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Effect of fertilizers on oil pumpkin seeds crude fat, fibre and protein quantity

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Abstract. An investigation of the chemical composition of seeds of various oil bearing pumpkin cultivars grown with different forms of fertilizers was conducted in a certified organic field of the Lithuanian University of Agriculture; three oil pumpkin cultivars (*Cucurbita pepo* var. *styriaca* L.) – 'Miranda', 'Golosemiannaja' and 'Herakles' were grown in 2004–2005. The aim of the investigation was to evaluate the impact of organic and chemical fertilizers on the chemical composition of seeds of different cultivars. The following fertilizers were applied: humic acid fertilizers (the rate was calculated according to the required amount of Humistar) – 30 l ha^{-1}; complex fertilizers (N:P:K – 10:10:20) – 500 kg ha^{-1}; compost (70% manure + 30% plant residues) – 40 t ha^{-1}; complex fertilizers (N:P:K – 10:10:20)+ humic acid fertilizers – 500 kg ha^{-1} + 30 l ha^{-1}. Standard analytical methods were used to determine crude fat, protein and fibre content. Higher amounts of crude fats were found in seeds of the control (non-fertilized) pumpkins. Compost, humic acid and complex fertilizers had non-significant effects on the synthesis of crude fats, however, they increased the amount of crude fibre in seeds. The highest amount was found in seeds of the pumpkins fertilized with humic acid and complex fertilizers. A mixture of complex and humic acid fertilizers significantly reduced the amount of crude fat in oil-cakes. Complex fertilizers and mixtures of fertilizers stimulated the process of crude protein accumulation in seeds.

Key words: Oil pumpkins, cultivars, fertilizers, chemical composition

INTRODUCTION

Nowadays pumpkins are grown all over the world, except in the northern regions. Oil pumpkins originate from southern Austria (Styria district) and are being grown increasingly in the Czech Republic, Hungary and South Ukraine. This vegetable is valued in many countries, e.g. pumpkin seeds are at the top of Japanese table of food products. Seeds of oil pumpkins are a good raw material for the production of oil used in food preparation and in medicine (Lazos, 1986; Elmadfa et al., 1999). An average yield of pumpkin seeds reaches 2–4 t ha^{-1}. Seeds contain up to 50% fats, up to 30% protein, sugar, B vitamins, ascorbic acid, phytosteroles, phytin, lecithin, oxycerotine, tyrosine, salicylic acid and resins. Seed oil is rich in glycerides of linolic, oleinic, palmitin and stearine acids. Omega-3 fatty acids, present in pumpkin seeds, not only help to prevent artheriosclerosis, high blood pressure and heart diseases, but also stimulate metabolism of accumulated fats. Research indicates that omega-3 fatty acids help transport fats to cells, where they are metabolized. Oil dregs and oil-cake,

containing over 70% fats and 14% protein, can be a valuable source of fats and other components in animal feed. Oil-cake fats contain large amounts (almost 60%) of omega-3 acids, twice that of cod liver oil (Ekpedeme et al., 2000; Kreft, 2002; Paulauskiene, 2005; Jariene et al., 2007). Populations of West Ukraine, Hungary, Germany, Austria, Romania and Italy use pumpkin oil as a food (Elmadfa et al., 1999; Ekpedeme et al., 2000). In Lithuania, pumpkins are being "discovered" as a vegetable; earlier they were used as animal fodder or grown as ornamental plants. Pumpkin seed oil is still a novelty, although it has been sold in shopping centres, natural food stores and pharmacies for several years.

Pumpkins are drought-resistant but sensitive to soil acidity. Optimal pH is equal to 6.0–7.5. Soil should be light, quick to warm up, well fertilized and irrigated. Sandy loams and loams with permeable subsoil are best. Mobile phosphorus and potassium are very important for the setting, development and storage of pumpkin fruits (MacCarthy et al., 1990; Murkovic et al., 2004). According to literature, various complex fertilizers with macro- and microelements are recommended for pumpkin. Universal garden fertilizers containing N:P:K at the ratio of 10:10:20, are used for the basic fertilization. These are granulated complex fertilizers, which contain the optimal amount of macro- and microelements necessary for plant growth (N:P:K = 10:10:20 + 4.2% MgO, 11% S, 0,15% B, 1% Ca, 0.1% Cu, 0.1% Fe, 0.7% Mn, 0.01% Mo, 0.1% Zn, 0.001% Se). Fertilization rate at the level of 500–700 kg ha^{-1} is recommended for pumpkins (MacCarthy et al., 1990; Lundegardh, 2003; Paulauskiene, 2005). No data on the effect of complex mineral fertilizers on the biochemical composition of pumpkin seeds are available.

Recently, increasing attention has been paid to organic fertilizers such as humic acid fertilizer (N:P:K = 0:0:0), which is a product of huminic acids that occur naturally in humus and peat (Stevenson 1994). Humic and huminic acids have several ways of impacting plant development. First, huminic acids perform the physiological function of, and, in fact, are growth stimulators, stimulating root development, plant growth and the chlorophyll content of leaves. They also intensify respiration and photosynthesis, improve the intake of nutrients from soil, and reduce the intensity of chemical sorption. Therefore, in soil with high huminic acid content, less of the phosphorous available to plants is reversed to unavailable compounds. From the ecological point of view, humic acid fertilizers can be applied to reduce the impact of pesticides on plants (huminic acids combine toxic elements, including radioactive isotopes, to immobile compounds) and to increase the decomposition of pesticide residues in the soil to non-toxic compounds (Oshima, 1996; Zukov, 1997; Karr, 2001; Lundegardh, 2003). However, the literature does not provide sufficient data about the impact of organic (humic acid) fertilizers on pumpkins and their seeds. Reports presented by numerous authors show that with the proper nutritional regime, plants can accumulate valuable, biologically active organic compounds.

The aim of the investigation was to evaluate the impact of organic and mineral fertilizers on the chemical composition of seeds of various oil pumpkin cultivars of Lithuanian, Russian and Polish origin.

MATERIALS AND METHODS

Oil pumpkin cultivars 'Miranda', 'Golosemianaja' and 'Herakles' were grown in the Experimental Station of the Lithuanian University of Agriculture (LUA) in 2004-2005. Plants were set out in the second half of May and harvested at the end of September. Pumpkins were fertilized with different fertilizers: B_1 – control (no fertilizers); B_2 - humic acid fertilizers (the rate was calculated according to the required amount of Humistar) – 30 l ha^{-1}; B_3 - complex fertilizers (N:P:K – 10:10:20) – 500 kg ha^{-1}; B_4 - compost (70% of manure + 30% of plant residues) – 40 t ha^{-1}; B_5 - complex fertilizers (N:P:K – 10:10:20) + humic acid fertilizers – 500 kg ha^{-1} + 30 l ha^{-1}. Humic acid fertilizers were sprayed on the soil surface, while complex fertilizers and compost were spread and introduced into the soil of each plot before sowing.

Plants were grown in four replications. All fields were equally fertile, therefore all blocks given identical treatments were situated systematically, i.e. following the same order. The total size of the plot was equal to 3 m^2, the width of the protective passage – 0,5 m. The cluster sowing method was applied: 2-3 seeds were put into one hole of 5-8 cm depth.

Soil tillage was performed according to the standard technology. The soil characteristics were neutral, humus rich, limnoglacial loam on moraine loam, calcareous deeper gleyic lumisol, medium phosphorus rich and medium potassium rich (Table 1).

Table 1. Characteristics of soil conditions in the field used in the experiment.

pH	Humus content,	P_2O_5 (mg kg^{-1})	K_2O (mg kg^{-1})
6.9	3.28	132.5	130.0

After harvest there were determined:
- content of crude fats: with Soxlet device (Methodenbuch, 1993)
- content of crude proteins: by Kjeldal method (Methodenbuch, 1993)
- crude fibre: by Weender method (Methodenbuch, 1993)

The investigations and analyses were carried out at the Lithuanian University of Agriculture. The investigation data was statistically evaluated, using the ANOVA program. Two-way analysis of variance was applied (factor A – cultivar, factor B – form of fertilizer).

RESULTS AND DISCUSSION

Seeds of oil bearing pumpkins appear to be the perfect raw material for oil production. In Austria, this oil is called 'Green Gold of Styria'. Authors indicate that seeds of oil pumpkins contain 37–50% of crude fats (Tarek et al. 2001, Oshima et al. 1996). According to our results, crude fat content in seeds varies from 43.4 to 47.2%. A slightly higher content of crude fats (45.5%) was found in seeds of 'Herakles' pumpkin (Fig. 1). Fat content in seeds of oil bearing plants is believed to depend on fertilizing: phosphorus fertilizers increase fat content, and nitrogen fertilizers decrease it. However, our experiment did not confirm that. Results showed a slightly larger accumulation of fats in seeds of the control (B1, no fertilizers – 45.9%), while

compost, humic acids and complex fertilizers showed no significant influence on crude fat content.

Some authors indicate that the amount of crude fat in oil cakes reaches 9–15% (Kreft, 2002). The residual amount depends on the technology used for oil pressing and on the genotype of the cultivars. The cold pressing method for oil extraction was used in our investigation and the quantity of crude fat in oil cake was determined. According to our results, 'Herakles' cv. (Tab. 2) showed the significantly lowest amount of crude fat in the oil cakes. It was established that the mixture of complex and humic acid fertilizers significantly influenced (1.3 times) this index, compared with results from the second variant.

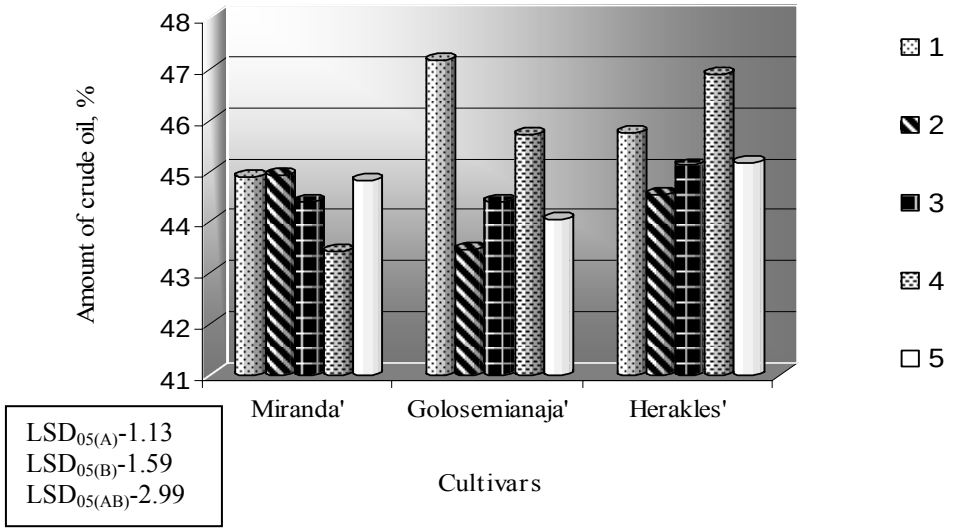

Fig. 1. Crude fat content in pumpkin seeds, means of 2004–2005 (%).
B_1 – control (no fertilizer), B_2 – humic acid, B_3 – complex, B_4 – compost, B_5 – complex + humic acid.

Table 2. Crude fat content in pumpkin oil cake, means of 2004–2005 (%).

Cultivar (A)	Fertilization (B)					$LSD_{05(A)}$
	B_1	B_2	B_3	B_4	B_5	0,54
Miranda	18.13	20.12	16.72	24.41	17.97	19.47
Golosemiannaja	19.21	18.18	21.67	22.38	15.45	19.38
Herakles	16.27	22.08	19.54	9.59	11.81	15.86
$LSD_{05(B)}$ 0.76	17.86	20.13	19.31	18.79	15.08	
$LSD_{05(AB)}$ 1.43						

Notes*: B_1 – control (no fertilizer), B_2 – humic acid, B_3 – complex, B_4 – compost, B_5 – complex + humic acid

Fibre (indigestible carbohydrates) stimulates the activity of bowels, combines heavy metals, cholesterol, and bilious acids and removes them from the organism, cleansing the human body of harmful materials, reducing the risk of artheriosclerosis and obesity, and even cancer. According to data, up to 13–14% of crude fibre is found in oil seeds (Tarek et al., 2001). In tested pumpkin seeds the amount of crude fibre made varied from 9.98% to 19.9% (Tab. 3). Seeds of 'Herakles' pumpkin contained the

largest amount of crude fibre (15.7%), which by 1.3 times exceeded that found in 'Miranda,' which had the lowest value of this index. In comparison with the control (B_1), fertilizers slightly increased the amount of crude fibre in pumpkin seeds. The highest amounts were found in seeds of the pumpkins fertilized with humic acid (B_2) and complex fertilizers (B_3), which exceeded the crude fibre amount in the control by 1.1 times. Potassium, which predominated in the composition of complex fertilizers, was the element that increased the amount of high-molecular carbohydrates in fibre. Only compost (B_1) had a slightly negative influence on mean values of this index. Results obtained indicate that the amount of fibre in pumpkin seeds, as well as in the fruit pulp, strongly depended on genotype.

Table 3. Crude fibre content in pumpkin seeds, means of 2004–2005 (%).

Cultivar (factor A)	Fertilization (factor B)					$LSD_{05(A)}$-1.37
	B_1	B_2	B_3	B_4	B_5	
Miranda	13.31	11.87	13.7	11.02	10.84	12.15
Golosemiannaja	13.40	16.56	9,98	10.11	13.88	12.79
Herakles	12.18	15.07	19.88	16.65	14.70	15.7
$LSD_{05(B)}$-1.94	12.96	14.50	14.52	12.59	13.14	
$LSD_{05(AB)}$ 3.62						

Notes*: B_1 – control (no fertilizer), B_2 – humic acid, B_3 – complex, B_4 – compost, B_5 – complex + humic acid

Proteins are easily absorbed by humans (in the rate of 65–80%) and appear to be the main 'building material' for cells of the human body. Seeds of oil-bearing pumpkins are a good source of crude proteins and can accumulate 35–40% of these compounds (Elmadfa et al., 1999, Tarek et al., 2001). The crude protein content in pumpkin seeds varied from 34.1 to 38.3% (Tab. 4); a slightly higher content of crude proteins (36,8%) was found in seeds of 'Golosemianaja' pumpkin. It was also established that all organic and mineral fertilizers increased the content of crude proteins in seeds. Significantly higher amounts of crude proteins, in comparison with the control (B_1), were found in seeds of pumpkins fertilized with complex fertilizers (B_3) and with a mixture of fertilizers (B_5) – 37.5 and 37.5%, respectively (Table 4). Nitrogen and phosphorus, existing as compounds of complex fertilizers, stimulate synthesis of crude proteins in pumpkin seeds, while huminic acids, contained in humic acid fertilizers, improve the intake of nutrients from the soil.

Table 4. Crude protein content in pumpkin seeds, means of 2004–2005 (%).

Cultivar (A)	Fertilization (B)					$LSD_{05(A)}$0.77
	B_1	B_2	B_3	B_4	B_5	
Miranda	36.23	36.06	36.91	36.86	37.01	36.61
Golosemiannaja	35.37	38.26	37.61	35.72	37.31	36.85
Herakles	35.93	34.09	37.92	35.99	38.07	36.40
$LSD_{05(B)}$-1.09	35.84	36.13	37.48	36.19	37.46	
$LSD_{05(AB)}$-2.05						

Note: B_1 – control (no fertilizer), B_2 – humic acid, B_3 – complex, B_4 – compost, B_5 – complex + humic acid

CONCLUSIONS

1. A higher amount of crude fat was found in seeds of unfertilized pumpkins. Compost, humic acid and complex fertilizers have no essential impact on the amount of crude fat.

2. A mixture of complex and humic acid fertilizers significantly reduce the amount of crude fat in oil- cakes.

3. All fertilizers increase the amount of fibre in pumpkin seeds compared with non-fertilized ones. The largest average amount of fibre was found in seeds of pumpkins fertilized with humic acid and complex fertilizers.

4. Compost, humic acid and complex fertilizers stimulate the process of crude protein accumulation in pumpkin seeds. Higher amounts of crude proteins were found in seeds of pumpkins fertilized with complex fertilizers and with a mixture of fertilizers.

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