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# EFFECT OF DIFFERENT FERTILIZERS ON THE MINERAL CONTENT OF PUMPKIN FRUIT

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Abstract

Pumpkin is a vegetable that contains relatively large amounts of biologically active substances. Vegetables are best known as a source of carotenoids and dietary fibres. In addition to this, the pumpkin pulp accumulates significant quantities of minerals. The aim of this work was to identify the most effective fertilizers stimulating accumulation of mineral compounds. The experiment was carried out at the Experimental Station of Aleksandras Stulginskis University, in the central part of Lithuania. Six pumpkins cultivars have been investigated: *Cucurbita maxima* Duch. – Stofuntovaja, Bambino, Kroshka; *Cucurbita moschata* (Duch.) Duch. ex Poir. – Zemcuzina; *Cucurbita pepo* L. – Miranda, Golosemiannaja. The experiment was carried out in five combinations: no fertilization (control), humic substances (HS) fertilizer, complex fertilizers, compost and mixture of complex fertilizers, and humic substances fertilizers. The amounts of macro- and micro-elements were determined in dry matter of the pumpkin fruit pulp by the inductive plasma mass spectrometry method. The data of the analyses showed that the mixture of complex and HS fertilizers had the strongest positive influence on the accumulation of dry matter in the pumpkin fruit. All the fertilizers increased the amount of crude ash in the pumpkin fruit, but no significant differences among the fertilizers and cultivars were found. The biggest amounts of crude ash accumulated in pumpkins fertilized with the complex fertilizers and the mixture of complex and HS fertilizers. The biggest average content of the macro- and micro -elements was found in pumpkins fertilized with the complex fertilizers. All the applied fertilizers increased the content of calcium, iron, manganese, sodium and zinc in the pumpkin fruit, but reduced the amount of copper.

**Keywords***:* *Cucurbita maxima*, *Cucurbita moschata*, fertilizers, macro-elements, micro-elements.

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# INTRODUCTION

In Lithuania, pumpkins have become more popular in the last years. This vegetable is valued for the simplicity of its growing technology. In comparison with other vegetable species, pumpkin gives the biggest yield. Pumpkin is suitable for eating raw and processed into juices, jams, marinates, baby food. Moreover, it can be used as a colorant of spaghetti and cakes (Danilchenko 2002).

The soil suitable for pumpkin cultivation should be light, well fertilized and irrigated (Akanbi et. al 2007, Kulaitiene et al. 2007). Pumpkins are sensitive to soil acidity. The optimal pH for pumpkin growth ranges from 6.0 to 7.5. General garden fertilizers containing N:P:K at a ratio of 10:10:20 are commonly used for basic fertilization. Pumpkin needs much easily assimilated nitrogen, phosphorus and potassium (Besiada et al. 2009). Oloyede et al. (2012) found that excessively high fertilisation with N reduces nutritional quality and health benefits of the pumpkin fruit.

Organic fertilizers are a necessary component in sustainable and long-term agro-ecosystems. Soil microorganisms decompose complex organic materials into simple mineral compounds. Organic fertilizers decompose more slowly than mineral fertilizers. Organic fertilizers contain the majority of macro- and micronutrients necessary for plants. They are important as a source of carbon dioxide. It is recommended to enrich soil with 30-40 t $ha^{-1}$ of manure under pumpkin plants.

Humic substances (HS) fertilizers can be also applied to ferttilize pumpkin plants. HS fertilizers consist of humic acids, fulvic acids and humins. Many studies have shown that the effect of HS fertilizers on plants is very complex (Koopal et al. 2005). They perform physiological function and act as a growth promoter (Canellas, Olivares 2014). They improve the absorption of nutrients from the soil (Verlinden et al. 2011). HS fertilizer can influence the plant growth and productivity by being an environmental source of auxinic activity (Zandonadi et al. 2007). The positive influence of these substances occurs indirectly (by improving soil physical and chemical properties) and directly in a presence of the ongoing processes in a cell. HS fertilizers reduce chemical sorption intensity as well. They are recognized as the most chemically active compounds in soil, with cation and anion exchange capacity far exceeding that of clays. In HS-enriched soil, phosphorus is more readily available. The plants become more resistant to adverse environmental conditions under the influence of HS (Cattani et al. 2009). In addition, the physiologically active HS may participate in the regulation of genetic information transfer (MacCarthy et al. 1990). The HS fertilizers are safe to the environment and to all living organisms.

Among plants species, vegetables are an excellent source of minerals and contribute to the RDA of these essential nutrients (Rumeza et al. 2006). Mineral compounds play an important role in a human organism. Therefore, consumption of food products containing sufficient amounts of these substances is very important. The pumpkin is an excellent source of many minerals.

The major minerals in the pumpkin pulp are potassium, iron, calcium and phosphorus, as well as magnesium, copper, cobalt and others (Lott et al. 2000, Besiada et al. 2009, Pandya, Rao 2010, Adebyo et al. 2013). Calcium and phosphorus are the minerals present in the largest quantities in the human body and in bones (Hanif et al. 2006). They are capable of preventing osteoporosis and hypertension. A strong relationship has been established between the dietary intake of potassium and the maintenance of normal muscular and neurological function as well as normal blood pressure (He, MacGregor 2008, EFSA 2010). Iron, which is necessary for blood production processes, accumulates in pumpkin fruit in higher amounts than in other vegetables. Magnesium is a component of chlorophyll and an important element for the proper heart function and good calcium metabolism in bones (Ishida et al. 2000). The pumpkin pulp contains little sodium, which makes this vegetable suitable for middle-aged and elderly consumers.

The aim of this work was to evaluate the influence of various fertilizers on the mineral composition of different pumpkin cultivars.

## MATERIAL AND METHODS

### Experimental scheme

Six pumpkin cultivars were selected for the experiment: *Cucurbita maxima* Duch. – Stofuntovaja, Bambino, Kroshka; *Cucurbita moschata* (Duch.) Duch. ex Poir. – Zemcuzina; *Cucurbita pepo* L. – Miranda, Golosemiannaja.

The experiment was carried out on limnoglacial loam deposited moraine loam, deeper carbonate gleyic luvisol ($ID_g$ p1/p2), located at the Experimental Station of Aleksandras Stulginskis University (54°53′ N, 23°50′ E). The main properties of the soil plough layer were: $pH_{KCl}$ 6.8-7.0, available phosphorus ($P_2O_5$) – 265 mg $kg^{-1}$, available potassium ($K_2O$) – 165 mg $kg^{-1}$, total nitrogen (N) – 0.16 %, humus – 2.5%. The total size of the experimental field was 2.0 x 2.0 m, the width of a protective belt was 0.5 m, and the size of a single plot was 4.0 $m^2$. The plots were designed randomly. The cluster sowing method was applied, where 3 seeds were put into each hole 5-8 cm deep. The experiments were carried out in five combinations, four replicates, according to the experimental scheme presented in Table 1. Humic substances fertilizers were sprayed on the soil surface, while all other fertilizers were incorporated into the soil before sowing.

In the experimental area, the soil was drained using drainage ditches and the relief had been artificially levelled. To carry out agrochemical tests of the soil's pH, mobile phosphorus and potassium, as well as the humus content, soil samples were taken from the 0-20 cm soil layer. Samples from total nitrogen determination were collected from the 0-30 cm soil layer.

Table 1

Pumpkin fertilization scheme

| No | Replications | Fertilizer dose | Amount of the introduced nutrients (active matter) | Amount of nutrients absorbed by plants (active matter) |
|---|---|---|---|---|
| 1. | No fertilizer (control) ($N_0P_0K_0$) | – | $N_0P_0K_0$ | $N_0P_0K_0$ |
| 2. | $N_0P_0K_0$ + HS fertilizers* | 30 L ha$^{-1}$ (4.4 kg of humic acids) | $N_0P_0K_0$ | $N_0P_0K_0$ |
| 3. | Complex fertilizers (N:P:K = 10:10:20) | 500 kg ha$^{-1}$ | $N_{50}P_{50}K_{100} + N_{50}$ | $N_{30}P_{15}K_{70} + N_{30}$ |
| 4. | Compost (70% manure + 30% plant residues) | 37 - 40 t ha$^{-1}$ | $N_{320}P_{40}K_{160}$ | $N_{60}P_{16}K_{80}$ |
| 5. | Complex fertilizers (N:P:K = 10:10:20) + HS fertilizers | 500 kg ha$^{-1}$ + 30 l ha$^{-1}$ (4.4 kg of humic acids) | $N_{50}P_{50}K_{100} + N_{50}$ | $N_{50}P_{50}K_{100} + N_{50}$ |

* HS (humic substances fertilizers = humic acid + fulvic acid + humins)

## Methods of chemical analysis

The following methods were applied to determine certain characteristics in a combined soil sample: soil pH ($pH_{KCl}$) – by the potentiometric method; available $P_2O_5$ and $K_2O$ – by the A-L method; humus content – by the Turin method; total nitrogen – by the Kjeldahl method. The following methods were applied to analyse the compost's chemical composition: the Kjeldahl method for total nitrogen, colorimetric method for total phosphorus, and the photometric method for total potassium .

Five pumpkin fruits of each cultivar were used immediately after harvest for chemical analyses by preparing laboratory samples weighing no less than 1 kg. The peel and seeds were removed before the analysis, and the fruit pulp was crushed. The amount of dry matter was determined by drying samples at the temp. of 105°C to constant weight, and the amount of crude ash was measured by dry burning of samples at the temp. of 500°C. The amount of macro- and micro-elements was determined in the dry mass (DM) of the pumpkin fruit pulp. The ash samples after dry-ashing at 500°C were dissolved in nitric acid ($HNO_3$) and analyzed using inductively coupled plasma mass spectrometry (ICP-MS). Chemicals used in this study were of analytical grade. Chemical analyses were performed in three replications.

## Statistical analysis

The research data were processed by analysis of variance (ANOVA) using the computer programme Statistica. The data was estimated by using oneand two-factor data dispersion analysis. Arithmetical means and standard deviation of the experimental data were calculated. Significant differences at $p < 0.05$ among the data were evaluated according to the Fisher's LSD test. Correlation analysis was performed to determine the strength and character of the relationships between variables. The correlation was statistically significant when $p \leq 0.05$.

## RESULTS AND DISCUSSION

Dry matter content is an important parameter that indicates nutritive value of pumpkins and influences storage potential of the fruit. The amount of dry matter varies from 6 to 25% depending on species and cultivar (DANILCHENKO 2002, KARKLELIENE et al. 2008, BESIADA et al. 2009, JAVAHERASHTI et al. 2012). The investigated pumpkin fruit accumulated on average from 5.48 to 14.83% of dry matter. The dry matter content was higher in *Cucurbita maxima* cv. Bambino, Stofuntovaja and Kroshka than in *Cucurbita moschata* cv. Zemcuzina and *Cucurbita pepo* L. cv. Miranda and Golosemiannaja. In addition, the biggest amount has been established in the Kroshka fruit. The data show that a mixture of complex and HS fertilizers had the strongest positive effect on the accumulation of dry matter in the pumpkin fruit (Table 2). Characteristics of these fertilizers can explain this effect. Complex fertilizers contain the biggest amount of macro- and micro-elements in the available form that are necessary for plant nutrition through roots. All these elements are important in photosynthesis and in energy circulation during the dry matter synthesis in the plant. The HS fertilizers improve absorption of compounds from the soil that are necessary for the synthesis, and they accumulate nutrients that are essential for the plant development (STEVENSON 1994). The HS fertilizers are widely recognized as a plant growth promoter, mainly by causing changes in the root architecture and

Table 2

Amount of dry matter in pumpkin fruit (%)

| Cultivars/ Fertilizers | No fertilizer (control) | $N_0P_0K_0$ + HS fertilizers | Complex fertilizers (N:P:K = 10:10:20) | Compost (70% manure + 30% plant residues) | Complex fertilizers (N:P:K = 10:10:20) + HS fertilizers |
|---|---|---|---|---|---|
| Stofuntovaja | 11.13 *cde** | 7.73 *abcd* | 10.35 *abcde* | 7.48 *abcd* | 9.85 *abcde* |
| Bambino | 7.41 *abcd* | 7.94 *abcd* | 9.20 *abcd* | 8.31 *abcd* | 9.99 *abcde* |
| Kroshka | 6.92 *abcd* | 11.02 *bcde* | 8.17 *abcd* | 11.85 *de* | 14.83 *e* |
| Zemciuzina | 6.29 *abc* | 9.01 *abcd* | 7.89 *abcd* | 8.60 *abcd* | 9.15 *abcd* |
| Miranda | 7.17 *abcd* | 6.13 *abc* | 7.13 *abcd* | 7.20 *abcd* | 7.43 *abcd* |
| Golosemiannaja | 6.48 *abcd* | 6.72 *abcd* | 5.48 *a* | 5.66 *ab* | 8.24 *abcd* |

* Significant differences ($p < 0.05$) between the cultivars and fertilizers are marked by different letters; $LSD_{0.05}$: cultivar – 0.02, fertilizer – 0.26, cultivar x fertilizer – 0.87

growth dynamics, which result in an increased root size, branching and/or greater density of root hairs, with a larger surface area (Canellas, Olivares 2014).

Oloyede et al. (2012) found that the ash content, which is an index of the mineral content, was significantly higher than those in young fruits. Depending on the characteristics of a cultivar and fertilizers, the amount of crude ash in the pumpkin fruit in our study varied from 0.32 to 1.06% (Table 3). Similar values were reported Kim et al. (2012), Bhat, Bhat (2013),

Table 3

Amount of crude ash content in pumpkin fruit (%)

| Cultivars/ Fertilizers | No fertilizer (control) | $N_0P_0K_0$ + HS fertilizers | Complex fertilizers (N:P:K = 10:10:20) | Compost (70% manure + 30% plant residues) | Complex fertilizers (N:P:K = 10:10:20) + HS fertilizers |
|---|---|---|---|---|---|
| Stofuntovaja | 0.77 *abcd** | 0.61 *abcd* | 0.87 *bcd* | 0.49 *abc* | 0.58 *abcd* |
| Bambino | 0.61 *abcd* | 0.94 *cd* | 1.06 *d* | 0.69 *abcd* | 0.86 *bcd* |
| Kroshka | 0.32 *a* | 0.46 *abc* | 0.54 *abc* | 0.64 *abcd* | 0.73 *abcd* |
| Zemciuzina | 0.36 *a* | 0.52 *abc* | 0.50 *abc* | 0.44 *ab* | 0.60 *abcd* |
| Miranda | 0.58 *abcd* | 0.51 *abc* | 0.64 *abcd* | 0.64 *abcd* | 0.56 *abc* |
| Golosemiannaja | 0.44 *ab* | 0.60 *abcd* | 0.51 *abc* | 0.52 *abc* | 0.60 *abcd* |

* Significant differences ($p < 0.05$) between the cultivars and fertilizers are marked by different letters; $LSD_{0.05}$: cultivar – 0.04, fertilizer – 0.46, cultivar x fertilizer – 0.97

Karanja et al. (2014). The biggest amounts of the crude ash were accumulated in *Cucurbita maxima* cv. Bambino and Stofuntovaja fruit. All the fertilizers increased the amount of crude ash in the fruit, but no significant differences ($p < 0.05$) among the fertilizers and the cultivars were found. The biggest amounts of crude ash were found in pumpkins fertilized with the complex fertilizers and the mixture of complex fertilizers and HS fertilizers. The correlation analysis showed a moderate relationship between crude ash and dry matter content ($r = 0.613$) in the pumpkin pulp.

The amounts of macro-elements varied greatly in the pumpkin fruit. The biggest average content of macro-elements was found in *Cucurbita maxima* Bambino and Stofuntovaja fruit. The major component of the fruit was potassium, and its concentration varied from 12.10 to 43.63 g $kg^{-1}$ of DM. The content of calcium in the fruit was almost half as low, i.e. 4.02-24.84 g $kg^{-1}$ of DM. The amounts of phosphorus and magnesium were 20– to 30-fold lower than the content of potassium, accordingly 0.73-1.30 and 1.07-2.47 g $kg^{-1}$ of DM. Our results are in accordance with Rahman et al. (2008) report, who found that pumpkins are rich in potassium, calcium, sodium, phosphorus and other elements. The biggest content of potassium and phosphorus was found in Bambino fruit, of calcium in Stofuntovaja, of magnesium in Miranda fruit (Table 4).

Our analysis of the impact of fertilizers on the amount of macro--elements shows that the fertilization with compost and with the mixture of

Table 4

Amounts of macro-elements in pumpkin fruit (g kg$^{-1}$ DM)

| Specification | K | Ca | P | Mg |
|---|---|---|---|---|
| Stofuntovaja | 22.99 *bc** | 24.84 *c* | 0.73 *bc* | 1.41 *a* |
| Bambino | 43.63 *e* | 19.41 *c* | 1.30 *a* | 1.52 *a* |
| Kroshka | 12.10 *a* | 4.02 *a* | 0.67 *b* | 1.07 *c* |
| Zemciuzina | 18.75 *ab* | 11.40 *b* | 0.94 *cd* | 1.41 *a* |
| Miranda | 27.03 *c* | 10.84 *ab* | 1.23 *a* | 2.47 *b* |
| Golosemiannaja | 34.63 *d* | 10.03 *ab* | 1.03 *a* | 2.20 *b* |
| No fertilizer (control) | 26.82 *a* | 9.45 *a* | 0.99 *ab* | 1.61 *a* |
| $N_0P_0K_0$ + HS fertilizers | 28.98 *a* | 10.48 *a* | 1.19 *b* | 1.74 *a* |
| Complex fertilizers (N:P:K = 10:10:20) | 29.60 *a* | 12.80 *ab* | 1.05 *ab* | 1.79 *a* |
| Compost (70% manure + 30% plant residues) | 24.33 *a* | 15.98 *ab* | 0.93 *ab* | 1.75 *a* |
| Complex fertilizers (N:P:K = 10:10:20) + HS fertilizers | 22.89 *a* | 19.13 *b* | 0.76 *a* | 1.52 *a* |

* Significant differences ($p < 0.05$) between the cultivars and fertilizers in columns are marked by different letters;
$LSD_{0.05}$ (K, Ca, P, Mg): cultivar, fertilizer, cultivar x fertilizer – 0.00

the complex and HS fertilizers had a negative influence on the accumulation of potassium. Fertilization with the compost decreased the amount of phosphorus and the mixture of complex and HS fertilizers decreased the amount of magnesium. The biggest amount of potassium was found in fruit of the plants fertilized with the complex fertilizers. The increase was almost 3 g kg$^{-1}$ compared with the control pumpkins grown without fertilizers. This corresponds to the data reported by Danilchenko (2002).

All the applied fertilizers increased the calcium content in the pumpkin fruit. The biggest amount of calcium was determined in the pumpkins fertilized with the mixture of complex and the HS fertilizers. The HS and the complex fertilizers slightly increased amount of phosphorus. The amount of magnesium was bigger in the case of fertilization with the HS, the complex fertilizers and the compost.

The biggest average content of macro-elements was found in the pumpkins fertilized with the complex fertilizers.

The highest average concentration of micro-elements was found in the fruit of *Cucurbita pepo* Miranda and Golosemiannaja (Table 5). The pumpkin fruit accumulated mainly iron (33.58-50.68 mg kg$^{-1}$ of DM), and slightly less boron and sodium (21.42-32.39 and 11.79-38.05 mg kg$^{-1}$ of DM, respectively). The fruit of the cultivar Bambino accumulated the biggest amounts of boron and manganese, Miranda was the richest in copper, iron and zinc, and Golosemiannaja gathered most sodium.

Table 5

Amounts of micro-elements in pumpkin fruit (mg $kg^{-1}$ DM)

| Specification | B | Cu | Fe | Mn | Na | Zn |
|---|---|---|---|---|---|---|
| Stofuntovaja | 24.61 *ab** | 4.67 *a* | 35.15 *a* | 7.41 *a* | 19.05 *ac* | 11.32 *abc* |
| Bambino | 32.39 *d* | 4.80 *a* | 44.87 *ab* | 7.42 *a* | 27.86 *ab* | 13.83 *ab* |
| Kroshka | 21.42 *a* | 4.63 *a* | 33.58 *a* | 3.47 *b* | 11.79 *c* | 13.89 *ab* |
| Zemciuzina | 22.91 *a* | 4.05 *a* | 38.86 *ab* | 7.23 *a* | 27.65 *ab* | 10.70 *ac* |
| Miranda | 30.74 *cd* | 7.78 *b* | 50.68 *b* | 7.22 *a* | 24.93 *abc* | 14.50 *b* |
| Golosemiannaja | 27.40 *bc* | 4.81 *a* | 49.48 *b* | 6.07 *ab* | 38.05 *b* | 9.90 *c* |
| No fertilizer (control) | 26.03 *a* | 6.14 *a* | 33.59 *b* | 4.31 *b* | 17.87 *a* | 10.76 *b* |
| $N_0P_0K_0$ + HS fertilizers | 26.22 *a* | 4.37 *a* | 42.30 *ab* | 6.64 *ab* | 20.04 *ab* | 11.85 *ab* |
| Complex fertilizers (N:P:K = 10:10:20) | 27.76 *a* | 5.42 *a* | 49.38 *a* | 6.49 *ab* | 28.52 *ab* | 13.93 *a* |
| Compost (70% manure + 30% plant residues) | 28.54 *a* | 5.49 *a* | 46.70 *a* | 7.64 *a* | 23.80 *ab* | 13.98 *a* |
| Complex fertilizers (N:P:K = 10:10:20) + HS fertilizers | 24.33 *a* | 4.21 *a* | 38.54 *ab* | 7.29 *a* | 34.23 *b* | 11.27 *ab* |

* Significant differences ($p < 0.05$) between the cultivars and fertilizers in columns are marked by different letters;
$LSD_{0.05}$ (B, Cu, Fe, Mn, Na, Zn): cultivar, fertilizer, cultivar x fertilizer – 0.00

The fertilizers used in the study showed different effects on the accumulation of micro-elements in the pumpkin fruit. The biggest amount of boron was found for the pumpkins fertilized with the compost. The mixture of the complex and HS fertilizers had a negative effect on the amount of boron compared with the control pumpkins, but no significant differences were found between the fertilizers used in the study. All the applied fertilizers reduced the amount of copper in the fruit, but increased the amounts of iron, manganese, sodium and zinc. The biggest concentration of iron was found in the pumpkins fertilized with the complex fertilizers – almost 1.5 times higher than in the pumpkins grown without fertilizers. Fertilization with the compost and the mixture of complex and HS fertilizers increased by 1.7-fold the amount of manganese. The pumpkins fertilized with the complex and HS fertilizers accumulated twice as much sodium as the control plants. The highest amounts of zinc were detected in the pumpkins fertilized with the compost and the complex fertilizers.

Danilchenko (2002) reported that higher levels of micro-elements were accumulated in pumpkins fertilized with the complex fertilizers. Our results are in accordance with those data, since the biggest content of the micro-elements was found in the fruit of pumpkins fertilized with the complex fertilizers.

# CONCLUSIONS

The mixture of complex and HS fertilizers showed the strongest positive influence on the accumulation of dry matter in the fruits of the pumpkin cultivars tested. All the fertilizers used in the study increased the amount of crude ash in the pumpkin fruit pulp. The biggest amount of crude ash was found in the pumpkins fertilized with the complex fertilizers and the mixture of the complex and HS fertilizers. The biggest average content of the macro- and micro-elements was found in the fruits of pumpkins fertilized with the complex fertilizers. All the applied fertilizers increased the calcium, iron, manganese, sodium and zinc content in the pumpkin fruit, although they reduced the amount of copper.

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