FERTILISATION IMPACT ON THE CONTENT OF SELECTED BIOACTIVE COMPOUNDS IN CAULIFLOWER

VPLYV HNOJENIA NA OBSAH BIOAKTÍVNYCH LÁTOK V KARFIOLE

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Abstract

Nitrogen and sulphur fertilization positively affected on crop yields and bioactive compounds (vitamin C, E_1 and ß-carotene) content in cauliflower edible heads. Applying fertilization doses of 250 kg N.ha^{-1} and 60 kg S.ha^{-1} compared to the control improved cauliflower harvest by 15,2 t.ha^{-1}. Increased fertilization doses of nitrogen and sulphur significantly increased vitamin C and ß-carotene content in the cauliflower. High significant difference in vitamin C level was found comparing the control variant and variant of nitrogen fertilization at the level of 200 kg N.ha^{-1}. In percentage terms this is an increase in vitamin C level by 22,4%. Fertilization with increased doses of nitrogen and sulphur affected significantly the amount of ß-carotene compared to unfertilized variant. Increased doses of N and S did not respond adequately to vitamin E_1 content in cauliflower.

Keywords: cauliflower, bioactive compounds, vitamins, fertilization

Abstrakt

Hnojenie dusíkom a sírou malo pozitívny vplyv na úrodu karfiolu a obsah vitamínov C, E_1 a ß-karoténu v ružiciach karfiolu. Aplikáciou dusíka a síry na úroveň 250 kg N.ha^{-1} and 60 kg S.ha^{-1} sme dosiahli zvýšenie úrody karfiolu o 15,2 t ha^{-1} v porovnaní s kontrolným variantom. Aplikované hnojenie dusíkom a sírou významne zvýšilo obsah vitamínu C a ß-karoténu v karfiole. Najvýraznejší, štatisticky preukazný rozdiel v obsahu vitamínu C bol zistený medzi kontrolným variantom a variantom, kde bol dusík aplikovaný na úroveň 200 kg.ha^{-1} (22,4%). Kombinované dusíkato-sírnaté hnojenie taktiež preukazne pozitívne ovplyvnilo množstvo ß-karoténu oproti kontrolnému variantu. Aplikácia dusíka a síry nemala významný vplyv z hľadiska obsahu vitamínu E_1 v ružiciach karfiolu.

Kľúčové slová: karfiol, bioaktívne látky, vitamíny, hnojenie

DETAILNÝ ABSTRAKT

Karfiol patrí do skupiny hlúbovej zeleniny (čeľaď *Brassicaceae*). Jednotlivé druhy z tejto skupiny sa vyznačujú vysokou nutričnou hodnotou a sú bohatým zdrojom významných a zdraviu prospešných antioxidačných látok (vitamín C, E, β-karotén, sulforafan a i.).

Karfiol, ako aj ostatné druhy hlúbovej zeleniny, má relatívne vysoké požiadavky na zásobu živín. Dusík a síra patria medzi najvýznamnejšie makroelementy, ktoré majú nezastupiteľnú úlohu v agrotechnike pestovania z hľadiska kvantity I kvality úrody karfiolu.

V rámci výskumnej úlohy sme sa sústredili na možnosti zvýšenia obsahu vybraných bioaktívnych látok (vitamín C, E_1, β-karotén) pri dosiahnutí optimálnej výšky úrody karfiolu. Pre dosiahnutie tohto cieľu bol založený maloparcelkový poľný pokus s karfiolom (odroda FLAMENCO F1) v areáli Botanickej záhrady SPU v Nitre v rokoch 2008 a 2009. V rámci poľného pokusu sme sledovali vplyv štyroch variantov hnojenia na úrodu a kvalitu karfiolu:

1. variant – kontrola (bez hnojenia),
2. variant – hnojenie dusíkom na úroveň N = 250 $kg.ha^{-1}$,
3. variant – hnojenie dusíkom a sírou na úroveň N:S = 250:50 $kg.ha^{-1}$,
4. variant – hnojenie dusíkom a sírou na úroveň N:S = 250:60 $kg.ha^{-1}$.

Dusík a síra boli aplikované vo forme hnojív LAD 27 a DASA 26/13. Zber karfiolu bol realizovaný postupne v období 2.-9. 9. 2008 a 28.-10. 9. 2009. Analýza sledovaných obsahových látok bola uskutočnená z ružíc karfiolu zberaných v dňoch 5. 9. 2008 a 2. 9. 2009.

Hnojenie dusíkom a sírou malo pozitívny vplyv na výšku úrody a množstvo vitamínov C, E_1 a β-karoténu v karfiole. Aplikované hnojenie vo variante 4 malo za následok štatisticky preukazné zvýšenie úrody karfiolu v porovnaní s kontrolou. Aplikácia dusíka a síry viedla ku zvýšenej kumulácii vitamínu C a β-karoténu v karfiole. Vo variante 2 bol zistený štatisticky preukazný rozdiel obsahu vitamínu C a β-karoténu oproti kontrolnému variantu. Hnojenie dusíkom a sírou nemalo preukazný vplyv na obsah vitamínu E_1 v ružiciach karfiolu.

Introduction

Antioxidants are present naturally in foodstuffs in the form of vitamins, minerals, phyto-substances. Most valuable antioxidants are vitamin A, carotenoids, vitamin C, vitamin E, selenium, flavonoids, polyphenols, coenzyme Q 10 and others. Lots of these substances are found in fruits and vegetables [11]. Deficit of antioxidants increases the risk of pathological changes in the vascular system, as well as the risk of cancer [7]. Regular consumption of antioxidants over years does not cause negative side effects. It is better to take antioxidants from natural sources such as vegetables, fruits, vegetable oils, cereals, nuts, legumes, etc. [16].

Vitamin C is the most significant vitamin in vegetables [15]. It increases the body's immunity against diseases, lowers cholesterol levels in the blood and improves the overall condition of the body [1]. ß-carotene in human body forms vitamin A (retinol), which acts as a growth and anti-infective vitamin. It is the basis for creation of photosensitive pigment important for vision [3]. Carotenoids inhibit the oxidation of lipids initiated by singlet oxygen, in combination with tocopherols, which protect it from oxidation [2]. The content of vitamin E in Brassica vegetables is generally between 1,8 and 20 $mg.kg^{-1}$. The main component of vitamin E is usually α-tocopherol [8, 12].

The aim of our research work was to determine if it is possible to positively effect on the bioactive compound accumulation at achievement of optimal cauliflower yield. There is necessary to find a way how we could cultivate a healthier vegetable so that human body could have a higher intake of health-promoting bioactive compounds. This fact is very important in these days when we are exposed to advanced stress and creation of civilization diseases as (cancer, cardiovascular diseases etc.).

Material and methods

The experiment on moderate soil with cauliflower was established in the area of Botanical Garden of Slovak University of Agricultural in Nitra in 2008 and 2009. The subject of the experiment was cauliflower variety FLAMENCO F1. This variety is suitable for field planting and also for cultivation in protected facilities.

Planting of seedlings was done on 24th June 2008 and 22nd June 2009. Each variant had four replications. In each of these replications, we planted eight seedlings into the plating space 0,5 x 0,5 m. The size of replication area was 2 m^2.

In the field experiment, we examined the effect of four fertilization variants on the quantity and quality of cauliflower yield:

1. variant – control (without fertilization),
2. variant – nitrogen application at the level of N = 250 $kg.ha^{-1}$,
3. variant – nitrogen and sulphur application at the level of N:S = 250:50 $kg.ha^{-1}$,
4. variant – nitrogen and sulphur application at the level of N:S = 250:60 $kg.ha^{-1}$.

In the control (1) no fertilizers were applied. For variants 2 and 3, fertilizers LAD 27 and DASA 26/13 were used to replenish the level of N and S to the corresponded level. LAD fertilizer is ammonium nitrate with dolomite, containing 27% nitrogen, 4% MgO and 7% CaO. DASA 26/13 is nitrogen fertilizer containing 26% of nitrogen and 13% sulphur. DASA fertilizer was applied three weeks before planting. Fertilizer LAD 27 was applied in two terms: 3 and 6 weeks after planting (50% and 50% of the dose). P and K were not applied because their content in soil was compliant to requirements of the cauliflower cultivation - 40 kg $P.ha^{-1}$ and 160 kg $K.ha^{-1}$.

The harvest of cauliflower was performed progressively from 2nd to 9th September 2008 and from 28th August to 10th September 2009. Analysis of bioactive compounds concentration was done from samples harvested from 5th September 2008 and 2nd September 2009. The content of ß-carotene and vitamin E_1 was determined by HPLC method according to Olives Barba et al. [10]. The vitamin C content was determined by method of titration. For statistical evaluation of results, Tukey HSD test was used.

Results and discussion

The highest average yield (72,1 $t.ha^{-1}$) during the reporting period was reached at the variant 4. There were cauliflowers fertilized with nitrogen dose of 250 $kg.ha^{-1}$ and sulphur does 60 $kg.ha^{-1}$ in pure nutrients. The control variant (non-fertilized) achieved the average yield of 56,9 $t.ha^{-1}$. The difference is 15,2 $t.ha^{-1}$, making 26,6%. Analysis of variance at the 95% probability proved significant increase of yields of cauliflower heads. The yield of cauliflower increased at the variant 3 by 13,2 $t.ha^{-1}$, when compared to control. In terms of percentage this is an increase of 23,2%. When applying nitrogen at a dose of 200 $kg.ha^{-1}$ without sulphur fertilization (variant 2), the yield increased by 8,9 $t.ha^{-1}$, which is increasing of 15,7%. We found, that nitrogen fertilization (250 $kg.ha^{-1}$) in combination with sulphur caused high-significant increase of the yield of cauliflower in comparison with control variant. These results confirmed fact that nitrogen fertilization has got unsubstitutable role from crops quantity (5, 17). The effect of applied fertilization on the quantity yield of cauliflower is illustrated in figure 1.

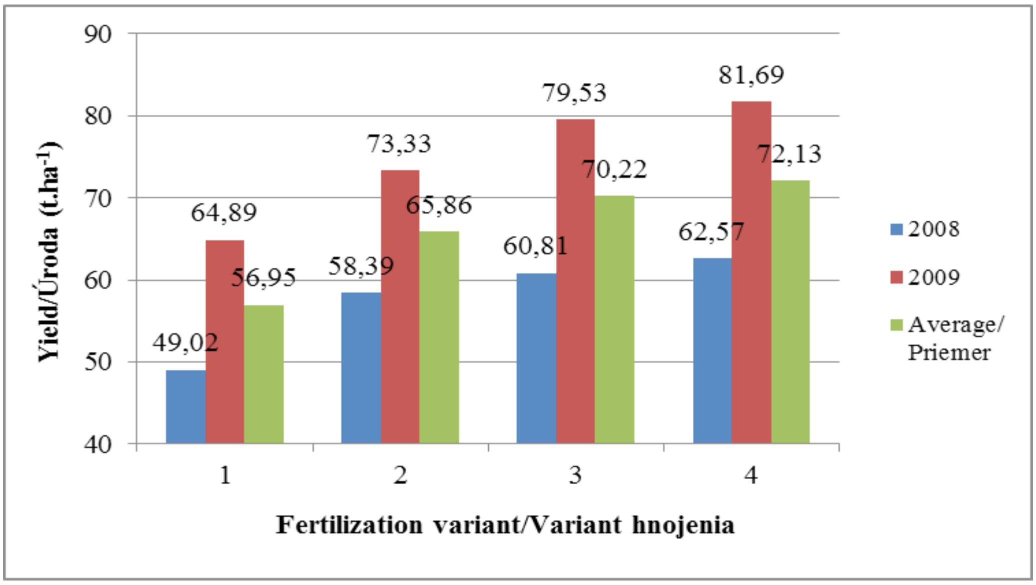

Figure 1 Effect of fertilization on the cauliflower yield in $t.ha^{-1}$
Obrázok 1 Vplyv hnojenia na úrodu karfiolu v $t.ha^{-1}$

Fertilization with nitrogen and sulphur has a positive impact on quantity of observed vitamins in the consumable parts of cauliflower (tab. 1). The content of vitamin C in cauliflower heads have increased according to treatments in variants order: 1 < 3 < 4 < 2. High significant difference was found in vitamin C content between control variant and nitrogen dose of 200 kg.ha^{-1}. Significant differences were found also between the control variant and variants 3 and 4 where sulphur was applied (tab. 2). Content of vitamin C was significantly influenced also by the year of production. In 2008, we recorded a value 288,54 mg.kg^{-1} and in 2009 it was 377,01 mg.kg^{-1} of vitamin C. Similar results were also achieved in experiments with broccoli [9, 13]. According to the authors Ducsay, Varga [4] by optimum doses of nutrients can be achieved increasing the production of vitamin C in Chinese cabbage.

Fertilization with nitrogen and sulphur as well as influence of production year significantly affected the content of ß-carotene in cauliflower edible organs. The lowest content of ß-carotene (14,9 mg.kg^{-1}) in the edible part of cauliflower was found at the control variant: Increasing doses of nitrogen (200, 250 kg.ha^{-1}) in combination with sulphur significantly increased ß-carotene content. The highest content of ß-carotene (19,43 mg.kg^{-1}) was observed at the variant 4. If we compare the different treatments (tab. 3) we find significant and high significant differences in the amount of ß-carotene comparing control and other variants of fertilization. The positive effect of nitrogen fertilization on the ß-carotene content was observed in the experiment with carrot and batata [6, 14].

Nitrogen fertilization (200 kg.ha^{-1}) of cauliflower increased vitamin E_1 content in the edible parts just slightly. Among the monitored variants, no significant differences were found (tab. 4). In percentage terms, we found increase in vitamin E_1 content between control variant and nitrogen fertilized treatment - dose 200 kg ha^{-1}. The content of vitamin E_1 in cauliflower was increased by 2,3%. The increased dose of nitrogen plus sulphur application even caused a reduction in the amount of E_1 vitamin. Significant differences were found only between the experimental years. The highest content of vitamin E_1 in 2009 was detected in the control variant (5,66 mg. kg^{-1}). The variant of nitrogen fertilization (200 kg.ha^{-1}) and sulphur (60 kg.ha^{-1}) decreased the amount of vitamin E_1. Similar results were achieved by Šlosár [13], when fertilization resulted of vitamin E_1 reduction in broccoli.

Conclusion

From gained experimental results, we can deduce a conclusion that nitrogen and sulphur are basic macroelements in cauliflower nutrition. Application of these two nutrients resulted to increase of cauliflower yield about 15,2% and it also had a positive effect on the yield quality. Nitrogen and sulphur application tended to increased accumulation of vitamin C and ß-carotene in cauliflower florets. Vitamin E_1 content was minimally affected. As optimal variant for cauliflower cultivation, it appears a variant with combined fertilization by nitrogen and sulphur at the level of of N:S = 250:60 kg.ha^{-1}. At this variant, we reached highest vitamin C and ß-carotene content together with highest yield quantity of cauliflower and it was a purpose of our experiment. Fertilization has unsubstitutable role in crop cultivation system and experimental results give us indication that there could be way how we can cultivate vegetable products with higher bioactive compound content. This fact is very important from aspect of human health because the consumption of vegetables is at low stage in Slovakia. Thus, we have lower intake of bioactive compounds such as vitamin C, ß-carotene, etc.

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Table 1 The content of bioactive compounds in edible parts of cauliflower (mg.kg^{-1} of fresh weight)
Tabuľka 1 Obsah bioaktívnych látok v konzumných častiach karfiolu (mg.kg^{-1} čerstvej hmoty)

Bioactive compounds/ Bioaktívne látky	Variants/Varianty 1	2	3	4
Vitamin C/Vitamín C	296,25	362,59	331,05	341,23
β-carotene/β-karotén	14,93	16,92	17,82	19,43
Vitamin E_1/Vitamín E_1	1,93	1,98	1,91	1,93

Table 2 Analysis of Variance for Vitamin C (mg.kg^{-1})
Tests of Contrasts (Tukey HSD, 95%)
Tabuľka 2 Analýza rozptylu pre obsah vitamínu C (mg.kg^{-1})
Test kontrastov (Tukey HSD, 95%)

Source of variability/ Zdroj variability	LS Mean/ Priemer	Homogeneous groups/ Homogénne skupiny		
Year/Rok				
2008	288,544	a		
2009	377,012		b	
Variants/Varianty				
1	296,250	a		
3	331,050		b	
4	341,225		b	
2	362,587			c
Replications/Opakovania				
1	328,700	a		
3	331,575	a		
4	334,875	a		
2	335,926	a		

Different letters between columns (a, b, c) show statistically significant differences at the level α=0,05/Rozdielne písmená medzi stĺpcami ukazujú štatisticky preukazné rozdiely na úrovni α=0,05

Table 3 Analysis of Variance for ß-carotene (mg.kg^{-1}) Tests of Contrasts (Tukey HSD, 95%)
Tabuľka 3 Analýza rozptylu pre obsah ß-karoténu (mg.kg^{-1}) Test kontrastov (Tukey HSD, 95%)

Source of variability/ Zdroj variability	LS Mean/ Priemer	Homogeneous groups/ Homogénne skupiny		
Year/Rok				
2008	14,935	a		
2009	19,613		b	
Variants/Varianty				
1	14,928	a		
3	16,918		b	
4	17,818		b	
2	19,431			c
Replications/Opakovania				
1	17,076	a		
3	17,093	a		
4	17,348	a		
2	17,579	a		

Different letters between columns (a, b, c) show statistically significant differences at the level α=0,05/
Rozdielne písmená medzi stĺpcami ukazujú štatisticky preukazné rozdiely na úrovni α=0,05

Table 4 Analysis of Variance for Vitamin E_1 (mg.kg^{-1}) Tests of Contrasts (Tukey HSD, 95%)
Tabuľka 4 Analýza rozptylu pre obsah vitamínu E_1 (mg.kg^{-1}) Test kontrastov (Tukey HSD, 95%)

Source of variability/ Zdroj variability	LS Mean/ Priemer	Homogeneous groups/ Homogénne skupiny	
Year/Rok			
2008	1,547	a	
2009	2,329		b
Variants/Varianty			
1	1,910	a	
3	1,930	a	
4	1,934	a	
2	1,979	a	
Replications/Opakovania			
1	1,899	a	
3	1,894	a	
4	1,984	a	
2	1,984	a	

Different letters between columns (a, b) show statistically significant differences at the level α=0,05/
Rozdielne písmená medzi stĺpcami ukazujú štatisticky preukazné rozdiely na úrovni α=0,05