POSITIVE EFFECT OF COMPOST APPLICATION ON OIL PUMPKINS GROWTH AND ZINC ENRICHMENT

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Pumpkins producing area is rather small (tens of hectares) in Lithuania, but crop is especially approved in organic farms. However, only a few studies for selection of varieties, growth technology and qualitative characteristics of pumpkins are carried out in Lithuania. Sientifically based reccomendations would encourage to choose most valuable varieties of pumpkins in terms of yield and its quality. Traditionally, pumpkin seed oil and pumpkin seeds in general have been said to boost mood and ward off depression, linked to positive effects on hair growth and skin condition. Pumpkin seed oil is rich in polyunsaturated fatty acids, antioxidants therefore has beneficial effects for heart and liver health and immune support. Futhermore, pumpkin seed oil seems to have a positive effect on the urinary tract.

The field experiment has been conducted with five different substrates used for pumpkin "Gleisdofer" (*Cucurbita pepo* L., Gleisdofer) fertilizing: thermally processed green waste; mixture of slightly fragmented horse manure, softwood sawdust and ground; fresh deciduous leaves; naturally rotten vegetables; and high degree of fragmentation horse manure substrate. Pumpkins harvested after 120 days of vegetation season. Basic chemical parameters of compost and pumpkins, also some biometric parameters of pumkins have been determined. It was found, that zinc content almost doubled from 6,4 mg/kg to 11,3 mg/kg in the tested composts. Zn accumulation in pumkin seeds depends not only on the agrochemical composition of the substrate, but also on the degree of maturity. Amount of zinc in analysed pumpkin seeds has increased by 3,5 times - from 8,76 mg/kg to 30,4 mg/kg. It has been determined, that the greatest possitive effect on the accumulation of Zn in pumpkin seeds has thermally processed green waste, the least effective – naturally rotten vegetables. Statistically significant difference of Zn accumulation in pumpkin seeds among other types of substrates has not been determined.

Key words: pumpkin seed quality, zinc, pH, dry matter content, level of maturity.

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INTRODUCTION

Cucurbita pepo is among the economically most important vegetable crops worldwide and is grown in almost all temperatures (Alius et al. 2011). Oil pumpkin (*Cucurbita pepo* L.) Gleisdorfer Öilkürbis, a naked seeded pumpkin, oil content amounts 43–45 %, registered in Slovenia since 1986, originally they come from the South Austria. Maturity is reached within 140-150 days in mild season. The length of stem up to 10-12 m, flowers are large, yellow, fruits are round, orange with green spots, seeds – dark green with a thin shell, crop potential 1,3-1,5 t/ha of dry seeds. The variety was especially created for oil. The oil has a dark green colour and is a source of zinc for human body. Also, these seeds are used in confectionary industry to produce various sweets. Pumpkin is becoming increasingly popular because of its technological and nutritional properties far superior to other cultures (Gong et al. 2012).) Pumpkins are appreciated not only for nutritional and healing properties, but for simple cultivation as well. Pumpkins are not high-calorie: 100 g energy value is hardly from 17 kcal to 31,6 kcal. Oil pumpkins belong to ordinary Cucurbita pepo pumpkin species; in Lithuania oil seeds pumpkins are commonly grown not only for oil seeds and flesh but also for fruit crops (Černiauskienė et al. 2015).

The highest percentage of proteins and oil in pumpkin seeds, reflecting the importance and the nutritional value of the product, have been reported in literature (Mohamed et al. 2009). Oil pumpkin seeds contain a lot of fiber, high in fat (about 50 %), proteins (up to 30 %), B vitamins, fitosterins, cucurbicin, beta and gamma tocopherols, resins, mineral elements (K, Mg, Ca, Na, P, Fe, Se et al.). One of the most important mineral elements is zinc, which is found in seeds up to 130-202 mg/kg (Brant-Loy 2004). Literature indicates that the zinc content in the seeds depends on soil chemical composition, the degree of seeds‘ maturity and the vegetation period. Zinc contet can vary from 15 mg/kg to 100 mg/kg (Zhimang et al. 2011). The Cucurbita pepo has been cultivated for a long time not only for food but also for its medical properties. Particular healing properties have been attributed to each part of the fruit and the plant. Pumpkin seeds stimulate the appetite, are beneficial for the teeth, nerves, hair and nails. The application of integrated fertilizers for substitution of chemical fertilizers could provide the nutrients needed for pumpkin to achieve its optimum growth. Usage of the chemical and integrated fertilizer systems, along with the pruning of head, played a significant role for the seed yield and oil content in pumpkins. Some authors point that combining biological and lower amounts (50 %) of chemical fertilizers under favourable conditions lead to increased pumpkin crop quantity and quality (Zarei et al. 2016). Plant nutrients in soils are gradually ingested by plants or redistributed to ground or underground waters, resulting in the degradation of soil fertility. Composts, such as composed sewage sludge and livestock manures, although slightly less in plant macronutrients (such as N, P, and K) than chemical fertilizers, are often abundant in relatively stable organic matters and plant micronutrients (Yu-Yu et al. 2004). There is a very limited amount of literature regarding the effects of organic matter and metal oxides in compost on the fate of nutrients.

Therefore, the effect of humic and fulvic acids extracted from compost on the adsorption of metal oxides in fruit of oilseed pumpkin has been investigated (Danilcenko et al. 2016). Some authors state that zinc content in pumpkin seeds may depend not only on the chemical composition of the cultivation substrate, but also on the degree of maturity (Bannayan et al. 2011). Other researchers have found that organic mulch has a significant impact on the accumulation of crude fibre in the flesh. Crude protein accumulation in the fruit flesh was essentially affected by 5 cm thick layer of substrate. Mulching with 5 and 10 cm compost layer has significantly influenced on increased amount of crude fibre (Černiauskienė et al. 2015).

Table 1. Zinc content and pH depending on compost composition

Treatment	Composition of Compost	pH_{KCl}	Zn, mg/kg
TP	Thermally processed green waste	5,8	9,92
HM+SD	Mixture of slightly fragmented horse manure, softwood sawdust and ground	7,2	10,0
FL	Fresh deciduous leaves	7,4	11,3
RV	Naturally rotten vegetables	7,2	7,3
HM	High degree of fragmentation horse manure substrate	6,9	6,4

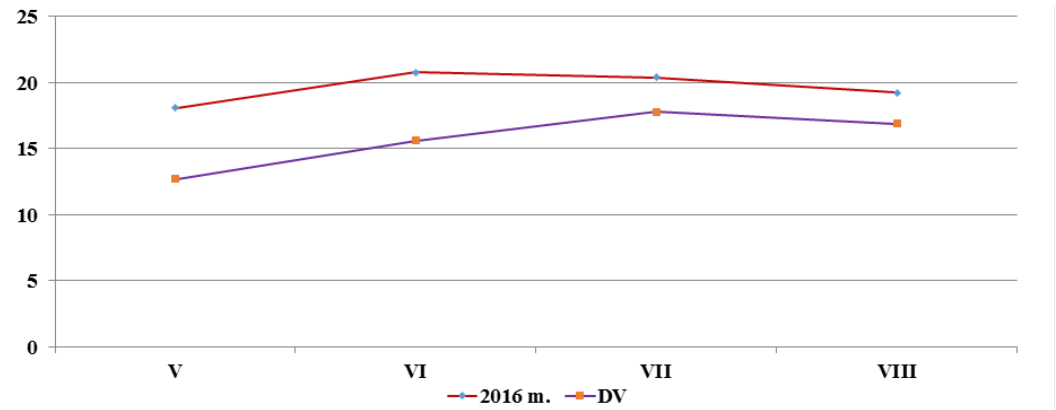

Fig. 1. Variation in mean temperatures during vegetation season (in May-August), 2016 compared with the average multi-annual temperature DV (Galvonaitė et al. 2013).

MATERIAL AND METHODS

Field experiment was conducted in the Vilniaus kolegija/University of Applied Sciences Agrotechnologies Faculty Training nursery (Buivydiškės, Vilnius area, 54° 43' 19.04", 25° 11' 38.61"). The plots were arranged in a randomized design with five treatment during the vegetation period from May 2016 to September 2016. Experiment was conducted with five different substrates used for pumpkin (*Cucurbita pepo* L.) fertilising. Different composts were prepared: 1. Thermally processed green waste (TP); 2. Mixture of slightly fragmented horse manure, softwood sawdust and ground (HM+SD); 3. Fresh deciduous leaves (FL); 4. Naturally rotten vegetables (RV); 5. High degree of fragmentation horse manure substrate (HM). Before planting the pumpkins, substrate samples were analyzed for agrochemical properties (Table 1). The article deals with the influence of pH and Zn content in different substrates on the productivity of oil pumpkins.

Sowing time – on the 20th of April, 2016 in a greenhouse to the universal substrate, planted into vegetative pots on the 6th of May, 2016. Date of harvesting – on the 9th of September, 2016. Plant care - during pumpkin fruit formation two early stages were left on the plant. During growth the pumpkins were watered every week. They were grubed up and loosened by hands. Additional fertilization was not applied. Mildew (Erysiphe cichoracearum) occurred in the second half of the vegetation, but the additional plant protection measures were not applied. Observation - morphological parameters were evaluated during plant growth; Principal growth stage 2 (formation of side shoots) BBCH – 21; Principal growth stage 6 (Flowering) BBCH – 61; Principal

Table 2. Pumpkin‘s fruit weight, dry matter content and level of maturity in terms of the BBCH

Treatment	Weight per Pumpkin, g	Dry Matter Content in Fruits, %	Fruit Ripeness
TP	2551	11,02	Fully ripe: fruits have typical fully ripe colour
HM+SD	1894	7,11	70 % of fruits show typical fully ripe colour
FL	1951	8,90	90 % of fruits show typical fully ripe colour
RV	2004	6,89	50 % of fruits show typical fully ripe colour
HM	2150	6,51	80 % of fruits show typical fully ripe colour

growth stage 7 (devolopment of fruit) BBCH – 71; Two fruits from each replication were assessed. The obtained data was processed by analysis of variance method.

Crop has been grown in open field therefore meteorological conditions are shortly presented below. Vegetation season was dry and with higher than regular temperatures (Fig.1). September started with early frosts, and pumpkins‘ vegetation period ended.

RESULTS

Pumpkin seeds and fruit maturity were fixed at harvest time. However, for successful management of nutrients cycle in the soil, matching crop needs, the rates of mineralization of organic amendments should be estimated, likewise the influence they exert on soil processes and properties.

One of the most important factors that determine the degree of maturity of the plants and the dry matter content are the weather conditions. The weather conditions were not especially conducive to the investigation, changeable at all stages of growth. The average air temperature at the beginning of the pumpkins‘ growing was 18,1°C, the highest air temperature in May has risen to 27°C in the third decade of the month. The months June and July were very changeable, although air temperature in day time went up, often above 25°C, but cool nights were able to influence the formation of pumpkin fruits. More chilly and less sunny August weather slowed development of pumpkins. An early frost in September brought forward the harvest time. The full degree of maturity has been reached only by pumpkins, which grew up in the thermally recycled green waste compost (TP), in this case, the highest dry matter content in the fruit flesh has been determined – 11,02 % (Table 2). The lowest maturity was established in pumpkins, which were grown up in naturally fragmented vegetable compost (RV) (colouring of the fruit was 50 %), it recorded a lower dry matter content (6,89 %) compared to the fruits of full maturity.

The dry matter content in plants is one of the most important indicators for the chemical composition which determines the quality of the products. After investigation has been carried out, it was determined, that the dry matter content in oil pumpkins‘ flesh ranged from 6,51 % to 11,02 % (Table 2). The highest fruit weight (2551 g) has been set in the pumpkins of complete ripeness. Mineral content in the fruits may depend not only on the chemical composition of the growing substrate, but the degree of ripeness as well.

Table 3. Pumpkin seeds yield and dry matter content in pumpkin seeds, %

Treatment	Seeds per Pumpkin, g	Seeds Weight, g/1000 seeds	Underdeveloped seeds, %	Dry Matter Content in Seeds, %
TP	58	180	12	92,31
HM+SD	42	184	6	87,16
FL	44	208	9	89,45
RV	55	222	2	80,76
HM	54	195	4	84,20

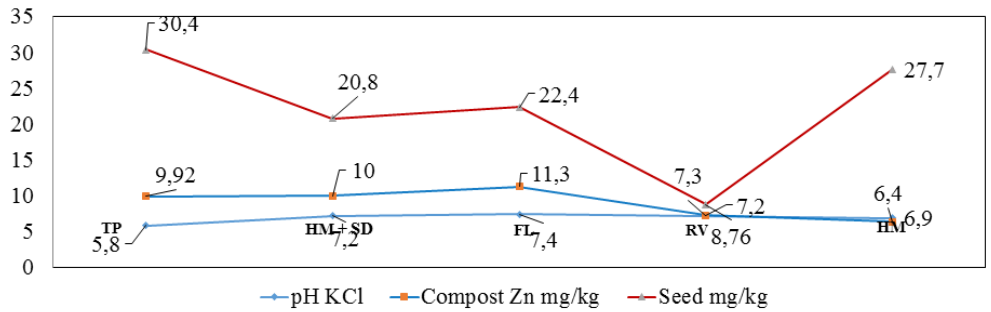

Fig. 2. Accumulation of zinc in seeds depending on the properties of compost.

Growing duration of oil pumpkins is directly dependent on meteorological conditions. During research, in all periods of growth, the weather conditions were not very favourable for pumpkins' development, a significant amount of undeveloped seeds shows this (Table 3). In May 2016 a monthly average air temperature was 18,1°C in Vilnius. The highest temperature in the third decade rose to 27°C. Months June and July were very changeable, though in the day time the temperature often rose above 25°C, but the cool nights could affect the pumpkins' fruit formation. More chilly and less sunny August weather hampered pumpkins' maturity. Dry matter content in pumpkins' seeds ranged from 80,76 % to 92,31 %. Comparing with the average multi-annual temperature, higher temperatures are recorded every year, so selection of oilseed pumpkins' varieties with shorter growing period should required and pumpkins' areas in Lithuania should increase.

Some agroclimatic features like temperature, precipitation, and sunshine hours are key variables for the optimum growth and sustainable yield of summer squash. Cultivation of marginal crops such as summer squash is a unique opportunity for increasing sustainability and biodiversity in agricultural lands.

Compost is widely used as a natural soil conditioner and fertilizer supplement in gardening, planting and agriculture. Ability of compost to retain and release nutrients over time offers potential use for control of excessive nutrient release to the environment; this ability may be further improved by the addition of adsorbents to facilitate rapid retention of nutrients. Vegetative composts, containing the modest zinc reserves, were used in the research. Composts differed in pH and zinc content (Table 1). The highest zinc content was determined in fresh deciduous leaves compost (FL), which pH, comparing with the other composts used in the study, was the highest (pH_{KCl} 7.4). Composts manage to improve soil structure and encourage soil biological diversity and activity but vary greatly in their composition, degree of stabilization and ability to release nutrients for plants. Assessing the effect

of the growth conditions, it was found that the most favorable substrate pH_{KCl} is 5,8 ir 6,9, the significantly highest zinc content in pumpkins' seeds was accumulated in these cases - 30,4 mg/kg and 27,7 mg/kg accordingly (Fig.2).

Zn content has been evaluated during the investigation, however, statistically significant difference between the zinc content in substrate and the degree of pumpkin maturity was not found. Fruit maturity of pumpkins, which have been grown in naturally rotten vegetative compost (RV), delayed (Fig. 3). It is likely that this was the reason for the accumulation of zinc in pumpkin seeds, in this case the least zinc content in seeds was determined – 8,76 mg/kg Zn (Fig. 4). The highest zinc content was determined in pumpkin fruits of full maturity - 30,4 mg/

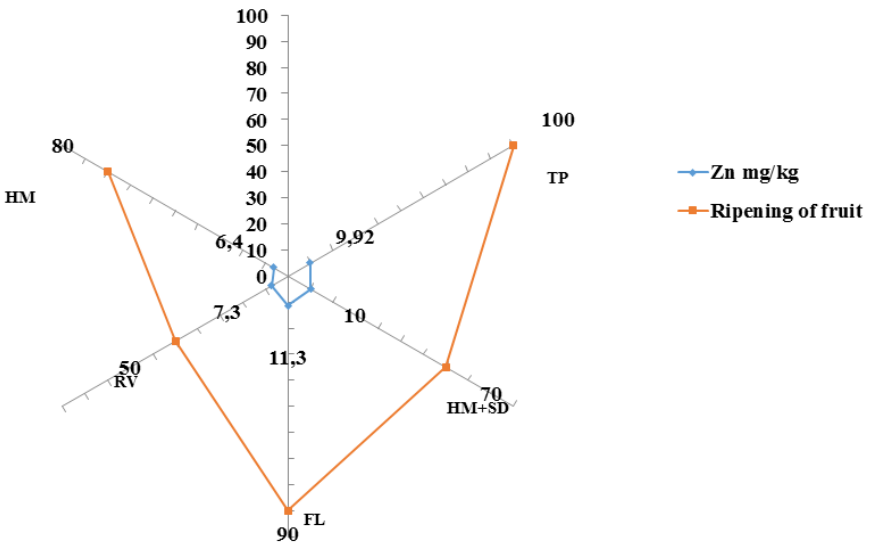

Fig. 3. Influence of zinc content in compost for fruits maturity.

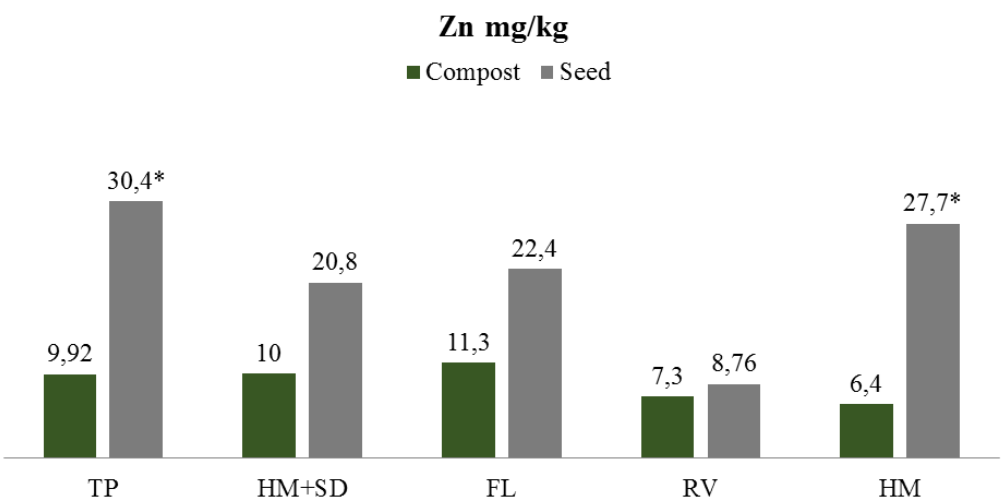

Fig. 4. Zinc accumulation in pumpkin seeds, depending on the level of zinc in compost (no significant differences; $p > 0,05$).

kg Zn. At harvest time pumpkin fruit maturity was determined by external characteristics. It is possible that pumpkin maturity was affected by adverse meteorological conditions in August 2016.

Analysis of research data has shown, that the most cumulative amount of zinc (30,4 mg/kg) was in pumpkin seeds, grown in thermally recycled green waste (TP) (Fig. 4). 3,5 times lower zinc levels were found in pumpkins, which have been grown in naturally fragmented vegetative compost (RV) seeds. In pumpkin seeds grown in composts of low decomposition (mixture of slightly fragmented horse manure, softwood sawdust and ground (HM+SD) and fresh deciduous leaves compost (FL)) statistically significant difference in accumulated zinc amount in seeds has not been determined.

Two important processes are going on in nature: migration and accumulation of the substances. The pH reaction of the substrate affecting not only conditions the soil‘s nutrient regime, its physical properties, biological activity of micro-organisms, normal development of plants, but also pH reaction of substrate influences amount of mineral substances, their mobility, toxicity, access to the output product. More acid medium increases the mobility of the metals, they migrate better, the possibility of better access to the plants emerges. After evaluation of results, it was found, that the highest quantity of zinc has been set in a substrate with pH 5.8_{KCl} (thermally processed green waste (TP).

CONCLUSIONS

Analysis of research data has shown that zinc content ranged from 6,4 mg/kg to 11,3 mg/kg in tested composts. The highest zinc content has been determined in fresh deciduous leaves compost (FL), which pH, comparing with the other composts used in the study, was the highest (pH_{KCl} 7,4). However, more favourable conditions for the accumulation of zinc in pumpkin seeds were established in substrates with a lower pH (pH_{KCl} 5,8 for thermally processed green waste (TP) and pH_{KCl} 6,9 for high degree of fragmentation horse manure (HM)), essentially the highest zinc content has been accumulated in these particular cases (30,4 mg/kg and 27,7 mg/kg accordingly).

Fruit maturity of pumpkins, which were grown in naturally rotten vegetative compost (RV), delayed, so it‘s likely the reason conditioned the accumulation of zinc in seeds, the least zinc content in the seeds has been determined in this case (8,76 mg/kg). Meanwhile, the highest zinc content (30,4 mg/kg) has been determined in the fruits of full maturity (thermally processed green waste compost (TP)).

The dry matter content in plants and seeds is one of the most important indicators for chemical composition which determines the quality of the product. It has been determined, that dry matter content in oil pumpkins‘ flesh ranged from 6,51 % to 11,02 %, meanwhile in pumpkins‘ seeds dry matter content reached from 80,76 % to 92,31 %.

It can be assumed that 2016 year was not favourable for medium early variety of “Gleisdofer“ (*Cucurbita pepo L.)* in the sense of meteorological conditions. Chilly and less sunny than usual weather in August 2016 stopped pumpkin maturity. It can be concluded, that shorter vegetation period oil pumpkin varieties should be grown in Lithuania to achieve the best qualitative and quantitative parameters for oil pumpkins diversity.

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