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CROP QUALITY ASPECTS OF POTATO VARIETIES AND BREEDING CLONES IN ORGANIC FARMING SYSTEMS

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One of the indicators of quality is the starch content of the tubers. In order to evaluate the starch content for each genotype, the Institute of Agricultural Resources and Economics had set up a field trial in organic crop production system with 10 potato varieties and 10 breeding clones. A field trial was carried out in 2018-2020. The aim of the study was to evaluate and select potato varieties and clones with high starch content in the organic farming system.
The results proved impact of meteorological conditions on the starch content in the potato tubers. Starch content of varieties and clones varied from 12.68% to 20.63% on average in 3 years, significant impact of genotypes and years were observed ($p<0.05$). The highest starch content was found in 2019 for the variety 'Kuras' (21.32%) and for clones 19922.29 (21.0%) and 2008-6.5 (21.11%), also the following year these clones had a high starch content of (20.9%) and (21.17%), respectively. The high starch content in 2020 was also for the early varieties 'Monta' and 'Rigonda', 'Prelma' (21.17%). In 2018, many varieties and clones had a significantly lower starch content compared to 2019 and 2020 ($p<0.05$).

Keywords: potato, starch content, starch yield, meteorological conditions.

INTRODUCTION

In breeding program of new potato varieties, not only the yield potential of the genotype, disease resistance, but also the quality aspects of the tubers are always taken into account. One of the indicators of quality is the starch content in the tubers. Starch is a polysaccharide, consisting of two polymers: amylose and amylopectin (Li et al.,2006). In potatoes, starch is formed by photosynthesis, first in the green leaves and then accumulates in the tubers (Soest, 1996). Starch from potato tubers is one of the most important ingredients as it is used as a raw material in many industrial processes. The main nutrient of potatoes are carbohydrates, particularly starch and starch is the second main ingredient after water in tubers (Kuur et al., 2002). Potatoes have a high energetic value (340 kJ) due to their starch content (Jimenez et al., 2009). Potato starch ranks third in world production after maize and wheat starches. Its unique properties differ from those of cereal and pulse starches and are directly related to its molecular structure and organization (Stijn et al.,2020). If the starch content is above 20%, the genotype will be useful for processing into starch. Table potato varieties contain from 14 to 19 % starch in tubers. Potato genotypes with starch content less than 14% are useful as dietary products (Симаков, 2008). Starch content depends on several factors: genotype, maturity, growing conditions (Kita, 2002). A multi-year field trial with varieties revealed that tuber yield and tuber size differed significantly between farming systems. Studies in Latvia proved impact of growing conditions on starch content changes for several varieties (Skrabule et al., 2018). However, the effect of the farming system on the dry matter and starch content in tubers is inconsistent: J. Hajšlova et al. (2005) and J.F. Herencia et al. (2011) reported significantly lower dry matter and starch contents in tubers grown conventionally, whereas other studies did not find significant differences between farming systems.

In Latvia, a potato starch processing company ('Aloja Sterkelsen') expands starch production each year. In 2020, a total of 1853 tons of potato starch was produced, including 100 tons of organic starch. It is planned to increase the production of organic starch in the future, as it is in demanded both in Latvia and abroad.

The aim of the study was to evaluate and select potato varieties and clones with high starch content in the organic farming system.

MATERIALS AND METHODS

The research was arranged at AREI Stende Research Center in 2018 -2020 in the field of the organic farming system in 4 replicates with 10 potato varieties: ′Monta′, ′Rigonda′, ′Lenora′, ′Prelma′, ′Brasla′, ′Jogla′, ′Imanta′,

'Magdalena', 'Kuras' and 10 breeding clones: S 07169–35; 2008-6.5; S 07131–15; S 10063–128; S 10063–48; 19922.29; 2001-33.17; S 09035-22; 19694.5; S 07156–22. The potatoes were planted in the third decade of May, by hand and within a distance of 0.3 m between the tubers and 0.70 m between rows in the organic field. Soil in the field was: podzolized glazed loamy sand, sandy loam with soil acidity pH_{KCl} – 5.6 – 6. 3, organic matter content 2.5 %, P_2O_5 -250 mg kg $^{-1}$ and K_2O -110-140 mg kg $^{-1}$. After planting the potato plots were loosed 4 times and harrowed once. As treatment against the Colorado potato beetle (*Leptinotarsa decemlineata*) was used permitted at the organic system insecticide Neemazal, at a dose of 1L per hectare twice a season.

The starch content was determined as soon as possible after harvest for all genotype samples at same time. The starch content was determined using underwater weight. The genotype samples were selected from mechanically uninjured and disease-free tubers. The selected sample was washed and dried. The method makes it possible to determine the amounts of starch and high molecular weight starch degradation products in a sample in order to verify compliance with the declared energy value (provisions of Annex VII) and Council Directive 96/25 / EC (1).

Analyse of variance was applied for data interpretation. The correlation coefficient was calculated using the MS Excel function CORREL.

Climatic conditions. In 2018 climatic conditions were unfavourable for the potato vegetation. The drought and heat did not promote germination of seed tubers. According to the meteorological data, the soil temperature and in June exceeded +25 – + 27 °C in the end of May, which was not suitable for development of sprouts (Fig. 1). In 2019 and 2020 the precipitation and air temperature were optimal in season for potato growing and development. In 2019, spring was comparatively warm, the air temperature in April and May was above long term data, but the amount of precipitation was insufficient for vegetation, but in June and July it often rained and the amount of precipitation in July was above norm. Air temperature in this year was close to long term data, on average + 15.7 ° C. In moderately warm and rainy July, potatoes develop quite well. August was warm and relatively dry, the rainfall was below long term data, but the moisture content in soil was sufficient for the tuber developing. Potato varieties and clones had favourable weather for starch acumulation. To characterize the moisture supply of the annual vegetation season, a hydrotemic coefficient was calculated. Hydrothermal coefficient has been calculated by applying formula of G. Selyaninov: HTC= Σ x / Σ t x 10; where Σ x and Σ t – accordingly sum of precipitations and temperatures in the period, when the temperature has not been lower than 10℃. HTC was 0.25 in 2018, 0.35 in 2019 and 0.44 in 2020, which indicates insufficient humidity.

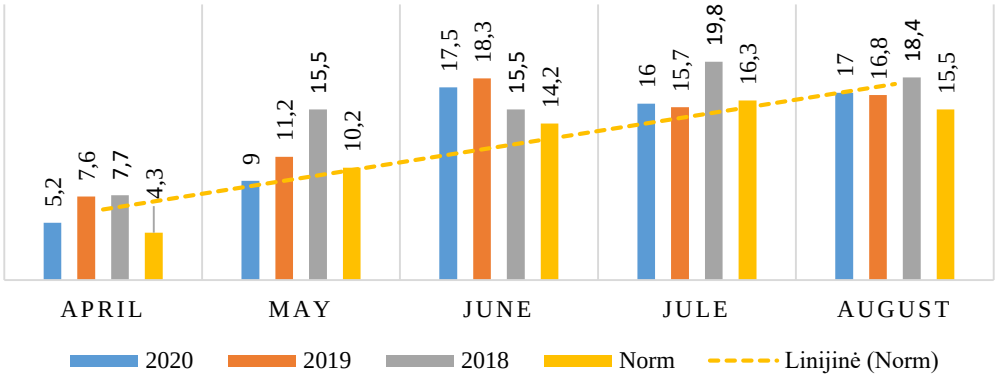

Figure1. Air temperature during trial years, ℃, 2018.-2020.

In 2020, the amount of precipitation was below the monthly norm in Stende in April and May. In May, rain was mostly in the 3rd decade of the month. Humidity in soil and air temperature were optimal during planting. Potatoes sprouting was observed evenly after 3 weeks. An average air temperature was about + 17.5 °C (3.3 °C above norm) in June, temperature was for 0.3 ° C lower than norm in July, and for 1.5 ° C higher than norm in August.

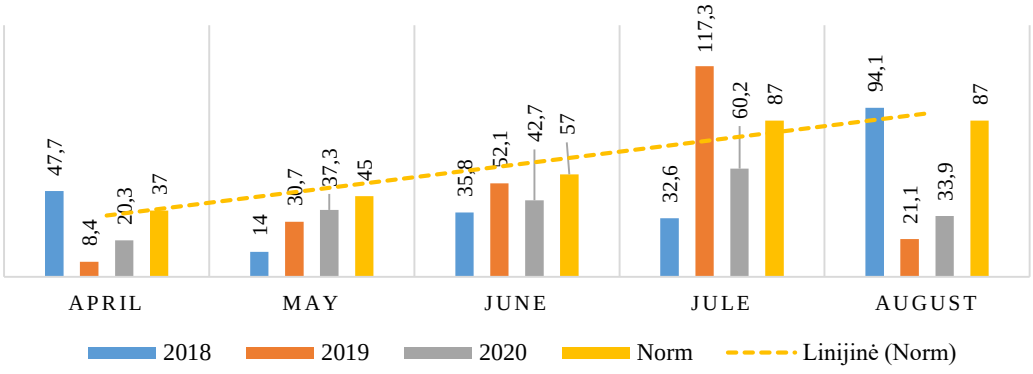

Figure 2. Total precipitation during trial years, mm, 2018-2020.

Precipitation was 74.9 %, 69.2 % and 39 % of the norm, respectively (Fig. 2). The weather conditions were suitable for potato development. Moisture in the soil was sufficient and the air temperature was acceptable.

RESULTS AND DISCUSSION

The results proved impact of meteorological conditions on the starch content in the potato tubers. Starch content of varieties and clones varied from 13.77 % to 20.56 % on average in 3 years, significant impacts of genotypes and years were observed ($p<0.05$).

Table 1. Starch content of potato varieties and clones in tubers, %, 2018-2020

Varieties/ breeding materials	2020	2019	2018	Average, starch content,%
Monta	21.17	17.09	15.02	17.76
Rigonda	21.17	16.97	13.67	17.27
S 07169-35	14.1	12.54	14.67	13.77
2001-33.17	16.19	15.06	11.78	14.34
Lenora	19.6	17.55	11.89	16.35
Prelma	21.17	12.16	14.63	15.99
S 07131-15	21.17	16.72	13.5	17.13
S 10063-128	14.1	15.15	13.35	14.20
S 10063-48	14.1	13.96	17.45	15.17
S 09035-22	14.1	13.67	15.13	14.30
19694.5	18.89	18.87	12.39	16.72
S 07156-22	16.48	15.25	13.94	15.22
Brasla	20.81	20.23	19.22	20.09
Imanta	19.6	20.31	18.26	19.39
19922.29	20.9	21.00	19.18	20.36
2008-6.5	21.17	21.11	19.41	20.56
Magdalena	17.09	15.23	15.27	15.86
Jogla	19.6	20.86	19.22	19.89
Gundega	19.6	17.84	17.24	18.23
Kuras	19.6	21.32	18.81	19.91
RS=3.23				

The highest starch content was found in 2019 for the variety ′Kuras′ (21.32 %) and for clones 19922.29 (21.0 %) and 2008-6.5 (21.11 %), also the following year these clones had a high starch content of (20.9 %) and (21.17 %), respectively. The high starch content in 2020 was also for the early varieties ′Monta′ and ′Rigonda′, ′Prelma′ (21.17 %), which can be explained by the warm and sunny August and plant foliage was not infected by late blight (*Phytophtotora infestans*), resulting in more starch accumulating in the tubers. In 2018, many varieties and clones had a significantly lower starch content compared to 2019 and 2020 ($p<0.05$). Studies elsewhere have also shown that starch content depends on several factors: genotype, growing and climatic conditions. In Poland, in the studies of A. Kitas, the starch content of five varieties ranged from 14.98 to 18.4 % (Kita, 2002), while in Italy the starch content of same varieties ranged from 12.22 to 18.63 % (Finotti et al., 2006).

The starch yield of potato varieties and clones is closely correlated with several factors: the starch content of the genotype, the tuber yield and the weather conditions. The correlation coefficient on average over 3 years was $r = 0.76033$, it indicated that there was a positive linear relationship between tuber yield and starch yield: with increasing tuber yield, starch yield increased, but the coefficient $r = 0.38864$ indicated that there is a positive linear relationship between starch content and starch yield: with increasing starch content, starch yield increased. Studies elsewhere also showed a strong positive correlation between precipitation and potato productivity ($r = 0.661$) (Norten and Gurung, 2020).

Table 2. Starch yield of potato genotypes, t ha^{-1}

Varieties/ breeding materials	2018	2019	2020	Average, t ha^{-1}
Monta	2.33	2.84	3.14	2.77
Rigonda	3.25	2.99	3.51	3.25
S 07169-35	3.13	3.67	2.86	3.22
2001-33.17	2.57	3.25	3.26	3.03
Lenora	2.52	3.49	2.40	2.80
Prelma	3.09	2.46	3.12	2.89
S 07131-15	4.25	3.82	4.51	4.19
S 10063-128	4.42	3.79	3.56	3.92
S 10063-48	3.31	2.56	3.06	2.97
S 09035-22	4.78	4.21	3.56	4.18
19694.5	4.21	2.80	4.04	3.68
S 07156-22	2.43	4.43	2.92	3.26
Brasla	5.12	4.69	3.94	4.59
Imanta	4.68	4.17	3.59	4.14

19922.29	5.74	6.46	3.93	5.38
2008-6.5	6.35	5.59	4.17	5.37
Magdalena	3.90	2.50	3.26	3.22
Jogla	4.75	7.07	4.80	5.54
Gundega	3.77	3.33	3.65	3.58
Kuras	5.17	7.48	5.90	6.18
RS $_{0.05}$=1.13				

Starch yield for potato varieties and clones differed significantly between growing years. The highest starch yield was for cultivars 'Kuras' – 7,48 t ha^{-1} and 'Jogla' – 7.1 t ha $^{-1}$ in 2019, and for clones 19922-29 – 6.5 t ha^{-1} and 2008-6.5 – 5.6 t ha^{-1}, which can be explained by higher tuber yields for these varieties and clones and high starch content – above 20%.

CONCLUSIONS

- The highest starch content was found in 2019 for the variety ′Kuras′ (21.32 %) and for clones 19922.29 (21.0 %) and 2008-6.5 (21.11 %);
- the highest starch yields were obtained in 2019 for potato variety ′Kuras′ – 7.5 t ha, ′Jogla′ – 7.1 t ha^{-1} and for clones 19922-29 –6.5 t ha^{-1}; 2008 – 6.5-5.6 t ha^{-1};
- In 2018, many varieties and clones had a significantly lower starch content compared to 2019 and 2020 ($p<0.05$).

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