23	12.19	8.21	379	2445	51.07
	III	99.67	15.33	9.44	277	878	53.75
		66.05	13.00	8.39	639	2425	51.45
2005	I	45.42	11.73	7.58	540	3383	29.60
	II	75.57	13.35	9.20	330	3300	30.91
	III	110.52	13.78	9.58	160	463	44.55
		77.17	12.95	8.79	343	2382	35.02
2006	I	45.73	9.60	7.14	808	4900	35.00
	II	78.32	15.61	9.13	550	4300	36.50
	III	106.62	16.17	9.81	390	1000	43.33
		76.89	13.79	8.69	583	3400	38.28
Mean	I	42.46	10.93	7.42	869	4079	38.04
	II	72.04	13.72	8.85	420	3348	39.49
	III	105.61	15.09	9.61	276	780	47.21
		73.37	13.25	8.63	522	2736	41.58
LSDα=0.05 for:							
term of harvest		16.18	1.00	1.06	181	424	4.20
years		n.s.	n.s.	n.s.	181	424	4.20
interaction (I x II)		n.s.	1.73	n.s.	314	734	n.s.

(780 $mg \cdot kg^{-1}$ fresh weight). Significantly lower contents of nitrates in leaf petioles was observed in plants grown in 2004–2005 (2425 and 2382 $mg \cdot kg^{-1}$ fresh weight), and the higher in 2006 (3400 $mg \cdot kg^{-1}$). The results confirm research by other authors, who proved that the nitrate level decreases along with a delay of the harvest time (Bohner et al. 2005, Kozik 2006), and accumulation of nitrates in leaf petioles is usually much higher than in blades (Kmiecik et al 2005).

The harvest time delay had a significant effect on the contents of vitamin C in leaf blades of Spinach beet. Plants picked in the latest term demonstrated a higher level of vitamin C (47.21 $mg \cdot 100\ g^{-1}$ fresh weight) than those in the remaining periods (38.04-39.49 $mg \cdot 100\ g^{-1}$ fresh weight).

Table 2

Content of P, K, Ca and Mg in blades and petioles of Spinach beet ($g \cdot kg^{-1}$) in relation to the term of harvest, mean for 2004–2006

Year	Term of harvest	P		K		Ca		Mg	
		blades	petioles	blades	petioles	blades	petioles	blades	petioles
2004	I	3.9	4.0	79.7	79.7	1.0	1.9	6.3	3.1
	II	3.9	3.6	49.4	74.6	1.1	1.3	4.3	3.0
	III	3.8	4.4	57.6	43.2	1.1	1.4	4.0	2.1
		3.8	4.0	62.3	65.8	1.1	1.5	4.8	2.7
2005	I	4.3	3.8	42.2	43.7	0.8	1.0	7.9	2.9
	II	3.0	3.1	57.2	42.5	1.1	1.5	6.0	2.2
	III	2.4	2.9	43.1	36.8	1.0	1.6	4.5	1.9
		3.2	3.2	47.5	41.0	1.0	1.4	6.1	2.3
2006	I	4.3	3.2	61.7	73.3	1.2	1.4	6.7	2.0
	II	3.0	4.2	54.7	47.5	1.2	1.7	4.7	1.8
	III	3.0	4.0	49.0	38.5	1.1	1.4	3.2	1.5
		3.4	3.8	55.1	53.1	1.2	1.5	4.9	1.8
Mean	I	4.1	3.7	61.2	65.6	1.0	1.5	6.9	2.7
	II	3.3	3.6	53.8	54.9	1.2	1.5	5.0	2.3
	III	3.0	3.8	49.9	39.5	1.1	1.5	3.9	1.8
		3.5	3.7	55.0	53.3	1.1	1.5	5.3	2.3
LSDα=0.05 for:									
term of harvest		0.6	n.s.	6.2	6.6	n.s.	n.s.	0.5	0.3
years		n.s.	0.4	6.2	6.6	n.s.	n.s.	0.5	0.3
interaction (I x II)		n.s.	0.7	10.7	11.4	n.s.	0.3	n.s.	n.s.

In 2004, the level of vitamin C in leaf blades (51.45 mg·100 g^{-1} fresh weight) was significantly higher than in 2005-2006 (35.02-38.28 mg·100 g^{-1} fresh weight).

The level of phosphorus in leaf blades was decreasing along with a delay in harvest time. In plants picked in the earliest time, the level of phosphorus was 4.1 g·kg^{-1}, while in the subsequent periods it decreased down to 3.3 g·kg^{-1} and 3.0 g·kg^{-1} (Table 2). No significant effect of this factor on the phosphorus level was found in leaf petioles. It is worth noticing that higher contents of this component appeared in plants grown in 2004 and 2006 (4.0 and 3.8 g·kg^{-1}), and lower in 2005 (3.2 g·kg^{-1}).

Significant effect of the harvest time on potassium contents was observed both in leaf blades and petioles. The highest level of this element in leaf blades occurred in plants picked in the earliest term (61.2 g·kg^{-1}), while those coming from the remaining two periods did not differ from each other considerably (53.8 and 49.9 g·kg^{-1}). The significantly highest amounts of potassium in leaf petioles appeared in plants picked in the earliest term (65.6 g·kg^{-1}); in the crop from second and third term this level dropped down to 54.9 g·kg^{-1}, and 39.5 g·kg^{-1} respectively. The highest level of potassium in leaf blades and petioles was observed in plants grown in 2004 (62.3 and 65.8 g·kg^{-1} respectively), and the lowest one in 2005 (47.5 and 41.0 g·kg^{-1}).

The harvesting time did not have any effect on the level of calcium in the plants, although the influence of this factor on the level of magnesium was significant. Both in leaf blades and petioles, as the harvest time was postponed, the magnesium contents was decreasing from 6.9 g·kg^{-1} of dry matter down to 3.9 g·kg^{-1} in blades and from 2.7 to 1.8 g·kg^{-1} in petioles.

CONCLUSIONS

1. Delayed harvesting time of Spinach beet resulted in enhancement of crop yield and contents of dry matter in leaf blades and petioles, as well as vitamin C in leaf blades. Simultaneously, a decrease in the level of nitrates, K and Mg in leaf blades and petioles and of P in leaf blades was observed.

2. Spinach beet leaf blades contained more dry matter, K and Mg, while leaf petioles were richer in P, Ca and had over 5-fold more nitrates compared with the blades.

REFERENCES

BIESIADA A., KOŁOTA E., ADAMCZEWSKA-SOWIŃSKA K. 2007. *The effect of maturity stage on nutritional value of leek, zucchini and kohlrabi.* Vegetable Crops Res. Bull., 66: 39-45.

BOHNER A., ADAM M., BAUMGARTEN A., EDER G. 2005. *Nährstoffkreislauf in einem Silomais-Ökosystem mit besonderer Berücksichtigung des Stickstoffs.* 11. Gumpensteiner Lysimetertagung, 5. und 6. April, Irdning, s. 99-107.

DYDUCH J., JANOWSKA K. 2004. *Plonowanie kilku odmian pietruszki naciowej*. Acta Sci. Pol., Hortorum Cultus, 3(1): 145-151.

DYDUCH J., NAJDA A. 2005. *Zmiany zawartości suchej masy i kwasu L-askorbinowego w liściach roślin dwu odmian selera naciowego (Apium graveolens L. var. dulce Mill./Pers.) w zależności od wieku zbieranych roślin i ściółkowania gleby*. Zesz. Nauk. AR Wrocław, Rol., 86(515): 111-119.

KMIECIK W., LISIEWSKA Z., GĘBCZYŃSKI P. 2005. *The level of nitrates, nitrites and oxalates in different usable parts of dill (Anethum graveolens L.) depending on plant height*. Acta Sci. Pol., Technol. Aliment., 4(1): 93-102.

KOZIK E. 2006. *Wpływ terminu zbioru oraz nawożenia azotem i potasem na zawartość azotanów w sałacie uprawianej w szklarni*. Acta Agrophs., 7(3): 633-642.

REKOWSKA E., SŁODKOWSKI P. 2005. *Wpływ płaskiego okrycia roślin oraz normy siewu nasion na plonowanie roszponki*. Zesz. Nauk. AR Wrocław, Rol., 86(515): 433-439.