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ORIGINAL PAPER

THE POSSIBILITY OF BUTTERNUT SQUASH GROWING IN CONDITIONS OF SLOVAK REPUBLIC

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Abstract

Butternut squash (Cucurbita moschata Duch ex Poir.) is an important specialty vegetable native from Mexico. It belong to the family of Cucurbitaceae. Cucurbita moschata is cultivated for its young shoots, fleshy edible flowers and fruit. It is a healthy and functional vegetable because of its rich nutrients and bioactive compounds. Since ancient times it has been essential in the diet of rural communities and some urban areas worldwide. This vegetable is so far less-grown in Slovakia. The aim of the work was to evaluate the influence of genotype on the yield of seven selected varieties of butternut squash in the conventional growing system under the field conditions. The three-year experiment was established at Slovak University of Agriculture in Nitra. We observed the selected morphological features and the quantitative parameters of the butternut squash fruits. The morphological analysis showed that evaluated varieties of the butternut squash did not have a homogeneous morphology. For large-scale cultivation systems and for the direct sale of fresh fruit are suitable pear shaped varieties (Liscia, Orange, Hannah F1, UG 205 F1 and Waltham F1), which have high yields of fruits. The average weight of fruit was from 1.63 to 3.40 kg.

Key words: butternut squash, Cucurbita moschata, morphological features, variety, yield

INTRODUCTION

Butternut squash *(Cucurbita moschata* Duch. ex Poir.) is an annual plant of the genus *Cucurbita.* It was native to the low lands of tropical and sub-tropical America (Phillips and Rix, 1993; Bisognin, 2002) It is eaten as vegetable and cultivated for its young shoots, fedible flowers and above all, for its fruits (Jacobo-Valenzuela et al., 2011). Its fruits are one of the most important crop-plants in traditional agricultural systems in the world and a source of biologically active components (Guiné et al., 2012; Mendelová et al., 2017). Meanwhile, it is growth only rare in our conditions, in south parts of Slovakia and on very small areas.
According to the foreign literary sources, the division of the varieties of *Cucurbita moschata* differs in several sources, but all of them place importance on the morphological features of the fruits. Robinson and Decker-Walters, 1997, Ferriol and Picó (2008), introduce following groups of the varieties: "Cheese", which usually includes varieties whose fruits have flattened fetal shape with cinnamon color skin; "Crooknecks", whose fruits are rounded both on the flower and the stem end; the group named "Bell" has fruits with bell shape, that are almost cylindrical shaped. This group includes 'Butternut' varieties, characterized by high quality of the pulp, which belong among the most cultivated varieties. However, this division doesn´t include all types of varieties that occur in tropical areas.

The aim of the work was to evaluate the influence of genotype on the yield of seven selected varieties of butternut squash in the conventional growing system under the field conditions.

The field experiment was established in the premises of the BZ SPU in Nitra, in years 2013, 2014 and 2017 in the conventional cultivation system. Before the establishing, in spring a soil sample was taken from the experimantal

area in all three experimental years, followed by agrochemical analysis of the taken soil at the Department of Agrochemistry and Plant Nutrition of the Faculty of Agrobiology and Food Resources of the SPU in Nitra (Table1).

Table 1. Agrochemical characteristics of the soil before the field experiment establishing in 2013, 2014 and 2017.

Year	humus %	pH/KCl	Nutrients content in mg.kg^{-1} of soil					
			Nan	P	K	S	Ca	Mg
2013	3.52	6.96	18.5	199	609	-	4976	576
2014	3.46	6.47	19.5	86.3	498	26.25	610	816
2017	3.75	7.18	10.1	147.5	478	91.3	5850	766

Based on the agrochemical analysis of the soil and the recommended norms for the pumpkin cultivation depending on the production line in a given year, we applied in all cultivating years, nitrogen in the form of nitrogen fertilizer LAD (27% N) (60% of the recommended standard in the experimental area) two weeks before the planned spring planting in the experimental area. During the vegetation was fertlized with nitrogen fertilizer LAD (27% N) (40% of the recommended standard). In 2013 and 2014 the experimental area was in the first line, which represented nitrogen fertilization to the level of 150 kg of N. ha^{-1}; in 2017 was in the second line, it means nitrogen fertilization to the level of 170 kg N.ha^{-1}. The other macroelements were not applied within the experimental year since their soil content corresponded to the need of the butternut squash cultivation.

Characteristics of the used varieties

In the experimental years we were observing 3 varieties and 3 hybrids of the butternut squash: ´Liscia´, ´Orange´, ´Hannah F1´, ´UG 205 F1´,´Waltham F1´,´Matilda F1´ and ´Serpentine´. The supplier and the origin of the evaluated varieties of butternut squash are mentioned in the table 2.

Table 2. Assortment of evaluated arieties of butternut squash

Variety	Supplier	Origin
Liscia	Semo a.s.	Czech Republic
Orange	ZKI Vetőmag KFT	Hungary
Hannah F1	Enza Zaden	Holland
UG 205 F1	Unigen Seeds	USA
Waltham F1	Hollar Seeds	USA
Matilda F1	Enza Zaden	Holland
Serpentine	Semo a.s.	Czech Republic

Experimentation process

In the 2013 growing season, experimental undergrowth of butternut squash was planted on May 30, 2013, from the pre-planted seedings, which were cultivated in heated greenhouse of BZ SPU in Nitra. In the other cultivation years, the field experiment was established on the direct sowing on May 13, 2014 and May 11, 2017, in united cultivating plant distance 2,5 m x 1,5 m in three repetitions of 2 seeds to the nest, followed by manual uniting, which corresponds to 2666 plants per 1 ha. Within the each repetition, three plants were grown. The treatment of vegetation during the vegetation was realized according to the ususal agrotechnical procedures. Vegetation of the butternut squash was kept in non-weeded conditions by hand-digging 2 to 3 times until the vegetation engagig and was treated against fungal diseases. Fruit harvesting in all experimental years was realized gradualy in botanical maturity: 24 September and 10 October 2013; 18 September and 30 September 2014; 27 September, 16 October and 25 October 2017. From the quantitative parameters we evaluated the average number of harvested fruits per plant, the average fruit weight and the total harvest achieve.

RESULTS

Within the quantitative parameters of observed varieties of butternut squash, we evaluated the average fruit weight, the average number of harvested fruits from one plant, followed by total harvest achieve calculating, that we examined the whole evaluated period. As there are no relevant data of butternut squash harvested in the conditions of Slovakia and its total yield, the results we obtained we compared only with foreign literature. Kiramana et al. (2016)

reported in their studies, in which they evaluated 79 genetic sources of butternut squash, that the quantitative crop parameters are affected by wide genetic variability, which is reflected in the average number of male and female flowers per plant, the number of fruits per plant (from 1 to 9), the weight of one fruit (from 0.2 to 4.2 kg), the length and breadth of the fruit, the number of leaves produced per plant, the number of seeds per fruit and the weight of 100 seeds. Authors Jaeger de Carvalho et al. (2015), when assessing 20 genotypes of butternut squash, determined the average fruit weight ranged from 1.46 kg to 7.82 kg.

Based on the results of our experiments, we can state that the average fruit weight of the observed varieties of butternut squash at 2,666 plants per hectare ranged from 1.63 to 3.40 kg. The highest average weight was recorded at the hybrid variety Matilda F1. The average number of fruits harvested from one plant ranged from 5 to 13 fruits. The highest number of fruits in all observed years, we determined at the hybrid variety UG 205 F1 (Table 3).

Table 3. The average weight of single fruit (kg) and the average number of fruits harvested from one plant, of observed varieties of butternut squash

	Fruit weight (kg)			Number of fruits		
Variety/ Year	**2013**	**2014**	**2017**	**2013**	**2014**	**2017**
Liscia	1.97	1.73	2.08	8	5	7
Orange	1.68	1.63	2.70	8	6	10
Hannah F1	1.96	1.88	-	7	5	-
UG 205 F1	1.84	1.87	1.99	12	10	13
Waltham F1	2.09	1.75	1.88	8	7	10
Matilda F1	-	-	3.40	-	-	9
Serpentine	-	-	1.78	-	-	10

The statistical evaluation of our three years results by multifactor analysis of scattering, show statistically proven effect of the variety on the weight of single fruit (Figure 1). There was no statistically significant difference in fruit weight of the observed varieties of butternut squash between the cultivating years (Figure 2 and 3).

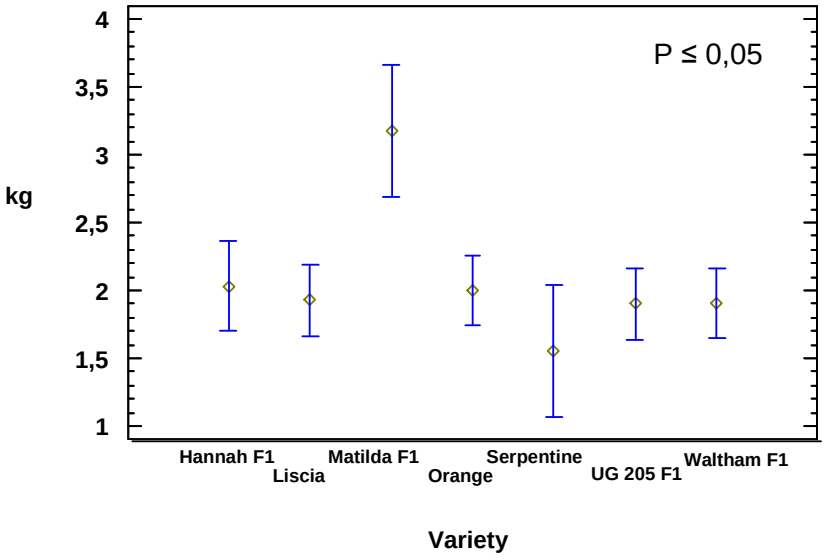

Figure 1. Graphical representation of 95% confidence intervals for the tested average weights of single fruit and varieties of butternut squash (LSD test)

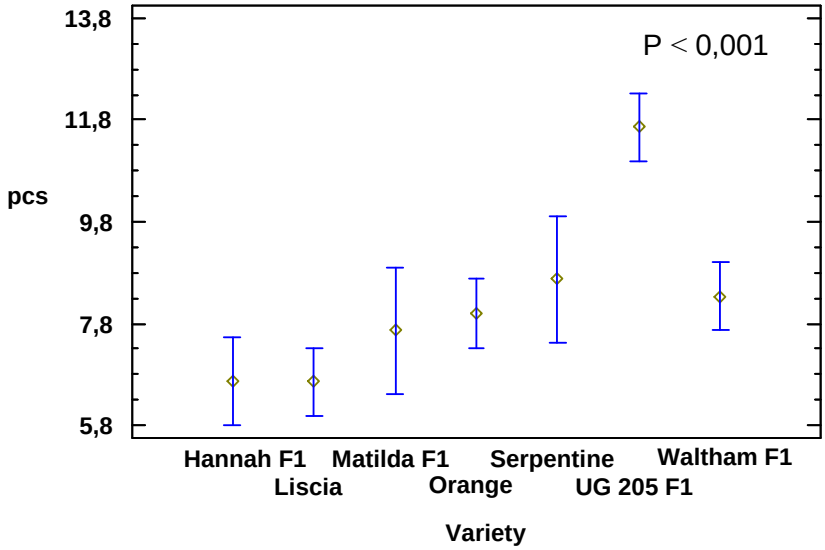

Figure 2. Graphical representation of 95% confidence intervals for the tested average number of fruits per plant and varieties of butternut squash (LSD test)

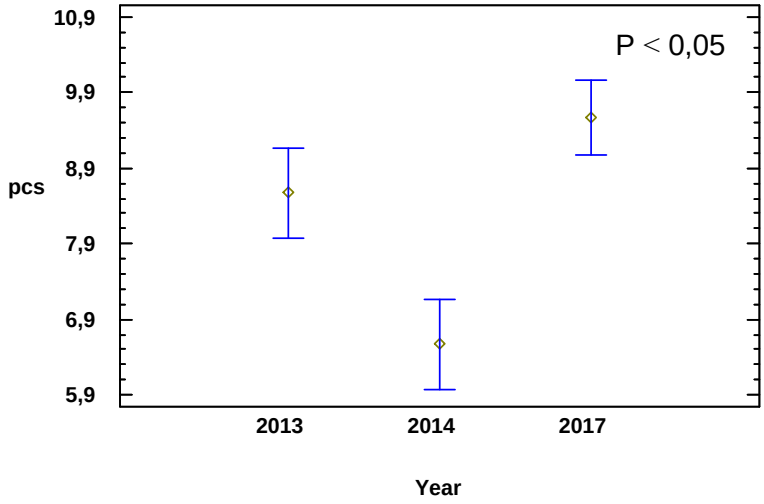

Figure 3. Graphical representation of 95% confidence intervals for the tested average number of fruits per plant of butternut squash, while showing years (LSD test)

In the cultivating year 2013, the fruit harvesting was carried out by gradual picking in two terms, the total harvest achieved for the observed varieties of butternut squash ranged from 35.80 to 58.36 $t.ha^{-1}$ (Table 4). The following year of 2014, we recorded a decline in total fruit harvest for all observed varieties of butternut squash. The highest yield of 49.98 $t.ha^{-1}$ was recorded at the hybrid variety UG 205 F1. In 2017, the total harvest achieved at all the observed varieties of butternut squash ranged from 37.02 to 78.61 $t.ha^{-1}$.

Table 4. Yield of fruits (t.ha^{-1})

Variety/Year	2013	2014	2017
Liscia	46.06	23.03	37.02
Orange	35.80	26.06	68.71
Hannah F1	36.08	25.07	-
UG 205 F1	58.36	49.98	66.72
Waltham F1	42.48	32.72	52.23
Matilda F1	-	-	78.61
Serpentine	-	-	45.23

Similar results are reported by Garza-Ortega and Serrano-Esquer (2007), who evaluated the crop yield at the 5 lines and 15 hybrids of butternut squash in field conditions in the area of Sonora in Mexico. Their findings show, that the average weight of single fruit was from 1.6 to 4.9 kg, depending on the line and hybrid. Total fruit yield ranged from 17.1 to 42.6 t.ha^{-1}. El-Hamed and Elwan (2011) evaluated in their two-years experiments the average fruit weight and total yield achieved at variety 'Dickinson' of butternut squash, dependig on the number of plants planted per hectar, namely 4780, 7170 and 9560 plants per ha^{-1}. Their results show that by increasing the number of cultivated plants on the unit of area, where the habit of the stem is creeping, there was an apparent increase in the average yield from 16.08 to 27.99 t.ha^{-1}, but at the same time the apparent reduction in the average weight of single fruit from 3.36 kg to 2.93 kg was present. Walters and Taylor (2006) report the positive effect of pollination by hive colonies on the total height of the yield of variety Libby's Select of butternut squash at the level of 74.83 kg, which is about 70.45 % higher increase compared to a version without the hives. On the basis of a statistical analysis of our results, using the multifactor analysis of variance, we can state that the genotype did not have a significant effect on the height of the yield of fruit of butternut squash (Figure 4). A significant difference in yield was found only between Matilda F1 and the Hannah F1, Liscia and Serpentine varieties. Impact of the year on the crop was statistically proven (Figure 5).

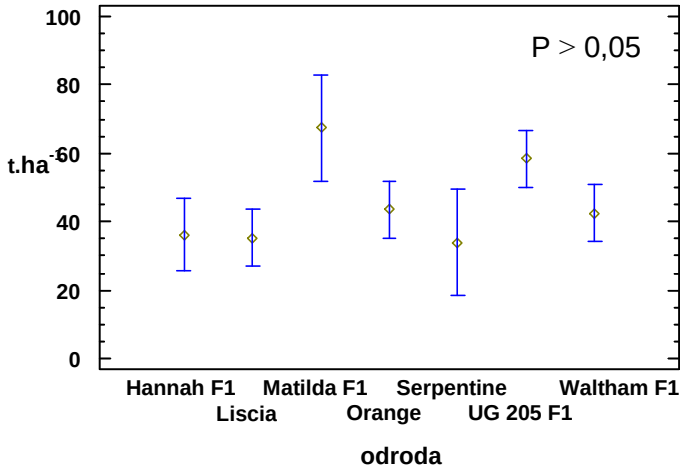

Figure 4. Graphical representation of 95% confidence intervals for the tested average yield of fruits and varieties of butternut squash (LSD test)

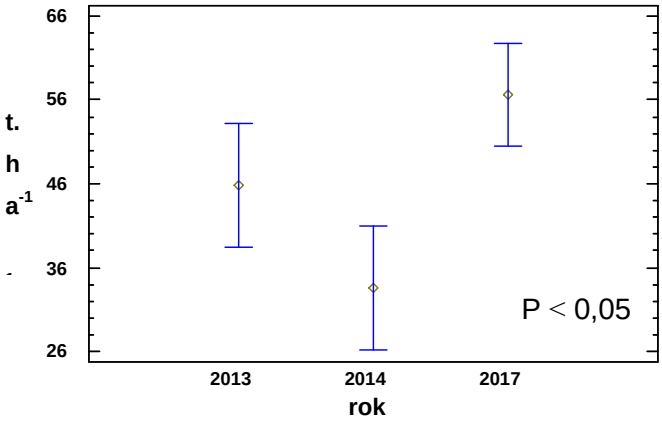

Figure 5. Graphical representation of 95% confidence intervals for the tested average yield of fruits and varieties of butternut squash, while showing years (LSD test)

CONCLUSIONS

Based on the evaluating of the average fruit weight, suitable varieties in terms of sales marketing for the direct sales of fresh fruits we do recommend following varieties: Liscia, Hannah F1, UG 205 F1 and Waltham F1, for which the average weight of the fruits during the reference period was 1.9 kg. The Matilda F1 variety has large fruits, with average weight of more than 2.5 kg and the fruits of the Orange variety have very unbalanced size, what may have negative impact on the marketing, especially in large commercial chains. The observed varieties of butternut squash are suitable for cultivating in field conditions in the warm locations of Slovakia, where they reach high yields.

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