

DOI:10.30901/2227-8834-2016-4-122-129

ОРИГИНАЛЬНАЯ СТАТЬЯ

УДК 633:491:632

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Ключевые слова:

картофель, селекция,
Phytophthora infestans

Поступление:

20.03.2016

Принято:

06.12.2016

СЕЛЕКЦИОННОЕ ИЗУЧЕНИЕ ЛИТОВСКИХ СОРТОВ КАРТОФЕЛЯ

Актуальность. Выведение ранних сортов картофеля, обладающих иммунитетом к нематодам, а также типичным картофельным заболеваниям, хорошей устойчивостью к механическим повреждениям, с хорошими агрономическими и поваренными качествами, достаточно урожайных – одна из основных задач селекции. Материалы и методы. Сорта картофеля, выведенные с использованием гибридного кросс-метода, исследовали в Филиале Воке научно-исследовательского центра сельского и лесного хозяйства Литвы. Родительские сорта для скрещивания были высажены в теплицу, гибридные семена выращивали в горшках с торфом. На следующий год растения пересаживали на селекционные участки, где проводили отбор лучших клонов. В настоящем исследовании в период 2008–2012 гг повреждения, вызванные картофельной гнилью, и степень развития заболевания определяли во время цветения картофеля, объем выборки – 100 растений. Тяжесть заболевания определяли по шкале, утвержденной и рекомендованной ОЕПП/ЕОКЗР. Сорт картофеля ‘VB Venta’ был выбран в качестве стандарта для тестирования чувствительности каждого тестируемого генотипа к *Phytophthora infestans* (Mont.) de Bary. Устойчивость к болезням и картофельным нематодам была протестирована в Институте защиты растений в Белоруссии. Статистический анализ данных проводили с использованием программы StatView ANOVA, полученные данные оценивались методом дисперсионного анализа, применяя программное обеспечение ANOVA (LSD0.05). Результаты и выводы. В течение последних пяти лет испытаний на конкурсном поле самая низкая урожайность была у сорта ‘Mėta’, самая высокая – у ‘Goda’. Наибольшее количество крахмала содержалось в клубнях предназначенного для крахмальной промышленности сорта ‘VB Aista’. Лучший вкус имели ‘VB Venta’, ‘VB Liepa’, ‘Vokė’, ‘Goda’ и ‘Mirta’. Испытания показали, что на естественном инфекционном фоне более устойчивы к гнили сорта картофеля ‘Vokė’, ‘VB Rasa’, ‘VB Aista’. Для создания новых сортов картофеля, иммунных к *P. infestans* большое внимание было уделено исследованиям этого заболевания. Картофельная листва наиболее уязвима в полевых условиях. В течение испытательного периода (2008–2012) повреждения варьировались в зависимости от температуры воздуха, влажности, интенсивности света, сорта картофеля. Первые признаки заболевания – мелкие, от темно-зеленого до коричневатого цвета, неправильной формы вкрапления. При искусственном заражении они быстро расширяются, превращаясь в темно-серые или коричневые бесформенные пятна. На естественном фоне инфекции первые симптомы заболевания появились не только на листьях, но и на стеблях. Это указывает на повышенную агрессивность, вирулентность локальных популяций патогена. В результате проведенной селекции были протестированы одиннадцать литовских сортов картофеля: ‘Mėta’, ‘Vilnia’, ‘VB Aista’, ‘Nida’, ‘Mirta’, ‘Goda’, ‘VB Venta’, ‘Vokė’, ‘VB Liepa’, ‘Vaiva’ and ‘VB Rasa’.

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Key words:

potatoes, breeding, *Phytophthora infestans*

Received:

20.03.2016

Accepted:

06.12.2016

BREEDING ASPECTS OF POTATO IN LITHUANIA

Background. Potato (*Solanum tuberosum* L.) breeding and seed production in Lithuania is performed at Voke Branch of Lithuanian Institute of Agriculture. It was started in 1958. The aim of long-term research was to breed early potato cultivars, immune to wart disease, potato cyst nematodes, with other advantages – good resistance to diseases, mechanical injuries, with good agronomic and cookery qualities, suitability for processing industry. **Materials and methods.** Investigations were conducted in the crop rotation of the Voke Branch of the Lithuanian Research Centre for Agriculture and Forestry during the period of 2008–2012. The experimental plots were established on sandy loam on carbonaceous fluvial-glacial gravel eluviated soil (IDp), according to FAO-UNESCO classification. The growing of resistant varieties reduces wart infection *Phytophthora infestans* (Mont.) de Bary in the field. The infection usually disappears after ten years. In the Republic of Lithuania it is obligatory for all new potato varieties ('Mėta', 'Vilnia', 'VB Aista', 'Nida', 'Mirta', 'Goda', 'VB Venta', 'Vokė', 'VB Liepa', 'Vaiva' and 'VB Rasa') to be wart resistant. **Results and conclusion.** The results have shown that new potato varieties 'VB Venta', 'VB Rasa', 'VB Liepa', 'Goda' and 'VB Aista' bred at Vokė Branch of Lithuanian Institute of Agriculture gave good quality yield not only in big farms but also in small potato plots in the gardens. All mentioned varieties are resistant to the main quarantine object in Lithuania – wart disease. Potato varieties 'Goda', 'VB Liepa', 'VB Rasa' and 'VB Aista' are immune to potato cyst nematode *Globodera rostochiensis* Ro1 pathotype. All varieties have good field resistance against the most widespread diseases – black leg, viruses, common scab, rhizoctonia, etc. During the years of investigations, potato foliage, plant apices, stems and tubers were damaged by the agent of potato blight (*Phytophthora infestans*). The intensity of potato blight spread in the natural infection background among different varieties was determined not only by the earliness of the variety, but by its individual properties as well. Among the 10 tested varieties 'Vokė', 'VB Rasa' and 'VB Aista' were more resistant to blight, while in the artificial infection background 'VB Aista' foliage showed higher resistance. The growing of resistant varieties reduces wart infection in the field. The infection usually disappears after ten years. In the Republic of Lithuania it is obligatory for all new potato varieties to be wart resistant.

Potatoes are one of the main crops in the world. They are widely spread in all worlds and well as in Lithuania.

Potatoes were started to grow in Lithuania in 18th century. But the main food crop it became in the middle of 19th century. It became second bread for Lithuanian farmers when cereals crop was low. Area planted with potatoes was increasing very fast and reached 8.8% of all crops in 1913 (Asakaviciute et al., 2007). The breeding of potato and seed production are carried out at the Voke Branch of Lithuanian Institute of Agriculture (Asakaviciute et al., 2007). Research on different agricultural cultures (issues) has been carried out here since 1953. Development of novel, high-yielding, high-quality, disease resistant varieties of potatoes those are suitable for organic production on less productive, light-textured soils receives particular attention. One of the main problems why people are gathering low potato yields are diseases and pests. They together with unfavourable meteorological conditions decrease yield up till 10–20 tons per hectare. Potato blight, caused by the oomycetes *Phytophthora infestans* (Mont.) de Bary, is one of the most devastating potato diseases (Hansen et al., 2005; Schepers, 2000). This disease causes serious problems in countries with high relative humidity, cool nights and warm days in summer. Damaged potato foliage reduces the as simulation surface which results in reduce yield (Hermansen, 2000). The fact that the *P. infestans* still thrives shows that this is not an easy problem to solve (Kroon et al., 2011). Potato blight issue is very complicated: it receives a lot of attention worldwide. The basis of potato breeding is collection of initial material, its testing and use for the breeding work. The invests gated and assessed Lithuanian potato varieties that are resistant to blight would become the initial material for the creation of blight resistant potato varieties. In Lithuania and in all European countries it is quite important to secure an early potato harvest in order to bring it to a summer market as early as possible, when prices are higher. The developing Lithuanian potato industry also needs early potatoes suitable for chips production, because main crop cultivars after long storage time are frequently until for such a use. From the agro-technic point of view early potatoes are also greatly valued because of their short growing period. In the crop rotation, the field after early

potatoes can be sown with winter crops. Then the total yield in feed units is higher than when growing other crops.

Potatoes are usually bred using the hybridization method (Bradshaw et al., 2006). Parental plants which have perfect quality features such as high yielding, earliness, resistance to diseases and pests, dry matter content are selected to bred. In the potato breeding process the most important are varieties and hybrids which belong to progeny of nine systematic groups: *Comersoniana*, *Glabresantia*, *Acaulia*, and *Transaequaatorialia*, *Andigena*, *Tuberosa*, *Longipedicellata*, *Demissa* and *Pinnatisecta*. They give proper genetic diversity for the cultivated potato varieties (Hijmans, 2001). The most effective and most expensive way against nematodes is new varieties, resistant to nematodes. Potato varieties which have no nematodes resistance die before yield production in soils with high number of nematodes. In the infected fields resistant varieties reduce the number of nematodes in the soil (Razukas and Jundulas, 2005). Resistant variety can reduce the number of the nematodes up to 70%. Potato nematode *Globodera rostochiensis* (Wollenweber) Behrens is included in quarantine pest list of Lithuania as in A2 list of European and Mediterranean Plant Protection Organization (OEPP/EPPO, 2013), therefore the import and export of infected tubers is strictly forbidden.

Another very important potato disease is wart (*Synchytrium endobioticum* Schilb.). This quarantine organism is included in Lithuanian quarantine pest list and into A2 list of European and Mediterranean Plant Protection Organization (OEPP/EPPO, 2004). The best way against wart disease is growing resistant varieties. The growing of resistant varieties reduces wart infection in the field. The infection usually disappears after ten years. In the Republic of Lithuania it is obligatory for all new potato varieties to be wart-resistant. The aim of long-term research was to breed early potato cultivars, immune to wart disease, potato cyst nematodes, with other advantages – good resistance to diseases, mechanical injuries, with good agronomic and cookery qualities, suitability for processing industry.

Material and methods

Investigations were conducted in the crop rotation of the Voke Branch of the Lithuanian

Research Centre for Agriculture and Forestry during the period of 2008–2012.

The experimental plots were established on sandy loam on carbonaceous fluvial-glacial gravel eluviated soil (IDp), according to FAO-UNESCO classification *Haplic Luvisols (LVh)* (Buividaite, 2005). Soil agrochemical characteristics: pH_{KCl} – 5.2–6.2, humus – 2.11–2.18%, mobile P₂O₅ – 108–152 mg kg⁻¹, mobile K₂O – 150–165 mg kg⁻¹.

Meteorological conditions during summer seasons of the 2008–2012 periods were not always optimal for the growth of potatoes. Rating of meteorological conditions by hydrothermal coefficients showed that entire summer season of only one year (2008) was favourable for plant growth (table 1). In other summer periods were too wet.

Potato varieties were bred using hybrid cross method (Bradshaw et al., 2006). For the crossing, tubers of parental varieties were planted in the glasshouse on the peat and organic manure mixture on the top of a brick. The first varieties were a mother plant and the second one – a father plant. The hybrid berries were collected, planted to the peat pots next year and transplanted to the potato selection field after spring freezing danger. The best potato clone was selected from others. Manifold selection of the clone resistant to late blight and other diseases in the field and during potato storage showed the expected results. The resistance to wart disease and potato cyst nematodes was tested at the Institute of Plant Protection in Byelorussia.

Таблица 1. Метеорологические данные 2008-2012 гг. Среднее за период 1961–1990 гг.
Table 1. Meteorological data of 2008-2012. Long term average of 1961–1990

Month	Meteorological conditions					Long term average
	2008	2009	2010	2011	2012	
Air temperature, °C						
June	15.8	14.9	16.7	18.3	14.8	15.7
July	17.8	18.0	21.8	19.6	19.5	16.9
August	17.6	16.4	19.8	17.3	15.2	16.3
Precipitation, mm						
June	69	129	142	41	99	77
July	58	107	208	155	81	78
August	55	68	117	101	83	68
Hydrothermal coefficient						
June	1.45	2.88	2.8	0.75	2.22	-
July	1.05	1.92	3.1	2.55	1.34	-
August	1.01	1.34	1.9	1.88	1.67	-

All five varieties were tested and grown on carbonaceous fluvial-glacial gravel eluviated soil sandy loam soil in a crop rotation field of the breeding department after grasses. The trial field was fertilized with organic manure – 50 t/ha⁻¹ and mineral fertilizers N₉₀ P₉₀ K₉₀. Tubers were planted by hand into the rows. All plots of the field were fully randomized; the number of replications in different years was up to four. The size of the plots was also different, but each plant feeding plot was always 0.7 × 0.35 m². In the first three years potatoes were harvested by hand, later with a potato digging machine. Tubers were stored in the underground potato storage at natural conditions: +1

to +2°C and 80–90% humidity in winter (Razukas et al., 2009).

Damages caused by potato blight and degree of the disease development were determined at the time of potato flowering (for each tested genotype). 100 plants were used for the assessment. Disease severity was measured by the scale approved and recommended by OEPP/EPPO (Schepers, 2000). Potato variety ‘VB Venta’, which is very susceptible to blight, was cultivated as a standard for testing the susceptibility of other varieties to *P. infestans* (Asakaviciute et al., 2007)

Statistical analysis of the data was performed using a StatView ANOVA program. The obtained data were assessed by the method

of dispersion analysis, employing the ANOVA (LSD_{0.05}) statistical data processing software (Tarakanovas, 2002).

Results

Description of the potato varieties

'*VB Venta*' (2009). The maturity of the variety 'VB Venta' is very early. Tubers are round, with medium-deep eyes. Skin and flesh color is light yellow. Cooking characteristics are perfect. There is no browning after peeling. Taste is excellent. The variety is salad type. Starch content is up to 14–16%. The variety 'VB Venta' is resistant to wart disease; it possesses good field resistance to the black leg, potato leaf roll virus. Storage characteristics under controlled conditions are excellent.

'*VB Liepa*' (2010). The variety is early. The plants are compact, flowers are violet. Tubers are round, medium in size, with shallow eyes. Flesh and skin color is light yellow. Sugar content is low. No discoloration after peeling and cooking. Starch content is up to 20%. Resistant to potato cyst nematode R₀₁. Tubers are fully resistant to late blight.

'*Vaiva*' (2000). The variety is early. Tubers are long oval, medium in size, with shallow eyes, without discoloration. Skin colour is red. Flesh is yellow. Taste is good. It is suitable for processing industry. Starch content varies from 13% to 17%. The cultivar is resistant to potato cyst nematode R₀₁ and wart disease. Foliage is fairly resistant and tubers fully resistant to late blight. The cultivar has good resistance to virus diseases. Storage characteristics are good.

'*Goda*' (2004). The variety is early. Tubers are oval round, medium in size, with shallow eyes. Flesh and skin color is light yellow. Sugar content is low. No discoloration after peeling and cooking. Suitable for chips industry. Starch content is up to 16–17%. The variety is resistant to potato cyst nematode R₀₁ and wart disease. Foliage is fairly resistant and tubers fully resistant to the late blight. Storage is good.

'*Vokē*' (1981). It is an early food potato variety. The bushes are low and compact. Its flowering is short, produces rather few flowers. The flowers are light violet. The tubers are not big; yellowish, oval with shallow eyes. The skin is hard. The pith is light yellow. The variety pro-

duces many tubers. The potatoes are very suitable for industrial processing. The output of commercial tubers is 95%. Starch content is 15–17% and higher. The potatoes are palatable, boil soft, and do not get dark. The tubers contain little reducing sugars and thus are suitable for manufactured food production. It is especially suitable for potato dry industry, chips and crisps. Since the tubers contain very little mono sugars the products do not get brown, they are light yellow. The cultivar is resistant to potato blight, black leg, mosaic, is little affected by scabs, can be grown in all types of soil, but produces the highest yield on cultivated loamy soil. In dry summers the tubers are small. The potatoes are rather resistant to mechanical injuries, have good winter storage qualities.

'*Mirta*' (1994). It is a medium early, food potato variety. It has good taste and cooking characteristics, does not get brown after peeling and does not get black after cooking. Tubers are suitable for processing. Starch content is 15–18%. The cultivar can produce high yields and quality tubers. The tubers are of medium size, their shape is oval round, eye depth is shallow. Skin colour and flesh colour is light yellow. The cultivar has a short flowering period and produces rather few flowers, of white colour. The cultivar is resistant to summer heat and dry weather conditions. It is resistant to potato cyst nematode and wart disease. The cultivar is resistant to late blight, black leg, and potato leaf roll virus infection. Storage characteristics under controlled conditions are excellent. The cultivar is suitable for chips industry.

'*Nida*' (1989). It is a medium early, food potato variety. Its bush is compact, the stems are tall and big. It flowers abundantly, the flowers are red-violet, the flowering time is of medium length. The tubers are big, round with shallow, small eyes. The output of commercial tubers is 95%. Starch content is 14–16%. The potatoes are palatable, boil soft. The cultivar is resistant to wart disease, potato cyst R₀₁ nematode, Solanum virus 14, black leg. Medium resistant to potato late blight has good resistance to X virus. The cultivar can be grown on different types of soil, is resistant to dry weather, does not require any special cultivation techniques, storage conditions are good. The cultivar is not affected by machine harvesting as it has a hard skin.

'*VB Rasa*' (2006). The variety is late. The plants are compact, flowers are violet. '*VB Rasa*' has high yielding and starch content characteristics, field resistance to common scab, immunity to wart disease and to the R_{o1} patotype of golden nematodes.

Potato variety '*Méta*' (1965). The plants are compact, stems straight, flowers white. Tubers are light yellow, round, with shallow eyes, flesh colour is yellow. Starch content is 16%. The variety is late and has good cooking characteristics. Is resistant to potato cyst nematode, cancer and late blight.

'*Vilnia*' (1981). The variety is medium late, growing season 96 days, can be grown under dry conditions. Potato tubers are long oval, the skin is red, the flesh is yellow. The cultivar is very high yielding; starch content is 15–19%. The cultivar is not susceptible to potato blight, resistant to virus diseases, to wart disease, potato R_{o1} nematodes. Tubers are rather resistant to mechanical injuries, have good winter storage qualities.

'*VB Aista*' (2006). This is a late, food potato variety. The bush is stretched out, the stems are tall. The flowers are white, of medium size. The variety flowers abundantly and for a long time. The tubers are big, yellowish, flat round with shallow eyes. The output of commercial tubers is 90%. Starch content is high, up to 21%. The variety is good for starch industry. The potatoes are palatable. The boiled potatoes do not get dark, boil soft. The variety is resistant to wart disease, potato cyst nematode R_{o1} , late blight. The variety is resistant to drought, can be grown in all kinds of soil using proper cultivation techniques. The variety is resistant to mechanical injuries while harvesting; characterized by good storage quality.

Main quality points of Lithuanian potato varieties in competitive trials

Average quality data is presented in the table 2. Last five years of testing in the competitive potato trials show that the lowest potato yield was obtained of '*Méta*' variety, average data show that yield has reached 25.5 ± 0.68 t/ha⁻¹. The highest average potato yield was registered growing potato variety '*Goda*' which is the last

one in Lithuania potato breeding program. Seed potatoes yield reached 37.2 ± 1.24 t/ha⁻¹. Data of potato quality show that potato starch amount depends on genetic oneness of potato variety and special purposes. So the highest starch amount was produced by potato variety intended for starch industry – '*VB Aista*'. It was over $20.3 \pm 0.97\%$, while earlier maturity potato varieties accumulated starch amount up to 18%. The best taste over 8 points had main table potato varieties – '*VB Venta*', '*VB Liepa*', '*Voké*', '*Goda*' and '*Mirta*'.

Potato blight causes 15 to 50% of the yield losses each year, and in the years of blight epidemic up to 80% of the yield could be lost (Swiezynski et al., 2000). The damage caused by potato blight varies depending on locality of potato cultivation, growing conditions, weather conditions during the vegetation season, time of disease occurrence, resistance of a variety to blight, volume and quality of the applied protection measures.

The tests were conducted in 2008–2012 at Voké Branch of the LRCAF. In order to create new potato varieties immune to the agent of potato blight *P. infestans* great attention is paid to the investigations of this disease. Therefore, detailed research on the initial material for breeding of potato varieties is carried out. The tests revealed that among 10 Lithuanian potato varieties '*Voké*', '*VB Rasa*', '*VB Aista*' were more resistant to blight in natural infection background (figure). Potato foliage is the most vulnerable to blight in the field. During the test period damages varied depending on air temperature, humidity, light intensity, potato variety. First signs of the disease – small, dark green to brownish, irregularly shaped blotches. In artificial infection background they were rapidly expanding turning into dark gray or brown shapeless blotches. In recent years, in the natural infection background the first disease symptoms appeared not only on leaves but also on stems, leaf axes, unpaired leaf axle shafts – in the upper part of the plant and plant apex. This indicates the increased aggressiveness, virulence of local populations of the pathogen and disease harmfulness.

Таблица 2. Основные показатели качества литовских сортов картофеля (Воке филиал, 2008–2012)

Table 2. Main quality points of Lithuanian potato varieties in competitive trials (Voke branch, 2008–2012)

Variety	Vegetation	Yield, t ha ⁻¹	Starch, %	Dry matter, %	Taste points
‘VB Venta’	very early	28.7±0.89	15.0±0.67	20.2±0.74	8.1±0.09
‘VB Liepa’	early	30.3±0.90	18.5±0.74	22.4±0.57	8.3±0.07
‘Vokė’	early	33.4±0.11	16.8±0.71	20.5±0.75	8.1±0.09
‘Goda’	early	37.2±1.24	17.0±0.61	21.0±0.49	8.8±0.08
‘Vaiva’	early	30.4±0.91	17.3±0.62	21.4±0.49	7.4±0.07
‘Nida’	early	33.8±0.10	17.9±0.67	22.2±0.58	7.4±0.07
‘Mirta’	early	32.2±0.98	18.2±0.74	22.4±0.56	8.8±0.08
‘VB Rasa’	late	26.9±0.78	19.8±0.86	23.6±0.78	7.7±0.04
‘Mėta’	late	25.5±0.68	17.8±0.65	21.8±0.43	7.5±0.05
‘Vilnia’	late	29.8±0.89	17.6±0.64	21.5±0.42	7.3±0.06
‘VB Aista’	very late	29.4±0.84	20.3±0.97	24.7±0.84	7.3±0.05
LSD _{0.05}	-	2.196	1.976	2.549	0.048

Discussion

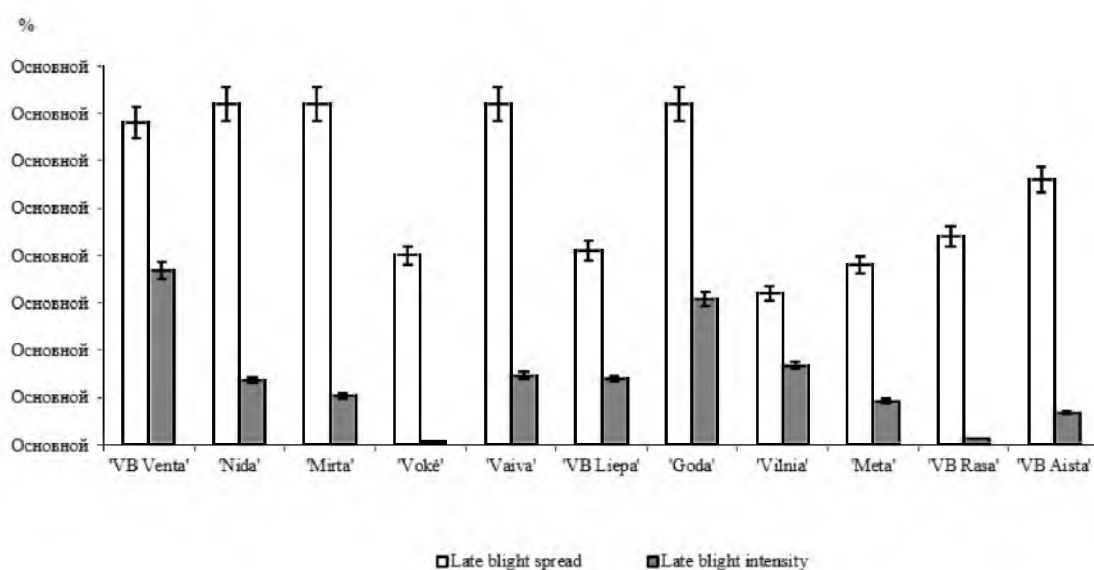
The success of the breeding work depends on the abundance and value of the initial material. New potato varieties ‘VB Venta’, ‘VB Rasa’, ‘VB Liepa’, ‘Goda’ and ‘VB Aista’ were bred at Vokė Branch of Lithuanian Institute of Agriculture. Varieties gave good quality yield not only in big farms but also in small potato plots in the gardens. All mentioned varieties are resistant to the main quarantine object in Lithuania – wart disease. Potato varieties ‘Goda’, ‘VB Liepa’, ‘VB Rasa’ and ‘VB Aista’ are immune to potato cyst nematode *Globodera rostochiensis* R₀₁ patotype. All varieties have good field resistance against the most spread diseases – black leg, viruses, common scab, rizoctonia, etc. During the years of investigations, potato foliage, plant apexes, stems and tubers were damaged by the agent of potato blight *Phytophthora infestans*. The intensity of potato

blight spread in the natural infection background among different varieties was determined not only by the earliness of the variety, but by its individual properties as well. Among the 10 tested varieties ‘Vokė’, ‘VB Rasa’ and ‘VB Aista’ were more resistant to blight, while in the artificial infection background – ‘VB Aista’ foliage showed higher resistance. Damages caused by potato blight to potato varieties of different maturation time were unequal. In early maturing potato varieties the disease was spreading more intensively, in maincrop varieties the spread was less intense. Lithuanian potato breeding program’s the main research object was and in the near future will be selection of early and maincrop potatoes, resistant to wart and nematodes. Due to high resistance to the diseases and pests all Lithuanian potato varieties are perfect for growing in ecological farms.

Acknowledgements

Research results are obtained through a long-term research program "Genetics and

purposeful change of genotypes of agricultural and forest plants" implemented by Lithuanian Research Centre for Agriculture and Forestry.



**Resistance of the foliage of Lithuanian potato varieties under natural infection pressure
(Voke branch, 2008–2012), LSD_{0.05} – 3.287**

**Устойчивость листьев литовских сортов картофеля при естественном инфицировании
(Воке филиал, 2008–2012), LSD_{0.05} – 3.287**

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