ACTA SCIENTIARUM POLONORUM Acta Sci. Pol., Hortorum Cultus 10(4) 2011, 263-274

THE EFFECT OF DIVERSIFIED POTASSIUM FERTILIZATION ON THE YIELD AND CHEMICAL COMPOSITION OF *Beta vulgaris* L.

Katarzyna Dzida, Zbigniew Jarosz, Zenia Michałojć
University of Life Sciences in Lublin

Abstract. The nutritive value of *Beta vulgaris* L. result mainly from its high content of protein gathered both in leaf blades and in petioles, and from high content of mineral salts, mainly iron and calcium, as well as vitamins C, A, B_1, B_2. Purpose of the research was to determine the effect of type potassium fertilizer (potassium chloride, potassium sulphate and potassium chloride + potassium sulphate in 1:1 K ratio) and different dose of potassium (0.6; 1.2; 1.8 g·dm^{-3}) on the yield and chemical composition of *Beta vulgaris* L. The plants were cultivated in a greenhouse, in pots filled deacidified highmoor peat. Regardless of the type of potassium fertilizer, the yield of *Beta* leaves was the highest with the application of 0.6 g K·dm^{-3}. Leaves of *Beta vulgaris* L. fertilized with potassium chloride contained least nitrates, whereas plants fertilized with K_2SO_4 and KCl + K_2SO_4 contained much more nitrates. Increasing doses of potassium had a positive effect on the content of vitamin C in the leaves. The research revealed a negative effect of increasing potassium dose on the plant unit weight, leaf length and percentage content of total nitrogen, protein and dry weight in leaves, especially at application of potassium chloride and potassium sulphate. The research showed the growth of potassium and total salt concentration content in bedding as the effect of increasing potassium doses at the application of KCl and K_2SO_4. In cultivation of *Beta vulgaris* L., the application of 0.6 g K·dm^{-3} bedding leads to the highest yield of leaf fresh weight, while application of 1.8 g K·dm^{-3} bedding leads to the highest content of vitamin C in fresh mass.

Key words: *Beta vulgaris* L., mineral nutrition, macroelements, vitamin C, nitrates

INTRODUCTION

Leaf vegetables are regarded as plants of high biological value, yet their consumption is mainly seasonal. The greatest availability of these vegetables on the market is observed in springtime. The high nutritive value of leaf vegetables is related to high

Corresponding author – Adres do korespondencji: Katarzyna Dzida, Department of Cultivation and Fertilization of Horticultural Plants, University of Life Sciences in Lublin, Leszczyńskiego 58, 20-068 Lublin, Poland, phone (+48) 81 524 71 22, e-mail: katarzyna.dzida@up.lublin.pl

content of protein (even up to 25% of dry mass), vitamin C, betakarotene, vitamins from B group and mineral compounds [Pokluda and Kuben 2002]. Leaf beet has short vegetation time and little requirements for climate and soil [Gapiński 1993]. Basis for the proper growth and yielding of vegetables is their proper nutrition depending on knowledge of basic nutrition needs of plants and on soil fertility [Dzida i Pitura 2008]. Beet has properties regulating metabolic changes in alimentary canal, it aids digestion and mineral compounds contained in leaf beet help in completing deficiency of both micro- and macro-elements [Siwek 2004].

One of the basic macro-elements which decide about yielding and usability of the plant is potassium. Physiological functions of potassium are not fully known, but it has been stated as a fact that when lack of potassium is noticed, the plant's growth is inhibited. Along with other compounds potassium is one of the conditions of proper metabolic processes in a cell, and thus of production of maximum yield. Relatively high concentration of potassium is a required condition for protein biosynthesis. In case of deficiency of potassium ions most physiological processes are disrupted, first of all assimilates transportation and growth of main parts of the plant. Potassium is the key ion and its quantity in a cell determines size of osmotic potential. This ion plays a special role in osmoregulation of cells and in stoma movement [Lester et al. 2010, Cakmak 2005, Talbott and Zeiger 1996].

The aim of this research was to define dependencies between the type of potassium fertilizer applied in the form of .potassium chloride, potassium sulphate and mixture of these two fertilizers in 1:1 K ratio, different dose of potassium and the yield and chemical composition of *Beta vulgaris* L.

MATERIAL AND METHODS

Experiment with *Beta vulgaris* L. 'Vulcan' was conducted in the spring of 2006 (29.03–22.05) and 2007 (17.03–14.05) in a greenhouse. The experiment was set up with the method of complete randomization, in the scheme of 9 series in 6 repetitions, where repetition was in a pot of 4 dm^3 capacity, with one plant inside, as a two factor one.

Highmoore peat limed with $CaCO_3$ up to pH 5.8 was used as medium. Mineral compounds content in the moor prior to planting was ($mg \cdot dm^{-3}$): N-NH_4 – tr., N-NO_3 – 25, P-PO_4 – tr., K – 10, Ca – 40, Mg – 8. Top dressing with macro-elements and dressing prior to vegetation was applied. During the entire process of vegetation nutrients were applied in the following quantities ($g \cdot dm^{-3}$): nitrogen 0.75; potassium 0.6; 1.2; 1.8; phosphorus 0.5; magnesium 0.6; and ($mg \cdot dm^{-3}$ medium) Fe – 8.0; Cu – 13.3; Mn – 5.1; B – 1.6; Mo – 3.7; Zn – 0.74.

Potassium in the experiment was applied in the form of KCl, K_2SO_4, KCl + K_2SO_4, nitrogen as ammonium nitrate (34% N), phosphorus as triple granular superphosphate (20% P), magnesium as $MgSO_4 \cdot H_2O$ (15.6% Mg), and particular microelement as Fe – chelate, Cu, Mn, Zn – sulphates, B – boric acid, Mo – ammonium molybdate. Before planting of seedlings microelements were applied once, as well as ½ dose of nitrogen, potassium and magnesium, and full dose of phosphorus and calcium. The remaining doses of nutrients (N, K, Mg) were applied in two top-dressing doses after planting the plants to their permanent spot.

Medium samples for chemical analysis were taken at liquidation of the experiment. Mineral compounds content ($N-NH_4$, $N-NO_3$, P, K, Ca, Mg, $S-SO_4$, Cl) in medium was marked in 0.03 M extract of acetic acid, at volumetric ratio of the solution to the medium 10 – 1 with addition of active carbon. Nitrate nitrogen and ammonium nitrogen were marked with Bremner method in Starck modification. Phosphorus with ammonium metavanadate, $S-SO_4$ with barium chloride, Cl with silver nitrate underwent colorimetric determination, and potassium, calcium and magnesium were determined with atomic absorption spectrometry, ASA (Perkin-Elmer, Analyst 300). In addition, pH of medium was determined as well as salt concentration (EC) in $mS \cdot cm^{-1}$ in suspension being a mix of distilled water and examined medium in volumetric ratio 2 : 1 [Nowosielski 1988].

The following measurements were taken at the end of experiment: height of plants and weight of aboveground parts of beet, thus determining yield of fresh mass.

In fresh plant material L-ascorbic acid was determined with Tillmans method [PN-A-04019 1998], whereas in dry material total nitrogen was determined with Kjeldahl method and after dry burning in temperature of 550°C, as well as P, K, Ca, Mg with methods like during medium analysis. $N-NH_4$, $N-NO_3$, $S-SO_4$, Cl were determined in 2% extract of acetic acid with the same methods like during medium analysis. Protein content was provided with the use of formula 6.25 × total N concentration.

Results were verified statistically using analysis of variance on mean values and evaluated by multiple Tukey's test at the significance level $\alpha = 0.05$. Tables present mean values from 2006 and 2007.

RESULTS

The experiment showed significant effect of potassium dose and type of potassium fertilizer on *Beta vulgaris* yield, which remained in the range from 107.2 to 193.5 $g \cdot plant^{-1}$ (tab. 1). Regardless of the potassium fertilizer applied, the highest yield of fresh mass was obtained with application of the lowest dose of potassium (0.6 $g \cdot dm^{-3}$ of medium). Application of potassium fertilizer had effect on the size of *Beta vulgaris* plants. In objects with the lowest dose of K, through application of KCl, K_2SO_4, as well as KCl + K_2SO_4 plants were higher in comparison to plants fertilized with medium and highest dose of K (tab. 1).

Interesting results were obtained from analysis of vitamin C content in *Beta vulgaris* L. Dose of potassium fertilizer significantly differentiated concentration of vitamin C in the examined plant. Plants fertilized with the highest dose of potassium (1.8 $g K \cdot dm^{-3}$) had the highest content of vitamin C, and those fertilized with the lowest dose of potassium (0.6 $g K \cdot dm^{-3}$ of medium) had least vitamin C. Considering the effect of type of potassium fertilizer on the content of vitamin C in *Beta vulgaris* L. it was noted that plants fertilized with K_2SO_4 had the highest concentration of vitamin C (tab. 2).

There was quite a lot of ammonium nitrogen in medium, average of about 247 $mg\ N-NH_4 \cdot dm^{-3}$, this content is related to the applied nitric fertilizer – ammonium

Table 1. Plant unit weight, plant height, L-ascorbic acid, dry matter and protein contents in beet leaves, depending on potassium fertilization

Tabela 1. Masa jednostkowa roślin, wysokość roślin, zawartość suchej masy, kwasu L-askorbinowego i białka w liściach buraka liściowego w zależności od nawożenia potasowego

Potassium fertilizer Nawóz potasowy	Dose Dawka K $g \cdot dm^{-3}$	Plant unit weight Masa jednostkowa roślin, g	Plant height Wysokość roślin cm	Dry matter Sucha masa %	L-ascorbic acid in f.w. Kwas L-askorbinowy w św.m $mg \cdot 100 g^{-1}$	Protein Białko % d.m.
KCl	0.6	189.7	47.6	10.8	13.56	34.42
	1.2	183.5	44.5	9.95	18.64	32.75
	1.8	148.6	42.0	9.2	23.20	30.79
Mean for KCl – Średnia dla KCl		174.0	44.7	9.98	18.47	32.65
K_2SO_4	0.6	193.5	48.0	11.15	15.43	33.75
	1.2	107.2	38.0	10.1	23.37	31.73
	1.8	108.5	37.9	9.6	23.84	30.58
Mean for K_2SO_4 – Średnia dla K_2SO_4		136.4	41.3	10.28	20.88	32.02
$KCl+K_2SO_4$	0.6	163.5	47.8	9.8	15.70	33.92
	1.2	131.3	40.3	9.35	18.76	29.65
	1.8	152.7	42.8	8.9	22.80	28.48
Mean for $KCl+K_2SO_4$ – Średnia dla $KCl+K_2SO_4$		149.2	43.6	9.35	19.09	30.68
Mean for K dose Średnia dla dawki K	0.6	182.3	47.8	10.58	14.8	34.03
	1.2	140.7	40.9	9.8	20.26	31.37
	1.8	136.6	40.9	9.2	23.28	29.95
$NIR_{0.05}$						
Dose – Dawka K		17.561	2.804	1.035	6.094	1.628
Fertilizer – Nawóz K		17.561	2.804	i.d. – r.n.	i.d. – r.n.	1.628
Dose potassium × fertilizer potassium Dawka potasu × nawóz potasowy		40.705	i.d. – r.n.	i.d. – r.n.	i.d. – r.n.	i.d. – r.n.

i.d. – insignificant differences – r.n. – różnice nieistotne

Table 2. Chemical concentration ($mg \cdot dm^{-3}$) and pH. EC values ($mS \cdot cm^{-1}$) in substratum after *Beta vulgaris* L. cultivation
Tabela 2. Skład chemiczny ($mg \cdot dm^{-3}$) oraz wartości pH i EC ($mS \cdot cm^{-1}$) w podłożu po uprawie buraka liściowego

Potassium fertilizer Nawóz potasowy	Dose Dawka K $g \cdot dm^{-3}$	$N\text{-}NH_4$	$N\text{-}NO_3$	$P\text{-}PO_4$	K	Ca	Mg	$S\text{-}SO_4$	Cl	EC	pHH_2O
KCl	0.6	240.3	215.6	178.0	153.6	1527.6	166.0	515.3	340.0	2.41	5.91
	1.2	241.3	219.0	187.3	478.3	1463.0	213.6	530.6	424.0	2.96	5.94
	1.8	255.3	196.0	187.3	735.0	1275.3	179.3	599.6	471.6	3.45	5.96
Mean for – Średnia dla KCl		245.6	210.2	184.2	455.6	1422.0	186.3	548.5	411.8	2.94	5.91–5.96
K_2SO_4	0.6	195.6	233.3	187.0	136.3	1729.0	201.0	736.3	63.0	2.45	5.92
	1.2	270.3	301.0	173.0	508.6	1195.0	178.0	754.3	74.6	3.15	5.71
	1.8	282.3	305.3	201.6	953.0	1505.3	189.0	812.0	120.0	3.29	5.83
Mean for – Średnia dla K_2SO_4		249.4	279.8	187.2	532.6	1476.4	189.3	767.5	85.9	2.96	5.71–5.92
$KCl+K_2SO_4$	0.6	205.3	149.3	178.0	157.3	1319.0	177.0	607.6	176.0	2.53	5.87
	1.2	262.3	193.6	195.6	416.0	1291.0	186.3	655.0	362.3	2.77	5.91
	1.8	272.3	230.3	178.0	966.6	1298.3	137.0	702.6	553.3	2.91	5.85
Mean for – Średnia dla $KCl+K_2SO_4$		246.6	191.1	183.8	513.3	1302.7	166.7	655.1	363.9	2.74	5.85–5.91
Mean for K dose Średnia dla dawki K	0.6	213.7	199.4	181.0	149.1	1525.2	181.3	619.7	193.0	2.46	5.87–5.92
	1.2	258.0	237.8	185.3	467.6	1316.3	192.6	646.6	287.0	2.96	5.71–5.94
	1.8	270.0	243.8	189.0	884.9	1359.6	168.4	704.7	381.6	3.22	5.83–5.96
$NIR_{0.05}$											
Dose – Dawka K		20.25	19.61	i.d. – r.n.	19.75	137.24	i.d. – r.n.	40.46	27.64	0.452	
Fertilizer – Nawóz K		i.d. – r.n.	19.61	i.d. – r.n.	19.75	137.24	i.d. – r.n.	40.46	27.64	i.d. – r.n.	
Dose potassium × fertilizer potassium Dawka potasu × nawóz potasowy		48.20	46.67	i.d. – r.n.	47.00	326.61	i.d. – r.n.	i.d. – r.n.	65.77	i.d. – r.n.	

i.d. – insignificant differences – r.n. – różnice nieistotne

Table 3. Effect of potassium fertilizing on chemical composition of beet leaves, % d.m.
Tabela 3. Wpływ nawożenia potasowego na skład chemiczny buraka liściowego, % s.m.

Potassium fertilizer Nawóz potasowy	Dose Dawka K g·dm^{-3}	N-total N-og.	$N\text{-}NH_4$	$N\text{-}NO_3$	P	K	Ca	Mg	$S\text{-}SO_4$	Cl
KCl	0.6	5.51	0.13	0.56	1.04	5.44	1.49	1.11	0.17	3.32
	1.2	5.35	0.15	0.57	0.98	6.49	1.44	1.24	0.17	3.74
	1.8	4.93	0.15	0.50	1.13	7.31	1.51	1.24	0.18	4.18
Mean for – Średnia dla KCl		5.26	0.14	0.55	1.05	6.41	1.48	1.20	0.17	3.74
K_2SO_4	0.6	5.40	0.13	0.84	1.28	5.25	1.40	1.2	0.37	1.08
	1.2	5.08	0.07	0.98	1.19	7.09	1.66	1.75	0.41	1.04
	1.8	4.89	0.07	1.03	1.18	7.33	1.44	1.72	0.49	0.99
Mean for – Średnia dla K_2SO_4		5.12	0.09	0.95	1.22	6.56	1.50	1.66	0.42	1.03
$KCl+K_2SO_4$	0.6	5.43	0.08	0.78	1.01	6.25	1.40	1.41	0.26	2.76
	1.2	4.74	0.06	0.76	1.07	7.69	1.41	1.36	0.32	2.90
	1.8	4.56	0.06	0.75	1.00	8.66	1.36	1.49	0.36	3.27
Mean for – Średnia dla $KCl+K_2SO_4$		4.91	0.06	0.76	1.03	7.53	1.39	1.42	0.31	2.97
Mean for K dose Średnia dla dawki K	0.6	5.44	0.11	0.72	1.11	5.65	1.43	1.35	0.26	2.38
	1.2	5.06	0.09	0.77	1.08	7.09	1.50	1.45	0.30	2.56
	1.8	4.79	0.09	0.76	1.10	7.77	1.44	1.48	0.34	2.81
$NIR_{0.05}$										
Dose – Dawka K		0.246	0.012	i.d. – r.n.	i.d. – r.n.	0.295	i.d. – r.n.	i.d. – r.n.	i.d. – r.n.	0.239
Fertilizer – Nawóz K		0.246	0.012	0.104	0.200	0.295	i.d. – r.n.	0.142	0.085	0.239
Dose potassium × fertilizer potassium Dawka potasu × nawóz potasowy		i.d. – r.n.	0.028	i.d. – r.n.	i.d. – r.n.	0.703	i.d. – r.n.	i.d. – r.n.	i.d. – r.n.	0.569

i.d. – insignificant differences – r.n. – różnice nieistotne

nitrate. Concentration of nitrate nitrogen stayed within very wide range from 149.3 mg $N\text{-}NO_3 \cdot dm^{-3}$ in objects when $KCl + K_2SO_4$ was applied, to 305.3 mg $N\text{-}NO_3 \cdot dm^{-3}$ in objects with K_2SO_4.

Plants were very well supplied with phosphorus. Content of this element in medium equaled average 185 mg $P\text{-}PO_4 \cdot dm^{-3}$. No visible relation between the tested factors and the quantity of phosphorus in medium was noticed. Slight differences in phosphorus concentration between potassium doses and type of potassium fertilizer did not affect plants' supply in this component. This element appeared in high quantities and stayed in a range from 0.98 to 1.28% d.m.

The experiment showed that concentration of potassium in medium where *Beta vulgaris* was cultivated, depended on examined factors. In objects with KCl as well as in objects with K_2SO_4 and $KCl + K_2SO_4$, quantity of potassium in medium increased along with the dose of potassium fertilizers applied. More potassium, in comparison to KCl, was noted with increasing doses of K when K_2SO_4 and $KCl + K_2SO_4$ were applied.

Calcium concentration in medium stayed within range from 1195 to 1729 mg $\cdot dm^{-3}$. Increasing potassium doses and variety of potassium fertilizers had non significant influence on magnesium content in medium. Its content ranged from 137 mg $Mg \cdot dm^{-3}$ at application of highest potassium dose in the form of $KCl + K_2SO_4$ to 213.6 mg $Mg \cdot dm^{-3}$ at application of medium potassium dose in the form of KCl (tab. 2).

Content of sulpahtes and chlorides in medium was appropriate for the applied potassium fertilizers. Most $S\text{-}SO_4$ was noted in medium when potassium sulphate was used. Opposite reaction was noted with chloride content in tested medium. It is worth mentioning that in medium with KCl about 400 mg $Cl \cdot dm^{-3}$ were discovered, which is approximately 4.5 times more in comparison to K_2SO_4 (tab. 2).

Medium pH changed slightly, and regardless of dose and potassium fertilizer type, it stayed in the range between 5.71 and 5.96 pH (tab. 2).

Varied potassium doses affected EC value. In the medium where KCl, K_2SO_4 and $KCl + K_2SO_4$ were applied, along with increase of potassium dose EC value increased as well reaching highest value in objects with highest dose of KCl (tab. 2).

Total nitrogen content in leaves ranged between 4.56 and 5.51% d.m (tab. 3). A falling tendency of percentage content of total nitrogen in leaves was discovered along with the increase of potassium quantity in medium regardless of the potassium fertilizer used. The type of potassium fertilizer significantly affected total nitrogen level in beet leaves. The highest content of N-total was found in the leaves of beets fertilized with KCl (average 5.26% d.m.), lower with application of K_2SO_4 (average 5.12% d.m.) and the lowest when $KCl + K_2SO_4$ (average 4.91% d.m.) was applied (tab. 3).

Nitrates content in dray mass of beet leaves depended on the type of potassium fertilizer applied. Fewer nitrates (by 42.1% on average) were discovered in the leaves of plants fertilized with potassium chloride in comparison to leaves of plants fertilized with potassium sulphate.

The effect of the examined factors in relation to potassium content in leaves was obvious. Potassium content in beet was first of all influenced by potassium dose. Regardless of the potassium fertilizer applied (KCl, K_2SO_4, $KCl + K_2SO_4$), its concentration increased with the growth of potassium dose in medium. Most potassium was discovered in plants fertilized with the highest dose of potassium in the form of $KCl + K_2SO_4$

(8.66% d.m.). Least potassium was discovered in plants fertilized with K_2SO_4, with the lowest potassium dose (5.25% d.m.).

The highest level of calcium and magnesium was discovered when K_2SO_4 was used as fertilizer at the average potassium dose (1.2 g · dm^{-3}). Calcium content in the plant ranged between 1.36 and 1.66% d.m., and magnesium content between 1.11 and 1.75% d.m. (tab. 3).

Concentration of sulphates and chlorine in leaves was tightly related to the type of potassium fertilizer applied. About 3.5 times more chlorine was discovered in objects with KCl compared to K_2SO_4. Chlorine content was high at average 3.74% d.m. in objects with KCl. Quantity of sulphates in a beet stayed within ranges of 0.17 and 0.49% d.m. Most sulphates were found in beets fertilized with K_2SO_4, which caused increase of nitrates content in the leaves of these plants (1.2 g · dm^{-3}) (tab. 3).

DISCUSSION

Beta vulgaris L. is a vegetable which enriches human diet with additional nutritive values. It is a plant that is little known and slightly forgotten in our country. In West European countries *Beta vulgaris* L. is commonly cultivated, especially in Switzerland, Germany, France, England and the US [Anonim 2000]. Leaf vegetables play an important role in human diet, supplementing it in vitamin C which is an essential exogenic nutrient for men [Wierzbicka i Kuskowska 2002].

Potassium is the nutrient that vegetables absorb quickly and in largest quantities. Potassium plays a very important part in plant's nitrogen economy. Ion K^+ has a balancing role in transportation of NO_3^- ion and it activates protein synthesis. In case of potassium deficiency, simple nitrogen compounds are accumulated in a plant, among them toxic amines, for example putrescine. Magen [2008] emphasizes that in order to obtain high yield of good quality, a plant should be supplemented with nutrients especially N, P and K in appropriate proportion. Voogt [1981] claims that quality of yield is a complex characteristic and has many aspects dependent on various factors such as balanced doses of K, Mg and Ca. Isidora et al. [(2008] claim, based on results of experiments, that potassium has effect on better yield quality, disease resistance, greater tolerance to stress and more efficient use of other nutrients, especially nitrogen.

Experiments conducted with *Beta vulgaris* L. showed that applied fertilizers: potassium salt, potassium sulphate and mixture of the two, that is potassium salt + potassium sulphate affected size and quality of yield based on the potassium dose applied.

It was observed that in case of lower potassium dose, regardless of potassium fertilizer type, plants reached highest growth and fresh mass yield. Many tests on the effect of potassium chloride on yielding of various plants, mainly vegetables, were conducted. Results of the tests point to no negative effect of the fertilizer on growth and yielding of the examined plant [Michałojć and Nurzyński 1996, Michałojć 2000, Nurzyński 1976]. Two nutrients, potassium and chlorine, that are provided to the plants in the form of KCl play a double role in the growth and their development. It needs to be emphasized that their basic function is plant nutrition. Experiments are being conducted to confirm positive effect of potassium and chlorine on increased resistance of plants to pathogens

[Magen and Imas 2004]. As other authors note, size of beet fresh mass yield depends not only on type and dose of potassium fertilizer, but also on dose and form of nitrogen applied to the plant [Biesiada and Kołota 2010, Dzida and Jarosz 2010]. Huett [1980], Michałojć [1994], Kowalska [1997] and Dzida [2004] in their experiments with lettuce and leaf beet claim, that plants fertilized with higher dose of nitrogen showed higher yield of fresh mass in relation to plants fertilized with lower dose of the element.

Results presented in this paper indicate that the factor which lowered content of total nitrogen and protein in leaves of *Beta vulgaris* was potassium dose. The type of potassium fertilizer differentiated concentration of nitrates in the plant. The highest content of N-NO_3 in *Beta vulgaris* was noted when plants were fertilized with K_2SO_4. Experiments conducted by Nurzyński [1976, 1999] on various vegetables and by Jarosz and Dzida [2006] on lettuce, confirm this relation.

Vitamin C content in *Beta vulgaris* L. is dependent, to a large extent on fertilization. Test results undoubtedly show a positive effect of increasing doses of potassium on increasing content of vitamin C in a plant. Considering the effect of varied potassium fertilization on the quality of cultivated plants, Isidora et al. [2008] and Golcz [1996] point out positive that increasing doses potassium of vitamin C content. Kozik [1998] based on experiments with lettuce, that increasing doses of nitrogen lead to decrease of vitamin C content. Nurzyńska-Wierdak [2006] obtained similar results in her research on roquette.

Potassium content in plants is very high and can range from 0.3 to 8.0% K_2O. Experiments that were conducted noted luxury absorption of potassium by plants in quantities much higher than nutritive needs of *Beta vulgaris* L. Varied potassium fertilization that was applied affected concentration of nutrients in leaf beet. Plants fertilized with potassium chloride contained more total nitrogen and chlorine, and less nitrates, phosphorus, magnesium and sulphur in comparison to plants fertilized with potassium sulphate. In his experiments on spinach, cauliflower, kale and lettuce, Nurzyński [1994] noticed changes in the content of calcium and magnesium in the aboveground parts of plant, as effect of application of particular potassium fertilizers (KCl, K_2SO_4, KNO_3) K_2SO_4). He also noticed favorable effect of potassium chloride. Plants fertilized with KCl contained fewer nitrates and more Ca, Mg, Mo in comparison to K_2SO_4. In her research on beans, Michałojć [1998] noticed no effect of potassium fertilizer type on yield of seeds and aboveground parts of beans. The author proved an increase of potassium, calcium and chlorine with KCl, and lower nitrates, phosphorus and sulphate with application of K_2SO_4.

Increased nutrients content in medium affected EC value, which with the highest potassium dose (1.8 g $K \cdot dm^{-3}$) remained in the range of 2.91 to 3.45 $mS \cdot cm^{-1}$, reaching the highest value on objects with potassium chloride. In his research on tomatoes Nurzyński et al. [1998] observed similar reactions, because the highest concentration of salt appeared when fertilized with potassium chloride. Voogt [1981] points out that with the increase of potassium supply, total salt concentration in root environment of plants grows as well. At the same time, he points out to the correlation of potassium fertilization in relation to other cations especially calcium and magnesium.

CONCLUSIONS

1. Regardless of the type of potassium fertilizer, yield of beet leaves was highest with application of the lowest potassium dose (0.6 g · dm^{-3}).
2. Fewest nitrates were contained in leaves of beet fertilized with potassium chloride, many more fertilized with K_2SO_4 and KCl + K_2SO_4.
3. Increasing potassium doses had positive effect on L-ascorbic acid content in leaves of plants. Those fertilized with 1.8 g K · dm^{-3} had the highest concentration of L-ascorbic acid.
4. A negative effect of increasing potassium dose on percentage content of total nitrogen, protein and dry mass in leaves was indicated with application of potassium chloride, potassium sulphate and potassium chloride + potassium sulphate.
5. Increase of potassium content and salt concentration (EC) in medium as effect of increasing potassium doses with application of KCl, K_2SO_4 and KCl + K_2SO_4 was noted.

REFERENCES

Anonim., 2000. Stielmangold als Winterkultur. Gemüse 12, 22.
Biesiada A., Kołota E., 2010. The effect of nitrogen ferilization on yielding and chemical composition of radicchio chicory for autumn – harvest cultivation. Acta Sci. Pol. Hortorum Cultus, 9(4), 85–91.
Cakmak I., 2005. Potassium and Stress and Plant Disease. J. Plant Nutr. Soil Sci. 168, 521–530.
Dzida K., 2004. Wpływ nawożenia azotowo-potasowego na plonowanie buraka liściowego (*Beta vulgaris* var. *cicla*) i zawartość składników w podłożu. Rocz. AR Pozn. 356, 55 – 60.
Dzida K, Jarosz Z., 2010. Effect of calcium carbonate and differentiated nitrogen fertilization upon the yield and chemical composition of spinach beet. Acta Sci. Pol. Hortorum Cultus, 9(3), 201–210.
Dzida K., Pitura K., 2008. The influence of varied nitrogen fertilization on field and chemical composition of swiss chard (*Beta vulgaris* L. var. *cicla* L.). Acta Sci. Pol., Hortorum Cultus, 7(3), 15–24.
Gapiński M., 1993. Warzywa mało znane i zapomniane, PWRiL Poznań.
Golcz A., 1996. Ocena jakości owoców papryki w zależności od zrównoważonego nawożenia potasowego. Mat. VI Konf. Katedr Upr. i Naw. Roślin Ogr., Kraków, 53–54.
Huett D.O., 1980. Effect nitrogen on the yield and quality of vegetables. Acta. Hort., 247, 205–209.
Isidora R., Pavlovic M., Sala F., Adina B., 2008. Potassium fertilization influence upon vegetable yield quality and soil fertility protection. The first. International Symposium on Sustainable Agriculture for Subtropical Regions. 147–152.
Jarosz Z., Dzida K., 2006. Wpływ zróżnicowanego nawożenia azotowo-potasowego na plonowanie i skład chemiczny sałaty. Acta Agrophysica, 7(3), 591–597.
Kowalska I., 1997. Effects of urea, ammonium, and nitrate nitrogen on the field quality of greenhouse lettuce grown on different media. Folia Hort., 9/2, 31 – 40.
Kozik E., 1998. Wpływ poziomu nawożenia azotem na plon oraz zawartość cukrów i kwasu askorbinowego w siedmiu odmianach sałaty. VII Konf. Naukowa: Efektywność stosowania nawozów w uprawach ogrodniczych, Lublin, 93–96.

Lester G.E., Jifon J.L., Makus D.J., 2010. Impact of Potassium Nutrition on Food Quality of Fruits and Vegetables: A Condensed and Concise Review of the Literature. Better Crops 94, 1, 18–21.
Magen H., 2008. Balanced Crop Nutrition: Fertilizing for Crop and Food Quality. Turk J. Agric. For 32, 183–193.
Magen H., Imas P., 2004. Potassium chloride and suppression of diseases. XVth International Plant Protection Congress, Beijing, China, May 11–16.
Michałojć Z., 1994. Wpływ zróżnicowanego nawożenia azotowo-potasowego na plonowanie i skład chemiczny sałaty, rzodkiewki, szpinaku. Mat. Konf. Znaczenie potasu i magnezu w uprawie roślin ogrodniczych. Skierniewice.
Michałojć Z., 1998. Wpływ podłoża oraz nawożenia azotem i potasem na plon i skład chemiczny grochu. Zesz. Nauk. AR w Krakowie 333, 219–222.
Michałojć Z., Nurzyński J., 1996. Effect of the form potassium fertilization on the chemical composition of two vegetable crops. IX International Colloquium for the: optymalization of plant nutrition, Prague, Czech Republic, 333–335.
Michałojć Z., 2000. Wpływ nawożenia azotowo-potasowego oraz terminu uprawy na plonowanie i skład chemiczny sałaty, rzodkiewki oraz szpinaku. Rozpr. Nauk. AR w Lublinie, 238.
Nowosielski O., 1988. Zasady opracowywania zaleceń nawozowych w ogrodnictwie. PWRiL, Warszawa.
Nurzyńska-Wierdak R., 2006. The effect of nitrogen fertilization on field and chemical composition of garden rocket (*Eruca sativa* Mill.) in autumn cultivation. Acta Sci. Pol., Hortorum Cultus, 5(1), 53–63.
Nurzyński J., 1976. Wpływ chlorkowej i siarczanowej formy potasu na ilość i jakość plonu niektórych roślin warzywnych w uprawie na torfie ogrodniczym. Biul. Warz. 19, 105–119.
Nurzyński J., 1994. Zawartość składników mineralnych w roślinach w zależności od nawożenia potasowego. V Jubil. Konf. Katedr Upr. i Naw. Rośl. Ogr. AR Poznań, 12–16.
Nurzyński J., 1999. Nawożenie a skład chemiczny warzyw. Zesz. Prob. Post. Nauk Rol., 466, 31–40.
Nurzyński J., Michałojć Z., Kalbarczyk M., 1998. Wpływ nawożenia potasowego na plon i skład chemiczny sałaty. VII Konf. Nauk. pt. Efektywność stosowania nawozów w uprawach ogrodniczych, 242–246.
Pokluda R., Kuben J., 2002. Comparison of selected Swiss chard (*Beta vulgaris* ssp. *cicla* L.). Hort. Sci. 29 (3), 114–118.
Siwek P., 2004. Warzywa pod folią i włókniną. Hortpress, Warszawa.
Talbott, L.D., Zeiger, E., 1996. Central roles for potassium and sucrose in guard-cell osmoregulation. Plant Physiol. 111, 1051–1057.
Voogt W., 1981. Potassium Management of Vegetables Under Intensive Growth Conditions. Netherlands J. Agric., 347–362.
Wierzbicka B., Kuskowska M., 2002. Wpływ wybranych czynników na zawartość witaminy C w warzywach. Acta Sci. Pol. Hortorum Cultus, 1(2), 49–57.

WPŁYW ZRÓŻNICOWANEGO NAWOŻENIA POTASOWEGO NA PLON ORAZ SKŁAD CHEMICZNY BURAKA LIŚCIOWEGO

Streszczenie. Wartość odżywcza buraka liściowego wynik głównie z dużej zawartości białka, gromadzonego zarówno w blaszkach liściowych, jak i ogonkach liściowych oraz na wysokiej zawartości soli mineralnych, głównie żelaza i wapnia oraz witamin C, A, B_1, B_2. Celem badań było określenie wpływu rodzaju nawozu potasowego (chlorek potasu, siarczan potasu oraz chlorek potasu + siarczan potasu podane w stosunku 1:1 K) oraz dawki potasu (0,6; 1,2; 1,8 g·dm^{-3}) na plon i skład chemiczny buraka liściowego. Rośliny uprawiano w szklarni w doniczkach wypełnionych odkwaszonym torfem wysokim. Niezależnie od rodzaju nawozu potasowego plon liści buraka był największy przy zastosowaniu 0,6 g K · dm^{-3}. Najmniej azotanów zawierały liście buraka nawożonego chlorkiem potasu, znacznie więcej natomiast nawożone K_2SO_4 oraz KCl + K_2SO_4. Wzrastające dawki potasu wpłynęły dodatnio na zawartość witaminy C w liściach roślin. Wykazano ujemny wpływ wzrastającej dawki potasu na masę jednostkową roślin, długość liści oraz procentową zawartość azotu ogółem, białka i suchej masy w liściach zwłaszcza przy stosowaniu chlorku potasu i siarczanu potasu. Stwierdzono wzrost zawartości potasu i ogólnej koncentracji soli (EC) w podłożu pod wpływem wzrastających dawek potasu przy stosowaniu KCl i K_2SO_4. W uprawie buraka liściowego najkorzystniejsze było stosowanie 0,6 g K·dm^{-3} podłoża z uwagi na najwyższy plon świeżej masy liści, natomiast z uwagi na największą zawartość witaminy C najlepszym okazało się podawanie 1,8 g K·dm^{-3} podłoża.

Słowa kluczowe: *Beta vulgaris* L., żywienie mineralne, makroelementy, witamina C, azotany

Accepted for print – Zaakceptowano do druku: 21.09.2011