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*Baltic Organic Potato for the World Markets*

# BALTORGPOTATO

## JOINT TESTING OF LATVIAN, ESTONIAN AND FOREIGN POTATO VARIETIES FOR SUITABILITY TO STARCH PRODUCTION IN ORGANIC FARMING

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## Introduction

The agricultural production in border rural regions of Latvia and Estonia is essential way of population's business and living standard providing today and it could increase in future. But large distance from cities and towns makes difficulties in agricultural products marketing. Due to Latvian Ministry of Agriculture support (subsidies for production organically certified production) a lot of farms turned to organic farming in Latvia. Especially during 2004-2007 they increased significantly - from 1043 ha in 2004 till 4120 ha in 2007, it makes 7 % of arable land. There are about 1000 organic farms in North Latvia region, for instance: 335 organic agricultural farms in Cesis region, 178 – in Limbazi region, 157 – in Aluksne region, 150 – in Valka region etc. As it is often characteristic for organic farms, they are wide-ranging in the broad assortment of production: dairy production and crop production, including potatoes and vegetables. According to our experience around 20 % of organic farms have significant areas under organic vegetables. Some of them are joined in the association/cooperatives with common marketing.

There was about 4 % of agriculture area converted as organic in Estonia in 2007. Most of the organic farms are mainly concentrated to the South-East Estonia. The marketing of organic products is rather poorly developed yet. The most common marketing channels are direct sales from the farms, and supplying hospitals, schools, kindergartens and local shops. Very few farms sell processed products. There is great potential for development.

Aloja Starkelsen ltd. (Latvia, Limbazi region) developed organic starch production for EU and world markets. The expected amount of produced starch will be 1500 t in 2013. For this purpose 7500 t of raw organic potato is required. It makes challenge for organic farmers in surrounding area – North Latvia and South Estonia. Farms have opportunity to market organic potatoes for providing starch production. Successful organic starch production arise requirement for qualitative organic potato seed material, so part of organic farms, which are not so close to starch factory, would produce organic potato seed for starch potato production. The initial potato seed material of varieties suitable for starch production will be provided by research and breeding institutes State Priekuli Plant Breeding Institute (Latvia) and Jõgeva Plant Breeding Institute (later Estonian Crop Research Institute) (Estonia).

Potato varieties with particular traits are required for organic starch production – starch content higher than 17 % and good resistance to *Phytophthora infestans*.

**The aim of study was to evaluate potato varieties for suitability to starch production in organic farming. The importance of seed tubers pre-sprouting was assessed.**

## Materials and methods

Field trials were carried out in Latvia at State Priekuli Plant Breeding Institute (Priekuli) and in Estonia at Jõgeva Plant Breeding Institute (later Estonian Crop Research Institute).

**Short description of institutions**:

***State Priekuli Plant Breeding Institute*** was founded in 1913, and is the oldest and most experienced agricultural scientific centre in Latvia. The institute covers wide range of activities on areas of practical plant breeding, seed production, preservation of plant genetic resources, applied and fundamental research, involvement in postgraduate studies and advisory activities. The main aim of Priekuli PBI is to develop and introduce into production new varieties of barley, winter rye, winter triticale, pea and potato with traits suitable for Latvia growing conditions and acceptable to producers demands. 16 researchers are involved in scientific work. Different research has been done with crops in frame of EU, Latvia Scientific Board, Ministry of Agriculture supported projects. The Institute has international collaboration with scientific institutions in Estonia (Jogeva PBI, EVIKA RC, Saku RC), Lithuania (LIA), Sweden (SLU), The Netherlands (Wageningen University) etc.

The total arable area is about 300 ha. The seed production of cereal, grasses and potato is carried out in institute. A part of fields (13 ha) has been certified for organic production and organic potato, rye, barley and clover seed material has been produced in organic crop rotation.

The potato breeding is carried out since 1931. During this time several varieties, suitable for starch production are bred in Priekuli. 'Brasla'- medium late variety with stable starch content higher than 16 %, 'Sigunda' – medium late variety, relatively resistant to late blight (*Phytophthora infestans*), 'Zīle' – medium late variety with high starch content, 'Imanta' – medium late variety with high and stable starch content and relatively resistant to late blight.

The research in organic farming was started in 2003 in Priekuli. Test trials for potato varieties suitability for organic farming was done, some trials of seed production improvement has been carried out as well. ESF co-financed project related to breeding for organic farming (environmentally friendly farming) is carried out in Priekuli from 2009. The potato research is one of project directions.

Plant breeding at Jõgeva was founded in 1920 as an institution dealing with breeding of field crops and agrotechnology studies of field crops in Estonia. Today, the **Jõgeva Plant Breeding Institute**, from the July 1st 2013 as **Estonian Crop Research Institute** (ECRI), is the state research and development institution under the supervision of Estonian Ministry of Agriculture dealing with plant breeding and applied plant sciences.

The main areas include practical breeding of agricultural and horticultural crops (winter rye, winter and spring wheat, barley, oats, field pea, potato, vegetables, forage grasses and legumes), applied research on agrotechnical aspects and seed production of agricultural crops and on genetics and heritability of valuable traits, selection and description of genetic resources.

Commercial activities of ECRI include maintenance breeding, production of breeder's seed, production and marketing of certified seed and representation of varieties of foreign breeding companies, and collection of royalties according to intellectual property rights based on the Plant Variety Protection Act. Since 1920

ECRI has bred all together 285 varieties from 56 different crops. Several varieties bred at ECRI are cultivated in other Baltic and Scandinavian countries.

**Description of potato varieties tested in trials**:
**'Brasla'** – developed in Priekuli, medium late, high and stable starch content, yellow skin and flesh, mealy after boiling, suitable for organic farming.
**'Imanta'** – developed in Priekuli, medium late, high starch content, and yellow skin with pink spots, white flesh, mealy after boiling.
**'Lenora'** – developed in Priekuli, medium early, comparatively high starch content, yellow skin and flesh, medium mealy after boiling.
**'Gundega'** – developed in Priekuli, medium late, comparatively high starch content, pink skin, yellow flesh, medium mealy after boiling.
'**Zile**' – developed in Priekuli, medium late, comparatively high starch content, relatively resistant to late blight, yellow skin, yellow flesh, medium mealy after boiling.
**'Kuras'** – developed in the Netherlands (Agrico), late starch variety, yellow skin, white flesh, suitable for organic farming
**'Eurostarch'** – developed in Germany (Europlant), medium late starch variety, suitable for organic farming.
**'Transit'** – developed in Germany (Norika), medium early, yellow flesh, high starch content, suitable for organic farming.
**'Zuzanna'** – developed in Germany (Europlant), medium early, yellow skin and light yellow flesh, high starch content, suitable for organic farming.
**'Magnat' ('Zdabytak')** – developed in Belorussia, late, red skin and white flesh, very high starch content, suitable for organic farming.
**'Ando'** – developed in Jõgeva, late, high starch content, yellow skin and flesh, mealy after boiling, suitable for organic farming.
**'Juku'** – developed in Jõgeva, late, high starch content, yellow skin and flesh, suitable for organic farming.
**'Maret'** – developed in Jõgeva, early, high starch content, red skin and yellow flesh, mealy after boiling, suitable for organic farming.
**'Anti'** – developed in Jõgeva, late
**'Sarme'** – developed in Jõgeva, late, light pink skin, creamy flesh, high yield, medium starch content, suitable for organic farming.
**'Reet'** – developed in Jõgeva, medium, yellow skin and flesh, medium starch content, medium mealy after boiling, suitable for organic farming.
**'Teele' (=1490-03)** – developed in Jõgeva, medium, yellow skin and flesh, medium starch content, medium mealy after boiling, suitable for organic farming.

**Growing conditions**:

***Priekuli.*** The soil in trial fields was sod-podzolic. The content of organic matter ranged from 17-23 g $kg^{-1}$, the soil pHKCL was 5.8-5.9, the availability of phosphorus in the soil was high ($P_2O_5$ 151–215 mg $kg^{-1}$), but the availability of potassium was medium ($K_2O$ 116–135 mg $kg^{-1}$). Winter cereal was used as the pre-crop.

***ECRI.*** The used experimental fields were located on sandy loam *Calcaric Luvisol*soil (FAO /UNESCO classification). According to Soil Monitoring Bureau of Estonian Agricultural Research Centre the pH of trial field soil was in the range of 5.5-6.0. The precrop in 2011 was buckwheat, in 2012 pea and in 2013 red clover. Manure 48 t $ha^{-1}$ was done and ploughed in autumn.

**Trial design:**

The 9 potato varieties (Priekuli) and 14 potato varieties (ECRI) using presprouted and not sprouted seed tubers were planted in 5 $m^2$ plots in three replications with a randomised plot layout in organic fields in Priekuli and Jogeva (ECRI). For variants with presprouting seed tubers were sprouted in light for 2-4 weeks.

In Priekuli the potatoes were planted in the second week of May and harvested in the late days of August or beginning of September in all three trial years. Harrowing and ridging were performed 4-5 times for weed control.

**In Jõgeva** – ECRI the field was twice cultivated and deeply ploughed over in spring. The trial was planted in 19 of May (2011), 21 of May (2012) and 24 of May (2013). During the growth period the plants were hilled three times and harrowed once. (Table 4). Three times was trial hoed and controlled mechanical Colorado beetles in summer.

Varieties or breeds with not acceptable results for starch production were excluded from ECRI trial and new varieties were included.

**Weather conditions:**

***Priekuli.*** Weather conditions in 2011 differed from the long-term data. In the first part of growing period, the level of precipitation was lower than long-term data, but at the beginning of August, precipitation level was almost two times higher than normally. The air temperature exceeded the long-term data during whole growing period, - the warm and hot conditions promoted a development of bigger sized tuber. In 2012 the beginning of growing period was cooler than long-term data and the precipitation level exceeded long-term data for 62 %. Later in the growing period, the air temperature became more similar to long-term data, differing only for some 2–3$^{o}$C. However, the precipitation level still remained high, exceeding long-term parameters for 40–160 % in several ten days periods during vegetation. In 2013 the air temperature exceeded long term data from the beginning of growing season till the 2$^{nd}$ decade of August, especially in the first decade of June (+4.8$^{o}$ C higher than long term data) and the first decade of August (2.7$^{0}$C higher than long term data). In July air temperature was more similar to annual data. Precipitation level was lower than long term data in period from the beginning of growing season till the 2$^{nd}$ decade of August. In June precipitation level reached 40% from long term data, but in July it was only 29% from annual data. The first decade of July was the driest in this growing season when only 4.9 mm precipitated (16% from long term data). Precipitation level in the first decade of August was only 36% from long term data, but the second decade become the most wet this season with 47.9 mm of precipitation (163% of long term parameters).

In ***Jõgeva - ECRI***. The potato was planted in II decade of May 2011. As well in Priekuli than in Jõgeva the plants emergence was in I decade of June. Amount of precipitation was low and the air temperature exceeded the long-term data in this period. As a result this was the development of plants inhibited. The air temperature was high almost all growing period, but precipitation in August improved the growing condition nonetheless late potato varieties do not realized your yield potential. Potato planting prevented precipitation in spring 2012. The beginning of growing period was cooler than long term data. Six day comparatively warmer period in middle-June positively affected the potato sprouting. I and III decade of July were hot but II decade was cool and rainy. The soil moisture conditions were variable in August. As the growth of tubers was intensive it decreased moisture reserves of soil. Only after

rain (70 mm) of 19-20 August the situation was improved. The end of August was actively warmth accumulated $1600^0$C. For biological maturing of late varieties it was not enough. The soil was wet during the period of planting in 2013, and after first hilling the furrows crusted, so the harrowing was used twice. Drought in June and July was a cause of very different development disorders. Air temperature exceeded long term data but precipitation level was lower than long term data in period after emergence till the second decade of August.

**Assessments:**

The time of seed tubers germination on the field was detected for presprouted and not sprouted seed tubers of each variety as number of days in Priekuli, but first emergence in days was detected in ECRI. The late blight (*Phythophthora infestans*) development on foliage was assessed as percentage of foliage area damaged by diseases infection.

The yield of potato varieties was assessed after harvesting. The tuber starch content was determined indirectly via specific gravity as a percentage of fresh weight. The starch yield was calculated.

Spatial distributions were analysed using NNA (Nearest Neighbour Analysis) with the AGROBASE 20 computer package. To determine significant differences between traits, the least significant differences ($LSD_{05}$) were calculated.

The ratio of amylose and amylopectin was detected using spectrophotometric method for variety samples grown in Priekuli in 2011.

## Results

**Time of germination.**

The time from seed potato planting to plant germination differed between varieties and growing years depending on varieties characteristics and weather conditions.

In Priekuli average time of germination in 2013 was only 19.4 days but in 2012 – 28.5 days. The weather in 2012 was cooler and air temperature was lower than in 2013, when air temperature significantly exceeded long term data. The germination time of presprouted tubers was shorter than of not sprouted tubers, especially in year with lower air temperature in the beginning of growing period – 2012 (Table 1). The presprouting of seed tubers fastened plant development each trial year for varieties ‘Brasla’, ‘Ando’ and ‘Maret’.

Table 1

The days from potatoes planting to plant germination in Priekuli.

| Variety | 2011 | | 2012 | | 2013 | | Average of 2011-2013 | |
|---|---|---|---|---|---|---|---|---|
| | Not sprouted | Presprouted | Not sprouted | Presprouted | Not sprouted | Presprouted | Not sprouted | Presprouted |
| **Brasla** | 26 | 24 | 29 | 25 | 19 | 18 | 24.6 | 22.3 |
| **Imanta** | 29 | 26 | 33 | 27 | 20 | 20 | 27.2 | 24.2 |
| **Lenora** | 28 | 26 | 29 | 29 | 21 | 21 | 25.9 | 25.3 |
| **Ando** | 27 | 27 | 31 | 27 | 19 | 18 | 25.7 | 24 |
| **Juku** | 25 | 24 | 33 | 27 | 19 | 19 | 25.6 | 23.3 |
| **Kuras** | 27 | 26 | 29 | 29 | 20 | 20 | 25.3 | 24.9 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Gundega** | | | 29 | 24 | 20 | 19 | 24.3 | 21.7 |
| **Maret** | | | 29 | 23 | 19 | 17 | 23.8 | 20.2 |
| **Eurostarch** | | | 33 | | 20 | 19 | | |
| *Mean* | *27.0* | *25.5* | *30.6* | *26.4* | *19.7* | *19.0* | ***25.3*** | ***23.2*** |

Table 2

The first emergence (days) of potato varieties in ECRI (Jõgeva)

| Variety | 2011 | 2012 | 2013 | Average of 2011-2013 |
|---|---|---|---|---|
| Maret* | 20,7 | 25,3 | 12,6 | 19,5 |
| Maret | 18,0 | 21,7 | 12,0 | 17,2 |
| Reet* | 24,0 | - | - | 24,0** |
| Reet | 22,3 | - | - | 22,3** |
| Ando* | 23,0 | 25,7 | 14,7 | 21,1 |
| Ando | 21,7 | 24,3 | 14,0 | 20,0 |
| Juku* | 19,0 | 23,7 | 14,0 | 18,9 |
| Juku | 19,0 | 23,3 | 14,0 | 18,8 |
| Sarme* | 22,0 | - | - | 22,0** |
| Sarme | 19,7 | - | - | 19,7** |
| Anti* | 23,7 | - | - | 23,7** |
| Anti | 21,7 | - | - | 21,7** |
| Lenora* | 24,7 | 26,0 | 17,7 | 22,8 |
| Lenora | 23,3 | 24,3 | 17,0 | 21,5 |
| Brasla* | 21,3 | 26,0 | 16,0 | 21,1 |
| Brasla | 20,3 | 24,7 | 16,0 | 20,3 |
| Zile* | 24,0 | - | - | 24,0** |
| Zile | 22,0 | - | - | 22,0** |
| Imanta* | 25,3 | 27,7 | 17,6 | 23,5 |
| Imanta | 20,7 | 26,7 | 15,3 | 20,9 |
| 1490-03* | 23,0 | 25,7 | 16,0 | 21,6 |
| 1490-03 | 22,3 | 23,3 | 14,3 | 20,0 |
| Zdabytak* | 25,0 | 28,0 | - | 26,5** |
| Zdabytak | 23,3 | 26,0 | - | 24,7** |
| 541-03* | 21,0 | - | - | 21,0** |
| 541-03 | 18,7 | - | - | 18,7** |
| Kuras* | - | 27,3 | 17,0 | 22,2** |
| Kuras | - | 25,0 | 16,7 | 20,9** |
| Eurostarch* | - | 27,0 | 16,7 | 21,9** |
| Eurostarch | - | 25,3 | 15,3 | 20,3** |
| Gundega* | - | 26,7 | 15,7 | 21,2** |
| Gundega | - | 24,3 | 15,0 | 19,7** |
| Transit* | - | 26,3 | - | 26,3** |
| Transit | - | 23,7 | - | 23,7** |
| Zuzanna* | - | - | 17,3 | 17,3** |
| Zuzanna | - | - | 16,0 | 16,0** |

*-without sprouting

**-not 3 years average

In Jõgeva - ECRI in the both variants during three years better first emergence average was for variety ‘Maret’. Variety ‘Zdabytak’ had the longest first emergence. Greater first emergence difference between variants had varieties ‘Maret’, ‘Sarme’, ‘Imanta’ and ‘Transit’. No difference in first emergence between variants had late variety ‘Juku’ (Table 2).

Table 3

The late blight (*Phythophthora infestans*) development on foliage of potato varieties in Priekuli, % of damaged foliage area from total

| Variety | Sprouting | 2011 | | | 2012 | |
|---|---|---|---|---|---|---|
| | | **14.07.** | **19.07.** | **5.08.** | **31.07.** | **13.08.** |
| **Brasla** | not sprouted | 0 | 0 | 27 | 5 | 50 |
| | presprouted | 0.7 | 1 | 60 | 7 | 73 |
| **Imanta** | not sprouted | 0 | 0 | 4 | 1 | 10 |
| | presprouted | 0 | 0 | 5 | 3 | 20 |
| **Lenora** | not sprouted | 0 | 0 | 30 | 5 | 40 |
| | presprouted | 0 | 0 | 32 | 5 | 73 |
| **Ando** | not sprouted | 0 | 0 | 1 | 0.7 | 7 |
| | presprouted | 0 | 0 | 4 | 0.7 | 8 |
| **Juku** | not sprouted | 0 | 0 | 4 | 0 | 17 |
| | presprouted | 0 | 0 | 5 | 2 | 17 |
| **Kuras** | not sprouted | 0 | 0 | 4 | 0 | 5 |
| | presprouted | 0 | 0 | 2 | 0.3 | 5 |
| **Gundega** | not sprouted | | | | 2 | 67 |
| | presprouted | | | | 4 | 87 |
| **Maret** | not sprouted | | | | 8 | 87 |
| | presprouted | | | | 13 | 97 |
| **Eurostarch** | not sprouted | | | | 1 | 17 |
| | presprouted | | | | | |

In **Priekuli** the late blight (*Phythophthora infestans*) infection started earlier in 2011 than 2012, but disease development was faster in the 2012 comparing with 2011 (Table 3). The late blight did not appear in 2013, the hot and dry weather was not favourable for disease development. The disease damaged leaflet area differed among varieties during both trial years. Lower damage level and continuously better resistance to late blight was observed for varieties ‘Imanta’, ‘Ando’, Juku’ and ‘Kuras’ (Table 3). Comparatively higher level of disease damages was observed on foliage of plants when presprouted seed tubers were used.

Table 4

The late blight infection development (% of leaf surface) of potato varieties in ECRI (Jõgeva)

| Vaeiety | 2011 | | | 2012 | | | 2013 | |
|---|---|---|---|---|---|---|---|---|
| Time of observ. | 02.08 | 23.08 | 31.08 | 06.08 | 13.08 | 21.08 | 21.08 | 26.08 |
| Maret* | 3,7 | 28,3 | 100,0 | 2,3 | 11,0 | 75,0 | 10 | 20 |
| Maret | 4,0 | 65,0 | 100,0 | 3,0 | 26,7 | 93,3 | 15 | 20 |
| Reet* | 46,7 | 86,7 | 100,0 | - | - | - | - | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Reet | 40,0 | 80,0 | 100,0 | - | - | - | - | - |
| Ando* | 3,7 | 8,3 | 30,0 | 0,0 | 1,3 | 20,0 | 0,7 | 2,3 |
| Ando | 3,0 | 10,0 | 35,0 | 0,0 | 1,3 | 20,0 | 0,7 | 1,3 |
| Juku* | 2,3 | 3,7 | 21,7 | 0,0 | 3,0 | 36,7 | 9,7 | 12,7 |
| Juku | 3,0 | 6,7 | 28,3 | 0,3 | 3,6 | 28,3 | 8,0 | 10,3 |
| Sarme* | 5,3 | 15,0 | 16,7 | - | - | - | - | - |
| Sarme | 10,0 | 15,0 | 21,6 | - | - | - | - | - |
| Anti* | 1,3 | 16,7 | 43,3 | - | - | - | - | - |
| Anti | 1,7 | 13,3 | 50,0 | - | - | - | - | - |
| Lenora* | 2,3 | 16,7 | 100,0 | 1,7 | 5,0 | 80,0 | 18,3 | 51,7 |
| Lenora | 3,7 | 26,7 | 100,0 | 1,7 | 8,3 | 91,6 | 20,0 | 50,0 |
| Brasla* | 15,7 | 50,0 | 100,0 | 1,0 | 6,0 | 36,7 | 5,0 | 21,7 |
| Brasla | 13,3 | 50,0 | 100,0 | 1,7 | 6,7 | 43,3 | 6,7 | 28,3 |
| Zile* | 3,7 | 10,0 | 95,0 | - | - | - | - | - |
| Zile | 11,3 | 21,7 | 95,0 | - | - | - | - | - |
| Imanta* | 20,0 | 21,6 | 51,7 | 0,0 | 0,0 | 1,0 | 0 | 0 |
| Imanta | 11,3 | 38,3 | 51,7 | 0,0 | 1,7 | 6,7 | 0 | 0 |
| 1490-03* | 4,3 | 11,7 | 91,7 | 0,3 | 2,3 | 6,0 | 14,3 | |
| 1490-03 | 11,3 | 28,3 | 93,3 | 0,3 | 3,7 | 36,77,7 | 35,0 | |
| Zdabytak* | 10,0 | 16,7 | 33,3 | 0,0 | 0,3 | 4,3 | - | - |
| Zdabytak | 11,6 | 20,0 | 30,0 | 0,3 | 0,3 | 2,0 | - | - |
| 541-03* | 6,7 | 31,7 | 83,3 | - | - | - | - | - |
| 541-03 | 6,0 | 38,3 | 83,3 | - | - | - | - | - |
| Kuras* | - | - | - | 0,0 | 0,3 | 3,0 | 0,3 | 0,7 |
| Kuras | - | - | - | 0,3 | 0,3 | 3,7 | 0,7 | 0,7 |
| Eurostarch* | - | - | - | 0,3 | 1,0 | 3,0 | 2,7 | 4,7 |
| Eurostarch | - | - | - | 0,3 | 1,7 | 3,7 | 2,0 | 4,7 |
| Gundega* | - | - | - | 0,0 | 1,7 | 6,7 | 0,3 | 1,0 |
| Gundega | - | - | - | 0,3 | 2,3 | 16,7 | 1,0 | 1,0 |
| Transit* | - | - | - | 0,7 | 1,3 | 18,7 | - | - |
| Transit | - | - | - | 0,7 | 1,7 | 28,3 | - | - |
| Zuzanna* | - | - | - | - | - | - | 10,0 | 34,3 |
| Zuzanna | - | - | - | - | - | - | 25,3 | 42,7 |

*-without sprouting

One of the most important factors affecting late blight infection is weather condition during the vegetation period, especially temperature, precipitation and relative humidity. In **Jõgeva ECRI** the first infection in the early varieties was observed in the end of July (31) in 2011, but infection development was stopped in the beginning of August (1-6), due to the hot and dry weather. The late blight infection development continued in the second decade of August, when weather was cool and relative humidity was very high. Hot and dry weather in the end of July and in the beginning of August in 2012 delayed the start of late blight infection. The first late blight infection was observed in the early varieties on August 6th. The rapid development of the disease began in the second decade of August, when weather turned cooler and relative humidity higher. In June and July 2013 were drought that probably could reduce tuber yield. Productive soil water resources in July dropped below the critical level. All those weather conditions delayed the begining of late blight infection. The lower damage level and continuously better resistance to late

blight was observed for varieties Imanta, 'Ando', 'Gundega' and 'Kuras' (Table 4). Not much more infected also varieties 'Eurostarch' and 'Juku'. Comparatively higher level of disease damages was observed on foliage of plants when presprouted seed tubers were used.

Table 5

The tuber yield of potato varieties using presprouted and not sprouted seed tubers in organic field in Priekuli

| Variety | Tuber yield, t ha$^{-1}$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2011 | | | 2012 | | | Average of 2011-2012 | | |
| | Not sprouted | Presprouted | Average | Not sprouted | Presprouted | Average | Not sprouted | Presprouted | Great mean |
| **Brasla** | 29.2 | 33.6 | 31.4 | 31.0 | 31.4 | 31.2 | 30.1 | 32.5 | 31.3 |
| **Imanta** | 26.7 | 32.9 | 29.8 | **31.1** | **37.0** | 34.05 | 28.9 | 35.0 | 32.0 |
| **Lenora** | 29.6 | 31.3 | 30.45 | 30.6 | 33.4 | 32 | 30.1 | 32.4 | 31.3 |
| **Ando** | 36.9 | 28.5 | 32.7 | 42.4 | 42.7 | 42.55 | 39.7 | 35.6 | 37.7 |
| **Juku** | 30.0 | 36.2 | 33.1 | 35.6 | 35.8 | 35.7 | 32.8 | 36.0 | 34.4 |
| **Kuras** | 31.4 | 28.7 | 30.05 | 33.5 | 36.4 | 34.95 | 32.5 | 32.6 | 32.6 |
| **Gundega** | | | | **25.7** | **30.8** | 28.25 | | | |
| **Maret** | | | | 33.3 | 32.3 | 32.8 | | | |
| **Eurostarch** | | | | 33.0 | | | | | |
| *Mean* | **30.6** | **31.9** | **31.3** | **32.9** | **35.0** | **33.9** | 32.4 | 34.0 | 33.2 |
| *Min* | 26.7 | 28.5 | 29.8 | 25.7 | 30.8 | 28.25 | 28.9 | 32.4 | 31.3 |
| *Max* | 36.9 | 36.2 | 33.1 | 42.4 | 42.7 | 42.55 | 39.7 | 36 | 37.7 |
| $LSD_{0.05}$ | *p=0.3* | | *p=0.8* | *3.9* | | *7.95* | | | |

The tuber yield of potato varieties in **Priekuli** was in range from 26.7 to 36.9 t ha$^{-1}$ for not sprouted seed tubers and from 28.5 to 36.2 t ha$^{-1}$ for presprouted seed tubers in 2011, and in range from 25.7 to 42.7 t ha$^{-1}$ for not sprouted seed tubers and from 28.3 to 39.7 t ha$^{-1}$ for presprouted seed tubers in 2012 (Table 5 ). The highest tuber yield was detected for potato variety 'Kuras' in 2011, and for variety 'Ando' in 2012. The difference among variety yields was not significant in 2011. Although, yields among varieties differed significantly in 2012. The average tuber yield was higher when presprouted tubers were used, but difference was not significant in 2011. The significant impact of presprouting on tuber yield was in 2012.

Table 6

The tuber yield of potato varieties in ECRI (Jõgeva) in 2011-2012

| Variety | Tuber yield, t ha$^{-1}$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2011 | | | 2012 | | | Average 2011-2012 | | |
| | Not sprouted | Pre-sprouted | Ave-rage | Not sprouted | Pre-sprouted | Ave-rage | Not sprouted | Pre-sprouted | Great mean |
| Maret | 25.6 | 30.3 | 28.0 | 32.7 | 30.2 | 31.5 | 29.2 | 30,3 | 29,8 |
| Reet | 16.0 | 18.1 | 17.1 | - | - | - | - | - | - |
| Ando | 22.4 | 23.4 | 22.9 | 20.3 | 24.7 | 22.5 | 21.4 | 24.1 | 22.8 |
| Juku | 32.4 | 30.7 | 31.6 | 25.0 | 30.3 | 27.7 | 28,7 | 30.5 | 29,6 |
| Sarme | 21.8 | 23.7 | 22,8 | - | - | - | - | - | - |
| Anti | 22.4 | 24.6 | 23,5 | - | - | - | - | - | - |
| Lenora | 22.7 | 24.6 | 23.7 | 31.0 | 28.7 | 29.9 | 26.9 | 26,7 | 26,8 |
| Brasla | 23.9 | 21.2 | 22.6 | 28.5 | 28.3 | 28.4 | 26,2 | 24.8 | 25,5 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Zile | 22.3 | 26.6 | 24.5 | - | - | - | - | - | - |
| Imanta | 11.2 | 19.7 | 15.5 | 25.3 | 33.0 | 29.2 | 18.3 | 26.4 | 22.4 |
| 1490-03 | 19.0 | 12.3 | 15,7 | 25.8 | 21.8 | 23.8 | 22.4 | 17.1 | 19.8 |
| Zdabytak | 18.5 | 20.3 | 19,4 | 31.0 | 32.7 | 31.9 | 24.8 | 26.5 | 25,7 |
| 541-03 | 19.1 | 21.3 | 20.2 | - | - | - | - | - | - |
| Kuras | - | - | - | 31.9 | 31.3 | 31.6 | - | - | - |
| Eurostarch | - | - | - | 31.8 | 33.1 | 32.5 | - | - | - |
| Gundega | - | - | - | 27.6 | 33.6 | 30.6 | - | - | - |
| Transit | - | - | - | 22.6 | 24.8 | 23.7 | - | - | - |
| *Mean* | 21.3 | 22.7 | 22.1 | 27,8 | 29.4 | 28,6 | 24.6 | 26.1 | 25.4 |
| *Min* | 11.2 | 12.3 | 15,5 | 20.3 | 21.8 | 21.1 | 15.8 | 17.1 | 16.5 |
| *Max* | 32.4 | 30.7 | 31.6 | 31.9 | 33.6 | 32.8 | 32.2 | 32.2 | 32.2 |
| $LSD_{0.05}$ | 5.4 | | | 7.8 | | | | | |

The tuber yield of potato varieties in **Jõgeva** ECRI was in range from 11.2 to 32.4 t $ha^{-1}$ for not sprouted variant and from 12.3 to 30.7 t $ha^{-1}$ for presprouted variant in 2011, and in range from 20.3 to 31.9 t $ha^{-1}$ for not sprouted variant and from 21.8 to 33.6 t $ha^{-1}$ for presprouted variant in 2012 (Table 6 ). Variety 'Imanta' was infected very early with *Alternaria* and later also with late blight in 2011. The summer was very hot and precipitation also was low, therefore the vegetation stopped and therefore the significant effect of presprouting for late varieties was missed. The highest effect of presprouting was for varieties 'Imanta', 'Maret' and 'Zile'. The highest tuber yield was detected for potato variety 'Juku' in 2011 (not sprouted variant) and for variety 'Gundega' (presprouted variant) in 2012. The significant impact of presprouting on tuber yield was in 2012 for varieties 'Ando', 'Juku', 'Transit', 'Gundega' and 'Imanta'.

Table 7

The starch content of potato varieties using presprouted and not sprouted seed tubers in Priekuli

| Variety | Starch content in tubers, % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2011 | | | 2012 | | | Average of 2011-2012 | | |
| | Not sprouted | Presprouted | Average | Not sprouted | Presprouted | Average | Not sprouted | Presprouted | Great mean |
| **Brasla** | 18.98 | 16.55 | 17.77 | 18.21 | 18.18 | 18.20 | 18.59 | 17.37 | 17.98 |
| **Imanta** | 19.72 | 19.56 | **19.64** | 17.66 | 18.39 | 18.03 | 18.69 | 18.92 | 18.81 |
| **Lenora** | 16.77 | 15.79 | 16.28 | 16.00 | 16.60 | 16.30 | 16.43 | 15.89 | 16.16 |
| **Ando** | 16.64 | 16.41 | 16.53 | 16.60 | 16.75 | 16.68 | 16.62 | 16.58 | 16.60 |
| **Juku** | 19.03 | 19.19 | 19.11 | 16.86 | 17.90 | 17.38 | 17.94 | 18.55 | 18.25 |
| **Kuras** | 20.46 | 18.78 | 19.62 | 19.38 | 20.80 | **20.09** | 19.92 | 20.80 | **20.36** |
| **Gundega** | | | | 15.64 | 16.12 | 15.88 | | | |
| **Maret** | | | | 17.00 | 16.96 | 16.98 | | | |
| **Eurostarch** | | | | 18.57 | | | | | |
| *Mean* | **18.60** | **17.71** | **18.16** | **17.32** | **17.71** | **17.52** | 18.03 | 18.02 | 18.03 |
| *Min* | 16.64 | 15.79 | 16.28 | 15.64 | 16.12 | 15.88 | 16.43 | 15.89 | 16.16 |
| *Max* | 20.46 | 19.56 | 19.64 | 19.38 | 20.80 | 20.09 | 19.92 | 20.80 | 20.36 |
| $LSD_{0.05}$ | *p=0.1* | | *1.44* | *p=0.53* | | *0.97* | | | |

The starch content in tubers of potato varieties in **Priekuli** was in range from 16.64 to 20.46 % for not sprouted seed tubers and from 15.79 to 19.56 % for

presprouted seed tubers in 2011, and in range from 15.64 to 19.38 % for not sprouted seed tubers and from 16.12 to 20.80 % for presprouted seed tubers in 2012 (Table 7). The highest starch content was detected for potato variety ‘Imanta’ in 2011, and for variety ‘Kuras’ in 2012. The difference between starch content of potato varieties was significant in both years. Although the impact of presprouting on starch content in tubers was not significant.

Table 8

The starch content of potato varieties in organic trial in ECRI (Jõgeva) in 2011-2012

| Variety | Starch content in tubers, % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2011 | | | 2012 | | | Average 2011-2012 | | |
| | Not sprouted | Pre-sprouted | Ave-rage | Not sprouted | Pre-sprouted | Ave-rage | Not sprouted | Pre-sprouted | Great mean |
| Maret | 18.5 | 18.5 | 18.5 | 19.5 | 19.5 | 19.5 | 19.0 | 19.0 | 19.0 |
| Reet | 16.6 | 16.4 | 16.5 | - | - | - | - | - | - |
| Ando | 17.7 | 16.5 | 17.1 | 17.5 | 17.5 | 17.5 | 17.6 | 17.0 | 17.3 |
| Juku | 20.1 | 19.7 | 19.9 | 19.5 | 19.9 | 19.5 | 19.8 | 19.8 | 19.8 |
| Sarme | 16.0 | 16.8 | 16.4 | - | - | - | - | - | - |
| Anti | 15.6 | 15.8 | 15.7 | - | - | - | - | - | - |
| Lenora | 17.3 | 17.1 | 17.2 | 19.5 | 19.5 | 19.5 | 18.4 | 18,3 | 18.4 |
| Brasla | 18.8 | 18.9 | 18.9 | 19.5 | 19.5 | 19.5 | 19.2 | 19.2 | 19.2 |
| Zile | 19.5 | 19.3 | 19.4 | - | - | - | - | - | - |
| Imanta | 18.0 | 18.6 | 18.3 | 18.5 | 18.5 | 18.5 | 18.3 | 18.3 | 18.3 |
| 1490-03 | 13.7 | 14.3 | 14.0 | 15.5 | 15.5 | 12.5 | 14.6 | 14.9 | 14.8 |
| Zdabytak | 22.7 | 23.4 | 23.1 | 20.6 | 21.7 | 21.2 | 21.7 | 22.6 | 22.2 |
| 541-03 | 15.5 | 15.7 | 15.6 | - | - | - | - | - | - |
| Kuras | - | - | - | 18.5 | 18.5 | 18.5 | - | - | - |
| Eurostarch | - | - | - | 19.5 | 19.5 | 19.5 | - | - | - |
| Gundega | - | - | - | 17.5 | 17.5 | 17.5 | - | - | - |
| Transit | - | - | - | 22.7 | 21.7 | 22.2 | - | - | - |
| *Mean* | 17.7 | 17.8 | 17.8 | 18.8 | 18.8 | 18.8 | 18.3 | 18.3 | 18.3 |
| *Min* | 13.7 | 14.3 | 14.0 | 15.5 | 15.5 | 15.5 | 14.8 | 14.9 | 14.9 |
| *Max* | 22.7 | 23.4 | 23.1 | 22.7 | 21.7 | 22.2 | 22.7 | 22.6 | 22.7 |
| $LSD_{0.05}$ | 0.8 | | | 0.7 | | | | | |

The starch content in tubers of potato varieties in **Jõgeva** ECRI was in range from 13.7% to 22.7 % for not sprouted variant and from 14.3% to 23.4 % for presprouted variant in 2011, and in range from 15.5% to 22.7 % for not sprouted variant and from 15.5% to 21.7 % for presprouted variant in 2012 (Table 8). The ranges of minimum and maximum starch content were greater in Jõgeva than in Priekuli. The highest starch content was detected for potato variety ‘Zdabytak’ in 2011, and for variety ‘Transit’ in 2012 in Jogeva. The difference between starch content of potato varieties was significant in both years as in Priekuli. Difference of starch content of presprouted and not sprouted variants was not significant.

Table 9

The starch yield of potato varieties using presprouted and not sprouted seed tubers in Priekuli

| Variety | Starch yield, t ha$^{-1}$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2011 | | | 2012 | | | Average of 2011-2012 | | |
| | Not sprouted | Presprouted | Average | Not sprouted | Presprouted | Average | Not sprouted | Presprouted | Great mean |
| **Brasla** | 5.4 | 5.5 | 5.5 | 5.6 | 5.7 | 5.7 | 5.5 | 5.6 | 5.6 |
| **Imanta** | 5.0 | 6.2 | 5.6 | 5.5 | 5.8 | 5.7 | 5.2 | 6.8 | 6.0 |
| **Lenora** | 4.5 | 4.4 | 4.5 | 4.9 | 5.3 | 5.1 | 4.7 | 4.9 | 4.8 |
| **Ando** | 5.8 | 4.6 | 5.2 | 7.0 | 7.2 | 7.1 | 6.4 | 5.9 | 6.2 |
| **Juku** | 6.2 | 7.3 | **6.8** | 6.0 | 6.4 | 6.2 | 6.1 | 6.9 | **6.5** |
| **Kuras** | 6.2 | 5.2 | 5.7 | 6.5 | 7.6 | 7.1 | 6.3 | 6.4 | 6.4 |
| **Gundega** | | | | 4.0 | 5.0 | 4.5 | | | |
| **Maret** | | | | 5.7 | 5.5 | 5.6 | | | |
| **Eurostarch** | | | | 6.1 | | | | | |
| *Mean* | **5.5** | **5.5** | **5.5** | **5.7** | **6.1** | **5.9** | 5.7 | 6.1 | 5.9 |
| *Min* | 4.5 | 4.4 | 4.5 | 4.0 | 5.0 | 4.5 | 4.7 | 4.9 | 4.8 |
| *Max* | 6.2 | 7.3 | 6.8 | 7.0 | 7.6 | 7.1 | 6.4 | 6.9 | 6.5 |
| $LSD_{0.05}$ | *p=0.66* | | *1.20* | *p=0.065* | | *1.40* | | | |

The starch yield of potato varieties in **Priekuli** was in range from 4.5 to 6.2 t ha$^{-1}$ for not sprouted seed tubers and from 4.4 to 7.3 t ha$^{-1}$ for presprouted seed tubers in 2011, and in range from 4.0 to 7.0 t ha$^{-1}$ for not sprouted seed tubers and from 5.0 to 7.6 t ha$^{-1}$ for presprouted seed tubers in 2012 (Table 9). The highest starch yield was obtained for potato variety 'Juku' in 2011, and for variety 'Kuras' in 2012. The difference in starch yield among potato varieties was significant in both years. Although the impact of presprouting on starch yield was not significant.

Table 10

The starch yield of potato varieties in ECRI (Jõgeva) in 2011-2012

| Variety | Starch yield, t ha$^{-1}$ | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2011 | | | 2012 | | | Average 2011-2012 | | |
| | Not sprouted | Pre-sprouted | Ave-rage | Not sprouted | Pre-sprouted | Ave-rage | Not sprouted | Pre-sprouted | Great mean |
| Maret | 4.7 | 5.6 | 5.2 | 6.4 | 5.9 | 6.2 | 5.6 | 5.8 | 5.7 |
| Reet | 2.7 | 3.0 | 2.9 | - | - | - | - | - | - |
| Ando | 4.0 | 3.9 | 4.0 | 3.6 | 4.3 | 4.0 | 3.8 | 4.1 | 4.0 |
| Juku | 6.5 | 6.0 | 6.3 | 4.9 | 5.9 | 5.4 | 5.7 | 6.0 | 5.9 |
| Sarme | 3.5 | 4.0 | 3.8 | - | - | - | - | - | - |
| Anti | 3.5 | 3.9 | 3.7 | - | - | - | - | - | - |
| Lenora | 3.9 | 4.2 | 4.1 | 6.0 | 5.6 | 5.8 | 5.0 | 5.0 | |
| Brasla | 4.5 | 4.0 | 4.3 | 5.6 | 5.5 | 5.6 | 5.1 | 4.8 | 5.0 |
| Zile | 4.3 | 5.1 | 4.7 | - | - | - | - | - | - |
| Imanta | 2.0 | 3.7 | 2.9 | 4.7 | 6.1 | 5.4 | 3.4 | 4.9 | 4.2 |
| 1490-03 | 2.6 | 1.7 | 2.2 | 3.2 | 2.7 | 3.0 | 2.9 | 2.2 | 2.6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Zdabytak | 4.2 | 4.8 | 4.5 | 6.4 | 7.1 | 6.8 | 5.3 | 6.0 | 5.7 |
| 541-03 | 3.0 | 3.3 | 3.2 | - | - | - | - | - | - |
| Kuras | - | - | - | 5.9 | 5.8 | 5.9 | - | - | - |
| Eurostarch | - | - | - | 6.2 | 6.5 | 6.4 | - | - | - |
| Gundega | - | - | - | 4.8 | 5.9 | 5.4 | - | - | - |
| Transit | - | - | - | 5.1 | 5.4 | 5.3 | - | - | - |
| *Mean* | 3.8 | 4.1 | 4.0 | 5.4 | 5.6 | 5.5 | 4.6 | 4.9 | 4.8 |
| *Min* | 2.0 | 1.7 | 1.9 | 3.2 | 2.7 | 3.0 | 2.6 | 2.2 | 2.4 |
| *Max* | 6.5 | 6.0 | 6.3 | 6.4 | 7.1 | 6.8 | 6.5 | 6.6 | 6.6 |
| $LSD_{0.05}$ | 1.1 | | | 1.5 | | | | | |

The starch yield of potato varieties in **Jõgeva ECRI** was in range from 2.0 to 6.5 t $ha^{-1}$ for not sprouted variant and from 1.7 to 6.0 t $ha^{-1}$ for presprouted variant in 2011, and in range from 3.2 to 6.4 t $ha^{-1}$ for not sprouted variant and from 2.7 to 7.1 t $ha^{-1}$ for presprouted variant in 2012 (Table 10). The highest starch yield was obtained for potato variety 'Juku' in 2011 as in Priekuli, and for variety 'Zdabytak' in 2012. 'Juku' has the highest starch yield in average 2011-2012. The difference between starch yield of potato varieties was significant in both trial years but between variants of used presprouted and not sprouted was not significant.

The starch consists of two polymers amylose and amylopectin. The higher amount of amylopectin in starch is preferable, because this polymer provides viscosity in gelatination process. The lowest amount of amylose in starch was detected for variety 'Imanta' – 26.2 % (Table 11). The highest amylose content from tested varieties was for 'Ando'- 40.2 %.

Table 11

The ratio of amylose and amylopectin in starch of potato varieties

| Varieties | Amylose, % | Amylopectin, % |
|---|---|---|
| Imanta | 26.2 | 73.8 |
| Maret | 30.3 | 69.8 |
| Lenora | 30.7 | 69.4 |
| Brasla | 30.7 | 69.4 |
| Kuras | 34.1 | 65.9 |
| Juku | 39.1 | 60.9 |
| Ando | 40.2 | 59.9 |

## Conclusion

The aim of the study was to evaluate the suitability of potato varieties for starch production in organic farming. The high starch yield should primarily arise from the starch content in tubers, not merely from the high tuber yield. The field trials in Jõgeva revealed that variety 'Maret' among the medium earlies, 'Juku' and 'Zdabytak' among the medium and late varieties might attain the goal. The trials in Priekuli demonstrated the superiority of varieties 'Juku', 'Kuras', 'Ando' and 'Imanta' for starch production. Variety 'Juku' is included in the Latvian Variety List (also to the EU-list) since 2011 as eligible for organic farming. ECRI supplied seed

material of this variety. The farmers have to select more acceptable varieties depending on potato growing region (Latvia or Estonia) and results of current variety assessment. In addition the trials approved that pre-sprouted tubers of the varieties gained an advantage over not-sprouted tubers. The quality of starch (higher content of amylopectin) obtained from varieties ‘Imanta’ and ‘Maret’ was better than from varieties ‘Juku’, ‘Kuras’ and ‘Ando’.