# Formation of Cover, Yield and Low Winter Temperature Tolerance of Lowbush Blueberry (*Vaccinium angustifolium* Ait.) on the Cutover Raised-Bog Peatlands of Belarusian Lakeland

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*Abstract*

A long-term introduction experiment conducted in 2009–2016 revealed that in the harshest weather conditions of the northern part of Belarus associated with a difficult environmental situation in a trial area, on weakly-decomposed acid sphagnum peat and with the lack of artificial watering, lowbush blueberry (*Vaccinium angustifolium* Ait.) due to the significant tolerance to harsh conditions in the environment is still able to fulfil its bioproductive potential. Lowbush blueberry plants formed a continuous bush cover and showed high resistance to cold. A sustainable cultivated plantation formed. Plant cover protected a peat substrate from fires, water and wind erosion, and showed a high level of berry fruit productivity during the whole recorded period. It proves the appropriateness of the ecological-biological type of the species to the extreme weather and conditions of the experiment. However, lowbush blueberry plants showed a need for improved mineral nutrition. The implementation of these conditions is a guarantee of successful introduction of the plant on the cutover raised-bog peatlands in northern Belarus.

**Keywords:** lowbush blueberry, cutover raised-bog peatland, introduction

## Introduction

As of 2014, Belarus' land reserves comprised 143.3 thousand ha of cutover peatlands not used by the peat extraction industry, 83.8 thousand ha of which have been restored in different ways. It is a serious ecological and economic problem. Some ways to solve this issue include growing of forest stands and agricultural crops, ecological rehabilitation of cutover peatlands by rewetting, and reclamation by the cultivation of berry bushes, mainly including representatives of the family *Ericaceae*. The first two ways are widely utilized, although they are not always efficient; but the rewetting of cutover peatlands has become increasingly wide spread, especially in recent years (Kozulin et al. 2017). On the other hand, the possibility of growing berry bushes on these peatlands has not been sufficiently studied.

Available information concerning particular species of berry plants is not complete. Our country has the scientific base and the experience in growing of the following species of the family *Ericaceae*: highbush blueberry (*Vaccinium corymbosum* L.), marsh cranberry (*V. macrocarpon* L.), swamp blueberry (*V. uliginosum* L.), and cowberry (*V. vitis-idaea* L.) (Evtuchova 1991, Morozov 2008, Volchkov et al. 2012, Titok et al. 2012). However, we do not have enough information to decide whether it is commercially reasonable to cultivate lowbush blueberry (*V. angustifolium* L.) on cutover peatlands (Listvan et. al. 2010, Rupasova and Jakovlev 2011).

The working hypothesis of our study is that in the process of introducing lowbush blueberry on the cutover peatlands in northern Belarus, the plants are more resistant to harsher conditions, such as a low temperature, than the highbush blueberry. Highbush blueberry has become widely cultivated in the southern and the central parts of the country, but its cultivation on the area of Belarusian Lakeland has no prospects because of regular freezing of young sprouts and flower buds. That is why in the north of Belarus the area under *V. corymbosum* cultivation is only 1.4% (Titok et al. 2012).

If our experimental results are positive, and the hypothesis expressed is confirmed, we will be able to conclude that the whole territory of Belarus is suitable for possible cultivation of lowbush blueberry (including the northern part) and highbush blueberry (in the southern and central parts of the country) through the introduction of hardy plant material. In future it could definitely have economic, environmental and social importance for Belarus.

Estonia is the leader in an introductory study of lowbush blueberry in Europe (Noormets et al. 2003, Tasa et al. 2015). In fact, the positive results of Estonian scientists are achieved in conditions that are even more severe than those of northern Belarus that have encouraged us to conduct this research. For instance, the yield of lowbush blueberry on the territory of cutover peat deposits in Estonia is 10–15 ton of berries per hectare (Paal 2000, Starast et al. 2005a, Starast et al. 2005b).

On the other hand, commercial plantations of lowbush blueberry are not widespread in their native area of North America, where a lowbush blueberry industry has developed based upon partially cultivated plants of natural berry bushes as well as small plantations of selected and varietal plants. The consideration of bilberry (*V. myrtillus* L.), which is native species related to lowbush blueberry, is a hypothetical wild local alternative. Bilberry plants are widespread in Belarus as well as in other northern countries. Its berries have valuable medicinal and nutritional properties. However, it is not cultivated in plantations, because substantial harvesting of wild growth berries, satisfying the needs of the market.

In North America *V. angustifolium* is characterized with a wide range of habitats and can be found in mixed coniferous and hardwood forests, along the sandy river banks, on uncovered rocky sediments, as well as on raised marshes and cutover peat deposits. Lowbush blueberry is a part of the plant community in old fields, pastures, along the roads, and is an early species in logging and burnt areas (Hall et al. 1979). It is a vegetatively flexible species. Under natural conditions lowbush blueberry propagate through seed spread by birds and other animals that over years spread further from resting buds located on the underground rhizomes (Camp 1945, Ahlgren 1960, Hall et al. 1979). This biological characteristic contributes to the formation of a continuous berry bush cover which indicates high phytocenotic resilience of the plant to competitive species in the process of developing new plantations. This biological peculiarity is important for the increase of berry productivity per unit of surface area in a natural or cultivated plantation.

The species under study is a true acidophile. The acidity of soil from 4.2 to 5.2 is the most suitable for its growing (Trevett et al. 1971, Korcak 1988). At the same time, lowbush blueberry grows well on cutover peat deposits even at pH 2.5–2.7 (Paal et al. 2011). Therefore, in selecting the site to establish plantations it should be taken into account that neutral and, especially, alkaline conditions of the soil solution limits the cultivation of *V. angustifolium*.

Twenty-five millimeters of precipitation is enough to provide lowbush blueberry with water for a whole week during the growing season (Hunt et al. 2009). Irrigation or artificial watering is optional for the successful growing of this species, and this helps to cut the cost of fruit producing. Excessive watering of the growing media can reduce the yield of the plant, and under flooding lasting more than 32 days leads to plant death (Lin et al. 2002). The awareness of these facts is essential, because rewetting has been widely applied in Belarus in recent years, eliminating the possibility of growing lowbush blueberry (Kozulin et al. 2017). Besides, large areas of forest stands and raised-bog cutover peat deposits have frequently become flooded resulting from the activity of the European beaver (Lesko 2009).

The lowbush blueberry prefers full sunlight. Its photophily becomes clear because this plant prefers wide open, well-lit locations (Hall 1958). The shadowing of it by weeds leads to the reduction in fruit yield, and at the illuminance of lower than 500 lux the formation of fruit buds almost completely stops (Hoefs and Shay 1981). These facts indicate that raised-bog cutover peat deposits, which are open to solar radiation during daylight hours and are not planted with competitive plants, are entirely suitable for the planting of the species.

Lowbush blueberry is winter-hardy, it withstands temperatures up to –35–40 °C (Trevett 1969, Cappiello and Dunham 1994) that are exceedingly rare even in northern Belarus (Republican HydroMeteoCentre 2008).

The grounds for the beginning of the long-term introductory study of lowbush blueberry (lasted from 2009 till 2017) were the following: our hypothesis was confirmed that large areas of cutover raised-bog peat deposits in the northern parts of Belarus were available, and Estonian scientists achieved positive results in their experiments with cutover peat deposits.

The purpose of the project was to determine the prospects of commercial cultivation of *V. angustifolium* on the cutover raised-bog peatlands of Belarusian Lakeland located in the northern part of Belarus.

## Materials and Methods

The target of research was lowbush blueberry plants represented by 26 breeding forms selected in 2002 from a set of seedlings grown from open-pollination of the best Canadian clones K70–62, K508, K510 and ME3. The seeds were kindly provided by Estonian researcher Dr. T.V. Paal. Potentially productive forms were vegetatively propagated by cutting from lignified sprouts from the parent seedlings in spring. These propagated plants were grown for two years and were planted on an experimental site, where each of the seedling clones was represented by 15–26 specimens. The overall number of plants from cuttings was 534 pieces. The use of a significant amount of selective heterogenic plants was caused by the need for an unbiased assessment of the range of intraspecific variability of *V. angustifolium* under the conditions to be tested.

The introductory investigation was started in spring of 2009, after the planting on the experimental site located in block 50 patch 3 of Polovsk forestry department of State Forestry Institution "Postavy Forestry" (Sharkowshchyna district, Vitebsk region) on one of the check plots of the cutover raised-bog peat deposit "Dolbenishki" (the number according to the peat fund cadastre of Belarus is 705, the area size comprised 4,263 hectares). According to Kozulin et al. (2017), it is one of the oldest peatbogs in Belarus. It began to form in the ancient Holocene period (12.0–10.5 thousand years ago) in the process of wetting of mineral soils; as a result; even at the initial stage the formation of the deposit was characterized by depleted nutritional conditions. Its stratification resulted from the dominance of transitional (sedge-sphagnum) and raised-bog (*Sphagnum magellanicum* complex raised-bog) types of peat.

The total area of the research site was 0.15 ha. The distance between rows of plants was 1.5 m and the distance in a row was 1.0 m; these distances were used throughout the planting. The root crown of all plants was planted 5–10 cm below the peat surface. No artificial watering of the plantation, or mulching of the plantings was provided.

The thickness of the residual peat layer on the site was more than 2.0 m, its surface was well levelled, without cavities and micro-hills (Figure 1), allowing to begin planting without preliminary soil treatment and surface grading. The botanical composition of the peat in an upper root soil layer (0–30 cm) was the following: 75% S*phagnum* sp., 20% common pine, 5% sheathed cotton sedge. The degree of decomposition was 35%. The potential exchangeable acidity (pH in KCl) varied within 2.4–2.8. According to the data mentioned above, the type of peat on the plantation was raised-bog, pine sphagnum, haemic, highly acidic. The natural fertilizer levels in the peat at the experimental site were generally low.

**Figure 1.** The area of the cutover peat deposit of a raised-bog type "Dolbenishki" used for experimental planting (photo by D.W. Gordej)

The ash content of peat comprised 1.67%. The total content of nitrogen was 1.08%; that of phosphorus expressed as $P_2O_5$ was 242 mg/kg, of which 15 mg/kg in an available form; the total potassium content expressed as $K_2O$ was 246 mg/kg, of which 210 mg/kg was in an available form.

Due to the availability of a hydro-reclamation network, which elements were represented on the site by two drainage ditches along its long side, water table level was maintained at a depth of 1.0–1.5 m beneath the soil surface during the summer periods of 2009–2011. Because of prolonged absence of precipitation, the drying of the upper layer 5–10 cm thick was observed.

After the work on the rewetting of the territory adjacent to the experiment site in 2012 water table level rose to a depth of 30–60 cm below the soil surface, and in certain periods after heavy rains it reached 20–25 cm.

Initially, there was almost no vegetation on the site (Figure 1). In 2009 it was represented by a few specimens of common heather (*Calluna vulgaris* (L.) Hill), wild rosemary (*Ledum palustre* L.), leatherleaf (*Chamaedaphne calyculata* (L.) Moench), bog rosemary (*Andromeda polifolia* L.), sheathed cottonsedge (*Eriophorum vaginatum* L.), cranberry (*Oxycoccus palustris* Pers.), swamp blueberry (*V. uliginosum*), and some other bog species such as sedge (*Carex* sp. L.), white birch seedlings (*Betula pubescens* Ehrh.), and Scots pine seedlings (*Pinus sylvestris* L.). They were usually found in stripes 1–2 m long on both sides of the drainage ditches.

The botanical composition of peat was determined on the basis of the average percentage of plant residues in 10 fields of microscope, using a morphological atlas (Dobrovolskaja et al. 1959).

The degree of decomposition of the upper peat level (0–30 cm) was determined by microscopical method on the basis of the average area occupied by humus in 20 fields of microscope, expressed in percent. The degree of decomposition of the underlying peat levels was determined in the field environment on the basis of plant residues' features, the colour of water and peat, flexibility of peat, and the characteristics of smears (Volkova 2009).

The potential exchangeable acidity (pH in KCl) was determined with the help of pH-meter-millivoltmeter HI 931400.

The introductory experiment was conducted in addition to the main agrotechnical measure – the introduction of mineral fertilizers. In 2009–2015 the cultivation of plants was carried out using a complex mineral fertilizer "Rastvorin" brand A. The composition of the fertilizer was the following: macroelements: 10% N (ammonia and nitrate in equal amounts), 5% $P_2O_5$, 20% $K_2O$, 5% MgO; microelements: 0.01% Zn, 0.01% Cu, 0.1% Mn, 0.001% Mo and 0.01% B. The application of the fertilizer and a forthcoming loosening of the upper peat level for a mount embedding were carried out manually around the bushes on the following days: April 15, 2009; May 06, 2010; July 20, 2010; April 20, 2011; June 29, 2011; March 22, 2012; May 08, 2013; June 10, 2014; March 24, 2015. The amount of the fertilizer in the mount used per one plant was 5 g in 2009–2011, 10 g in 2012, 14 g in 2013 and 17 g in 2014–2016.

After the regeneration pruning conducted on a part of the experimental site in 2016 a complex mineral fertilizer "Rastvorin" brand A1 was used for plant nutrition (May 05, 2016). The composition of the fertilizer was the following: 8% N, 6% P, 28% K, 3% $MgO_3$, 0.01% B, 0.001% Mo, 0.1% Mn, 0.01% Cu, and 0.01% Zn. The application of the fertilizer was carried out in random order mainly in the rows of parent plantings including spaces between rows where the bases of cut partial shrubs were seen. The amount of the fertilizer used per one hectare was 300 kg.

In the summer (July 18, 2016) the second step of fertilizing with the use of the complex mineral fertilizer Fertica "Osennee" was conducted. The composition of the fertilizer was the following: 4.8% N, 20.8% P, 31.3% K, 0.55% Ca, 0.5% MgO, 0.7% S, 0.09% B, 0.08% Cu, 0.16% Fe, 0.16% Mn, 0.08% Mo and 0.09% Zn. The amount of the fertilizer used per one hectare was 120 kg.

A visual monitoring of the forming of plant cover under study was carried out throughout the whole observation period several times during each growing season; the most important elements of the process were recorded.

The yield produced by each of the studied plant clones was determined as the arithmetic mean of the value for the 15 to 26 parent plants for each clone. The yield from one clonal plant was estimated by the addition of the weight of berries collected at all harvests over the season.

The average weight of a berry was determined according to the analysis of three weighed portions 100 berries each selected by random sampling technique. The length and width of a weight-average berry was measured using a caliper.

The assessment of winter-hardiness was the ability of blueberry plants to survive below-zero temperatures and severe frosts. The main criterion of winter-hardiness for the species under study was the degree of damage to vegetative and generative organs, which was necessary for substantiation of the economic possibility of cultivation of this specie in plantations. Thus, in carrying out this winter hardiness research, we set ourselves the following tasks: 1. to find out whether *V. angustifolium* was damaged by negative temperatures during the winter period, 2. if so, to determine the extent of frost damage and, 3. to determine the way to minimize it.

The damage was recorded at the beginning of active development of vegetative and generative organs (May 06, 2010; April 20, 2011; May 03, 2012; May 07, 2013), when it revealed itself distinctly enough (the drying of the sprout apexes and generative and vegetative buds). In accordance to the damage degree of the crown of plants of each clonal type caused by negative temperatures, the plants were divided into the following groups:

1) highly winter-hardy – the signs of damage caused by negative temperatures are absent;

2) winter-hardy – slight freezing occurs, up to 10% of the volume of the bush crown was damaged;

3) medium winter-hardy – freezing was medium, from 11 to 25% of the volume of the bush crown was damaged;

4) low winter-hardy – freezing was significant, from 26 to 50% of the volume of the bush crown is damaged;

5) non-winter-hardy – freezing was considerable, or the dying of the whole plant occurred; more than 50% of the bush crown is damaged, or a plant died (Sedov and Ogoltsova 1999).

The hardiness scores of each form were estimated as the difference between a constant value of ten and the ratio of the degree of damage caused by negative temperatures to one tenth of the maximum value of the considered index of the 26 plant forms or clones under study.

Statistical data processing aimed at determining the average of studied parameters and errors in these parameters was carried out with the help of the following programs: Microsoft Office Excel 2007 and STATISTICA 6.0 software package (Borovikov 2013; StatSoft 2001).

## Results

### *Formation of a berry bush cover*

A long-term study of the peculiarities of plantings' morphogenesis revealed that in the process of formation of sprouts from buds near the root crown a gradual spread of parent shrubs from the centre to the periphery takes place. A lot of new "layers" of sprouts emerge (Figure 2).

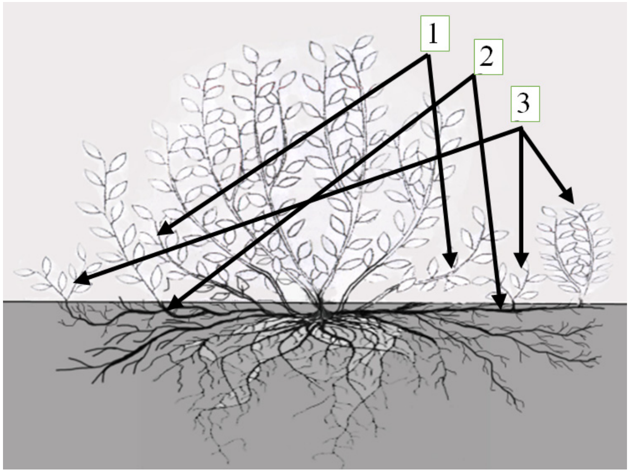


**Figure 2.** The scheme of development of a parent shrub, rhizomes and partial shrubs: 1 – the sprouts on the periphery of a parent shrub, 2 – rhizomes, 3 – partial shrubs (picture by A.A. Shurygina)

Each of these "layers" is characterized by increasingly strong plagiotropism. It means that the most prevalent part of sprouts that occupy the periphery of bushes and have an orthotropic growth direction of the apex is the one that tilts to the ground surface at a small angle or even is almost horizontal and touches the substrate. That is why the height of bushes does not increase proportionally to the gradual increase in the length of peripheral sprouts in the process of a parent plant growth. The following age-related transformation of the shape of bushes is observed: bushes are increasing in the diameter of the crown more and more actively, at the same time, their height does not change. And this means that the horizontal direction of growth prevails over the vertical vector. In the second year, the crown of certain plants cultivated with the use of a mineral fertilizer achieves a diameter of 2 meters. This is the first component of vegetative distribution of *V. angustifolium* throughout the site.

The second component of its territorial expansion is the development of the rhizome system. Some of the growth extensions reach several meters in length, extending along the ground surface in the horizon 5–10 cm deep and forming a fan-like system of sprouts of different kinds.

Partial shrubs begin to appear on these rhizome extensions from inactive buds in the first vegetation season after planting (Figure 2). Eventually, they gradually occupy the territory of the site (Figure 3).

**Figure 3.** The occupation of the space between parent plants by partial shrubs in four-year plantings (photo by D.W. Gordej)

Two layers of berry bushes are formed: an underground layer that is mainly a thick "net" of rhizomes (Figure 4), and above-ground one, that, 7 years after planting, is a thick cover, different from the look of the site immediately after plantation (Figure 5).

**Figure 4**. A fragment of a rhizome system and partial shrubs (photo by D.W. Gordej)

Each daughter plant is a new clone reference point, serving for further polycentric development of the site (Figure. 4). The significant number of partial shrubs located directly on the periphery of parent plants, closely to the last «layer» of plagiotropic sprouts, grows from the buds on the rhizomes.

The features of a morphogenesis described above are the guarantor of phytocenotic stability of a cultivated phytocenosis, and they represent an essential component of positive temporal development of berry productivity. Due to these features the possibility of wind and water erosions is minimised, and the risk of fire is reduced.

Due to the gradual shift from discrete parent shrubs to a thick cover of berry bushes (Figure. 5) the need for control over competitive species with the help of chemicals and hand weeding becomes unnecessary. This helps to reduce the cost of berry production.

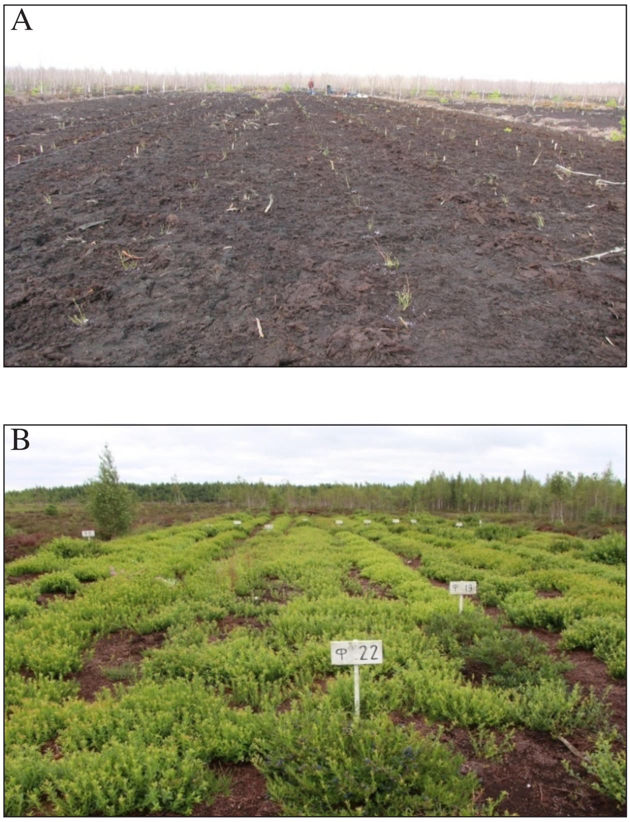


**Figure 5. A** – An experimental site immediately after planting (April 2009). **B** – The layer of berry bushes 7 years after (Photo by D.W. Gordej)

The ability of lowbush blueberry to form a continuous cover can be increased by 4–5 times if mineral fertilizing is applied annually and the peat around bushed is loosened regularly at least for the first three years (Figure 6).

Anyway, the site cannot remain without agrotechnical measures for a long time after the formation of a continuous berry bush cover. As will be shown in the next section, increased density may cause a decrease in fruit yield, and that is why it is necessary to carry out regeneration pruning. In spring 2016 we conducted such practice on a part of the experimental site in a 7-year-old cultivated plantation. We noted an excellent vegetative reproduction and good growth as its preliminary result.

**Figure 6.** The plant of forms 6, 8, 21 (rows from left to right) without application of mineral fertilizers (in the forefront) and with the application of the fertilizers during 2009–2012 (in the background) (Photo by D.W. Gordej)

***The yield of berries***

Mineral fertilizing had a significantly positive influence on the yield of berries. In Table 1, as an example, which confirms what has been said, we provide the data on three clones: 6, 8, 21 for three years: 2011, 2012, 2013. It should be noted that the situation these data reflect is typical for all years of observation, and for the remaining 23 forms. Forms 6, 8, and 21 were chosen randomly.

According to Table 1, the average yield of one bush without the application of a mineral fertilizer (check variants I) was the following: form 6 – 1.4%, form 8 – 1.6%, form 21 – 5.1%, as compared with the same form, using the fertilizer (experimental variants II). A year later, the relative yield of non-fertilized bushes slightly increased: in 2012 form 6 had 10.5%, form 8 had 11.8% and form 21 had 10.4% of the yield of the corresponding fertilized

**Table 1.** The average yield and weight of a berry depending on the conditions of mineral nutrition in 2011–2013

| Year | Form | Variant of the experiment | The average yield of a bush, g | | The average weight of a berry, g | |
|---|---|---|---|---|---|---|
| | | | $\bar{x} \pm s_{\bar{x}}$ | V, % | $\bar{x} \pm s_{\bar{x}}$ | V, % |
| 2011 | 6 | I | 2.9 ± 1.3 | 128.1 | 0.35 ± 0.02 | 20.9 |
| | | II | 210.2 ± 55.4 | 79.1 | 0.89 ± 0.03 | 10.0 |
| | 8 | I | 5.1 ± 1.2 | 51.5 | 0.47 ± 0.04 | 17.8 |
| | | II | 322.9 ± 51.4 | 45.0 | 0.75 ± 0.04 | 14.2 |
| | 21 | I | 8.6 ± 2.3 | 74.3 | 0.29 ± 0.01 | 3.9 |
| | | II | 168.3 ± 56.4 | 94.8 | 0.57 ± 0.06 | 22.5 |
| 2012 | 6 | I | 43.7 ± 2.4 | 26.5 | 0.29 ± 0.01 | 3.8 |
| | | II | 264.2 ± 15.6 | 18.7 | 0.42 ± 0.01 | 8.4 |
| | 8 | I | 36.7 ± 2.1 | 25.0 | 0.24 ± 0.01 | 3.1 |
| | | II | 310.9 ± 16.2 | 16.5 | 0.44 ± 0.02 | 4.4 |
| | 21 | I | 28.3 ± 2.1 | 32.4 | 0.24 ± 0.01 | 0.0 |
| | | II | 272.0 ± 10.3 | 11.9 | 0.31 ± 0.01 | 10.2 |
| 2013 | 6 | I | 50.1 ± 5.0 | 31.3 | 0.31 ± 0.01 | 1.4 |
| | | II | 534.6 ± 40.5 | 24.0 | 0.60 ± 0.03 | 12.4 |
| | 8 | I | 56.2 ± 5.2 | 294 | 0.33 ± 0.02 | 4.7 |
| | | II | 640.3 ± 37.0 | 18.3 | 0.48 ± 0.01 | 2.3 |
| | 21 | I | 40.8 ± 3.4 | 26.6 | 0.29 ± 0.01 | 4.4 |
| | | II | 470.0 ± 35.6 | 24.0 | 0.45 ± 0.01 | 5.6 |

*Note*: I – check variants without mineral fertilizing; II – experimental variants with mineral fertilizing.

forms. In 2013, in the experiments without the use of a fertilizer, the yield of bushes decreased as compared to the fertilized variants: the yield of form 6 fell to 9.4%, that of form 8 – to 8.8%, and the yield of form 21 – to 8.7%. In years 2014–2016 this tendency only intensified.

The first commercial yield of the variants under improved conditions of mineral nutrition was obtained as soon as in 2011. A completely different situation was recorded in the variants, where the production of berries occurred only due to the natural fertility. Six years later, the projected yield here was only 164.2–292.8 kg/ha (Table 1). This is clearly not enough to call it a commercial harvest.

The improvement of conditions of mineral nutrition contributed to a significant increase in the average weight of a berry. Firstly, it is one of the components of higher berry yield. Secondly, it has great importance in terms of increasing the attractiveness of berries to the consumer.

In 2011, the output of experimental variants of form 6 was higher by 2.5 times, that of form 8 – by 1.7 times, and that of form 21 – by 2.0 times comparing with the check variants.

This tendency remained in the following recorded years: in 2012, the exceedance of the average weight of berries of form 6 was 1.5 times, that of form 8 was 1.8 times, that of form 21 – 1.3 times; in 2013, the average weight of berries of form 6 increased by 1.9 times, that of form 8 increased by 1.5 times, and that of form 21 – by 1.6 times. In 2014–2016 years, the ratio of the average weight of berries of the experimental and check variants of our experiment did not undergo significant changes.

Thus, in our opinion, the improvement of nutrition conditions of cultivated plants through the annual application of mineral fertilizers is one of the most effective elements of agricultural techniques in the process of introduction of *V. angustifolium* on raised-bog peatlands.

In this regard, in the text below, we describe the yield indicators under the improved conditions of mineral fertilizing.

In 2010, or in the second year after planting of two-year-old plants from cuttings, several plants of 26 selected forms reached a fruiting stage. The yield of plants was not high, and it amounted to 14–33 g per bush. The yield from one hectare of the plantation was also insignificant; it was calculated taking into account the chosen planting scheme – 93–220 kg. All these facts in no way allowed us to consider the fructification in the two-year cultivated plantation as commercial.

As it was mentioned above, in 2011, all studied forms had such a yield that its amount allowed us to consider it commercial. The yield of the forms ranged widely – from 59.9 to 329.9 g per bush (Figure 7), which, with the adopted planting scheme, guaranteed the projected harvesting of from 401 to 2210 kg of berries per hectare.

A typical tendency in fruit yield from bushes of the 26 clones of *V. angustifolium* for the period of 2011–2015 was its constant increase (Figure 7). The value of this indicator increased by 6.8 times over this period. It should be noted that at this time the harvest on partial shrubs began to form, gradually filling the spaces in rows and between them (Figure 3). In this case, if consider the yield per one plantation surface unit, its increase is even more significant.

***Tolerance to the temperature conditions of a winter season***

A well-formed cover of vegetatively flexible berry bushes, such as lowbush blueberry bushes, is one of the fundamentally important conditions for high yields of berries. As it was shown in the two previous sections of the article, *V. angustifolium* undoubtedly has a strong ability to natural active regeneration in the conditions of cultivation, due to which a phytocoenotically stable, regularly yielding cultivated phytocoenosis is formed. This would be impossible without the tolerance of the introduced plant to the abiotic factors of the habitat, in particular, to the temperature conditions of winter.

Not only for *V. corymbosum*, as it was mentioned in the introduction, but also for some other species introduced in Belarus, the discrepancy of their biological properties to the peculiarities of the temperature conditions of a winter season is the main hindrance to the successful growing in new conditions.

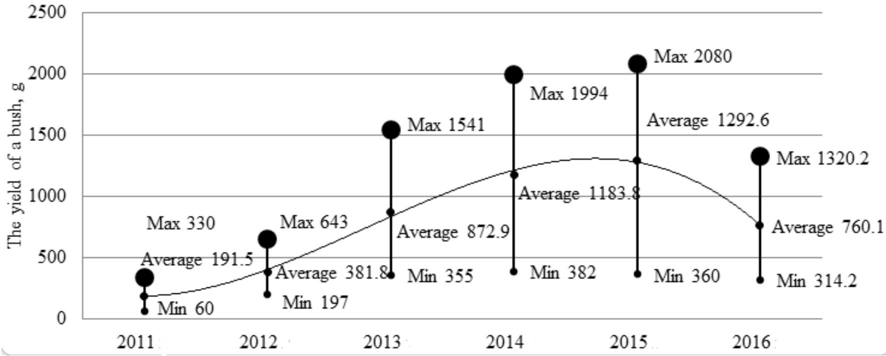


**Figure 7.** The dynamics of the highest, average and lowest yield of a bush of 26 forms of lowbush blueberry during 2011–2016

It should be noted that the damage to vegetative organs (as a rule they are non-lignified apical accretions of sprouts of the current year that bear vegetative buds embedded in leaf bases) inevitably results in the damage to generative buds. They are also formed in leaf bases in apical parts of one-year sprouts in the amount of 4–8 buds in the year before fructification.

In the observed time series of winters (2009–2010, 2010–2011, 2011–2012, 2012–2013), according to the data of the Sharkowshchina meteorological station (RP5.RU 2019), the closest to the experimental site, there were quite significant differences in the degree of their severity. As will be shown further, negative temperatures are often characterized by extreme values that go beyond the limits of the climatic norm.  Taking into account a sufficiently large number (26) of forms (genotypes) studied (Table 2), this gives grounds to assume that the obtained data are representative, and the conclusions drawn on the basis of their analysis do characterize the actual resistance of the plant under study to the negative temperatures of a winter period, when it is grown on raised-bog peat in the conditions of Belarusian Lakeland.

The winter of 2009–2010 was especially hard, and it had impact on young plantations that developed during only one growing season (spring planting of 2009). The average monthly air temperature in December 2009 was –11.2 °C, which is 7.1 °C lowlier the climatic norm. During January 2010 the weather was freezing, without thawing. The average air temperature in this month was 11 °C and even 7.8 °C lowlier the climatic norm. A milder weather was registered in February 2010, it was slightly lowlier than the norm at –5.1 °C.

The winter of 2010–2011 was also severe. The average monthly air temperature of the coldest months was the following: in December 2010 it was –7.7 °C, in February 2011 it was –10.2 °C, which was 3.6 and 6.1 °C lowlier than the climatic norm respectively. In January 2011, its value corresponded to the long-term annual average temperature of –4.1 °C.

The beginning of the winter of 2011–2012 was relatively late and mild. In December 2011, the average air temperature was +1.6 °C, which was 2.5 °C above the climatic norm. In January 2012, its value was slightly lowlier the climatic norm at –5.2 °C, but in February of this year it was –10.3 °C that is 6.2 °C lowlier the norm.

The average air temperature in December 2012 (–5.3 °C) was slightly lowlier the long-term monthly annual average temperature, in January 2013, even lowlier values were recorded (–9.1 °C), but February 2013 was characterized by relatively mild weather at –2.5 °C.

Absolute minimum temperature in the observed time interval ranged as follows: –27.3 °C in 2009–2010, –25.8 °C in 2010–2011, –28.5 °C in 2011–2012, –23.0 °C in 2012–2013.

Snow cover formed during all the years of monitoring, which, to a certain extent (depending on its thickness), minimized the adverse effect of negative air temperatures on plants (Figure 8).

**Table 2.** The damage characteristics of 26 forms of lowbush blueberry during the winter seasons of 2010–2013

| Form | 2010–2011 | | | 2011–2012 | | | 2012–2013 | | |
|---|---|---|---|---|---|---|---|---|---|
| | damaged plants, % | The damage to the crown, % | | damaged plants, % | The damage to the crown, % | | damaged plants, % | The damage to the crown, % | |
| | | $\bar{x} \pm s_{\bar{x}}$ | $V$, % | | $\bar{x} \pm s_{\bar{x}}$ | $V$, % | | $\bar{x} \pm s_{\bar{x}}$ | $V$, % |
| 1 | 90.9 | 8.0±0.9 | 47.1 | 81.8 | 6.1 ± 0.6 | 28.9 | 100.0 | 5.9 ± 1.2 | 36.2 |
| 2 | 94.1 | 9.4±1.0 | 43.0 | 82.4 | 3.4 ± 0.4 | 27.3 | – | – | – |
| 3 | – | – | – | 71.4 | 6.0 ± 1.0 | 37.3 | 90.0 | 4.7 ± 0.7 | 22.1 |
| 4 | 90.5 | 7.9±1.0 | 53.1 | 58.8 | 3.6 ± 0.6 | 26.8 | 66.7 | 3.5 ± 0.4 | 22.8 |
| 5 | 90.5 | 7.5±0.6 | 34.3 | 65.0 | 4.9 ± 1.1 | 34.6 | 66.7 | 4.1 ± 1.1 | 35.8 |
| 6 | 100.0 | 11.1±1.8 | 49.2 | 100.0 | 8.0 ± 0.7 | 26.5 | – | – | – |
| 7 | 100.0 | 17.5±0.7 | 17.3 | 90.0 | 4.0 ± 0.4 | 26.7 | 22.2 | 3.1 ± 0.2 | 16.1 |
| 8 | 100.0 | 9.4±1.0 | 31.8 | – | – | – | – | – | – |
| 9 | 100.0 | 12.8±0.8 | 28.4 | 100.0 | 8.8 ± 1.3 | 28.6 | – | – | – |
| 10 | 100.0 | 8.9±0.5 | 24.8 | 70.0 | 5.5 ± 0.9 | 20.2 | 52.6 | 3.3 ± 0.3 | 18.1 |
| 11 | 100.0 | 15.5±1.2 | 37.2 | 100.0 | 10.6 ± 0.6 | 16.6 | – | – | – |
| 12 | 93.3 | 7.3±0.7 | 35.5 | 100.0 | 16.5 ± 1.3 | 35.2 | 100.0 | 8.8 ± 0.9 | 31.3 |
| 13 | 95.7 | 10.9±0.7 | 30.5 | 41.7 | 3.0 ± 0.0 | 0.0 | 73.9 | 3.7 ± 0.9 | 19.4 |
| 14 | 95.7 | 10.5±0.8 | 35.9 | 66.7 | 4.2 ± 0.4 | 23.6 | – | – | – |
| 15 | 96.2 | 13.6 ± 1.1 | 40.4 | 76.9 | 7.4 ±0.7 | 30.7 | – | – | – |
| 16 | 90.9 | 7.0±0.6 | 35.9 | 80.0 | 5.3 ± 1.7 | 62.9 | – | – | – |
| 17 | 95.0 | 14.2±1.2 | 36.8 | 100.0 | 8.4 ± 1.4 | 47.6 | – | – | – |
| 18 | 85.0 | 7.6±1.0 | 52.3 | 94.1 | 5.7 ± 1.2 | 33.1 | 78.9 | 6.0 ± 0.3 | 28.6 |
| 19 | 100.0 | 21.6±1.0 | 20.5 | 100.0 | 12.8 ± 0.9 | 20.6 | 100.0 | 9.7 ± 0.4 | 24.5 |
| 20 | 100.0 | 12.7±1.1 | 43.4 | 53.8 | 5.6 ± 1.2 | 56.6 | – | – | – |
| 21 | 100.0 | 11.5±0.5 | 21.0 | 80.0 | 10.7 ± 1.7 | 42.1 | – | – | – |
| 22 | 100.0 | 13.0±1.0 | 38.5 | 80.0 | 5.4 ± 0.8 | 39.6 | – | – | – |
| 23 | 100.0 | 9.3±0.7 | 37.1 | 70.0 | 4.2 ± 0.3 | 23.9 | 34.8 | 3.0 ± 0.0 | 0.0 |
| 24 | – | – | – | 80.0 | 3.4 ± 0.3 | 31.6 | 29.4 | 3.0 ± 0.0 | 0.0 |
| 25 | 100.0 | 9.8±1.1 | 52.4 | 85.7 | 3.7 ± 0.4 | 28.2 | – | – | – |
| 26 | 100.0 | 15.3±1.8 | 51.8 | 100.0 | 10.0 ± 1.3 | 31.6 | 84.2 | 4.2 ± 0.4 | 27.9 |

*Note:* the "-" sign in the column "2010-2011" indicates that the analysis of frost damages to the forms was not carried out due to their destruction by the white hare, and in the columns "2011-2012" and "2012-2013" it denotes the absence of signs of frost damage to plants of these forms

**Figure 8.** The state of the plantation in December 2011 (Photo by D.W.Gordej)

According to the data in Table 2, the number of damaged plants and the degree of their injury resulting from negative temperatures differs considerably from year to year. This was caused by varying weather conditions, sometimes very significant, as shown above, by the hardiness of plants, as well as by the changes in agricultural practices used.

We suppose that it is necessary to pay special attention to agrotechnical measures. As stated in two previous sections, the successful cultivation of lowbush blueberry on a cutover raised-bog peat deposit is impossible without the improving of nutritional conditions by the application of mineral fertilizers. This agrotechnical technique undoubtedly has a positive influence on the quantitative parameters of growth processes and the yield of berries. At the same time, it can also contribute to the damage to plants due to negative temperatures of a winter period to a significantly large extent. This happens indirectly, because of the changes in the dynamics of seasonal development of lowbush blueberry. The improvement of conditions of mineral nutrition results not only in the activating growth processes of lowbush blueberry that are expressed quantitatively, but also in the plants lateness of dropping leaves in autumn and preparing for winter. As a result, the plants meet winter with an non-lignified accretion of the current year, i.e. “unprepared”. It is very easy to identify manually – the apex has a distinctly herblike, inelastic consistency in contrast to rather stiff to the touch endings of “prepared” for the winter sprouts.

If plants are unprepared for winter, there is a high probability that plants will be damaged even by early autumn frost (typical for peatlands), not to mention the possibility of their response to negative winter temperatures.

The following facts confirm this. In 2009 fertilization with mineral fertilizer was carried out in one step before the growth began (April 15, 2009), and, therefore, the activation of this process occurred in a spring-summer period. This did not influence the duration of a vegetation period, which remained the same, but the plants entered the autumn “prepared”. In addition, during almost the whole winter they were covered with snow. And that is why, despite the severity of the winter of 2009–2010, practically, no damage to very young plants was registered in the first winter season after the spring planting. Therefore, there was no information on the plants damage rating for the winter of 2009–2010 in Table 2.

In 2010, plant nutrition with mineral fertilizer was carried out in two steps; moreover, the second step was taken quite late (July 20, 2010). This was done with the aim of equal distribution of a positive effect of fertilizers on growth processes during a vegetative season. But the result was that even at the end of September the plants continued to grow vegetatively, which undoubtedly reduced the resistance of non-lignified apical meristems to the influence of freezing temperatures of early autumn. The following fact is the evidence of the damage to plants in a pre-winter period. Despite the fact that throughout the winter of 2010–2011 the plants on the site were, to some extent, covered with snow, not only orthotropically growing endings of sprouts, but also plagiotropic sprouts that ended their seasonal growth parallel to the surface of the ground, were damaged. These sprouts were certainly protected by a layer of snow during the period of the most significant drop in temperature. However, in the spring recording it was found that they showed distinctive signs of harmful effects of negative temperatures. This can be definitely interpreted as the damage that took place before snow fall, i.e. in the autumn under the influence of early freezing.

After the winter of 2010–2011, the number of damaged lowbush blueberry plants varied between 85.5 and 100%. The average degree of damage was the highest for the entire period of a four-year observation and ranged from 7.0 to 21.6% (Table 2). As a result of the spring recording, all forms were divided according to winter-hardiness into two groups: winter-hardy – 11, and medium winter-hardy – 13 forms.

The second step of fertilization was carried out much earlier than in 2010 – at the end of June (June 29, 2011). This allowed, to a certain extent, to avoid the increasing of the duration of vegetation by the reduction of this process in an autumn period and assured timely ripening of sprouts. As a result, the number of plants damaged by negative temperatures in the autumn-winter period of 2011–2012 decreased by 9.1 to 54.0% in comparison to the same period of 2010–2011. The degree of damage of 13 forms decreased by 1.1–2 times that of 7 forms decreased by 2.1–3 times, and of 2 forms – by more than 3.1 times. One form had no symptoms of damage caused by negative temperatures. Only the degree of damage of form 12 increased by 2.3 times. The grouping according to winter-hardiness has changed for the better in comparison with the previous winter: one form has been regarded as highly winter-hardy, 20 as winter-hardy, and 5 as medium winter-hardy.

In 2012, again, as in 2009, we applied a fertilizer in one step at the beginning of the growing season (March 22, 2012). At the end of the winter of 2012–2013, 13 forms, or 50.0% of their total amount, had no signs of damage resulting from the negative temperature. The rest of forms had from 22.2 to 100% damaged plants. The degree of their damage varied within 3.0–9.7% (Table 2), at the same time the value of this indicator of 9 forms decreased by 1.1–2.4 times as compared with the winter of 2011–2012, and that of only 4 forms remained unchanged or slightly increased. The condition of the plants of 13 forms made it possible to characterize them as highly winter-hardy, and 13 – as winter-hardy.

In 2013–2016, as in 2012, the introduction of a mineral fertilizer was carried out in one step in the first half of the growing season, which also made a positive contribution on the winter-hardiness of the plants. The apexes of one-year sprouts were damaged only in rare cases. The degree of damage to the above-ground part of certain bushes did not exceed 2–5% of the bush crown volume. The dying out of old branches recorded in all forms was a consequence of the natural aging process.

In the spring of 2016, soon after the regeneration pruning a higher dose of a mineral fertilizer was applied on a part of the experimental site that comprised 300 kilogram per hectare. This was necessary because, by that time, every parent shrub had formed a sufficiently well-developed system of partial shrubs that also needed additional nutrition. It should be noted that the second step of fertilizing, which was carried out in the summer of 2016, was absolutely different from all the previous ones, because a new fertilizer with the predominance of P and K in the composition was applied, and this favourably affected the ripening of sprouts. At the end of the winter period of 2016–2017 the plants, which emerged as a result of the pruning and fed with sufficiently high doses of mineral fertilizers twice during the growing season, did not reveal any cases of damage to sprouts resulting from negative temperatures.

The importance of heredity as a factor that minimizes or increases the adverse impact of negative temperatures in a winter period is mainly connected to the parameters of the above-ground vegetative sphere of the bushes (height), to the peculiarities of seasonal development of the forms, and to the damage to plants resulting from diseases.

For instance, the forms with a height of bushes not exceeding 30–35 cm were damaged by negative temperatures to a lesser extent than the taller, which was because they were better covered with snow.

The influence of the peculiarities of seasonal development of the studied forms on their traumatizing by negative temperatures was determined not only by the ability of plants to complete a vegetative period before early autumn frosts, but also by the depth of rest at the time of periodic air temperature risings in the late autumn and during frequent thaw periods.

The susceptibility of certain forms to diseases reduces their stability in general and enhances their sensitivity to negative temperatures.

## Discussion and Conclusions

In the north of Belarus (Gluboksky district) on a cutover peat deposit under the conditions of microplot experiment in 2009–2010, a study of lowbush blueberry was also conducted simultaneously with our research (Rupasova and Jakovlev 2011). The age interval included young 3- and 4-year-old plants. The features of seasonal development and the parameters of biological productivity were investigated comparing with other berry species of the *Ericaceae* family. The main attention was paid to the study of biochemical composition of berries. The conclusion was made that the introduction of *V. angustifolium* in the north of the country is promising, despite relatively low production parameters.

We did not find the data characterizing the development of parent and partial shrubs during the introduction of the studied species in the north of the country in domestic literature sources. These data determine the formation of this species' cover. In contrast, the yield of berries depends largely on the degree of development of the above-ground vegetative sphere. It is obvious that representative data on the process of vegetative development of a cultivated plantation and on the dynamics of berry yields can be obtained only with a long-term experiment.

Further research is needed to identify the optimal variant of plant arrangement. We adopted the scheme of planting 1 × 1.5 m empirically. The Estonian scientists recommend the scheme of planting 2 × 2 m in using planting material of seed origin on raised-bog peatlands (Paal 2000).

If planting is excessively thin, a berry bush cover will be formed too slowly, making the presence of plant-free spaces possible for a long time. But too thick planting leads to the closing of the crowns of parent shrubs and the beginning of their competition, without complete realization of the potential of vegetative reproduction through rhizomes. Besides, with the increase of planting density, the cost of plant establishment also rises.

We did not find any publications devoted to the study of the influence of agricultural practices, mineral fertilization in particular, on the formation of a berry bush cover, its yield and resistance to unfavourable abiotic factors in the case of Belarus. But, Estonian scientists, for example, have investigates these questions (Noormets et al. 2017). This information, which is certainly necessary for successful introduction, can be correct only under the conditions of long-term observations.

Various aspects of introductory study of lowbush blueberry are presented in the works of scientists from neighboring countries such as Ukraine, Russia, and Estonia (Paal 2000, Starast et al. 2005a,b, Tyak 2011, Konovalchuk 2014, Egoshina et al. 2017).

First of all, it should be noted that there exists the similarity of the authors' views on soil conditions that are the most favourable for the introduction of lowbush blueberry. The opinion prevails that, as a rule, it should be acidic soils of cutover raised-bog peatlands (Paal 2000, Starast et al. 2005a,b, Tyak 2011, Konovalchuk 2014, Egoshina et al. 2017). These data confirm that we chose the location of the experimental plantation correctly. Moreover, according to the State Program "Peat", the area of cutover peat deposits will increase due to the extended use of peat in power industry and agriculture to 7.5 million tons by 2020.

According to Egoshina et al. (2017), who conducted a research in the Volga-Vyatka region of Russia, the species is characterized by the plagiotropization habit of the bushes. The fact of formation of partial shrubs was also established by these authors. Similar data are presented in our studies. Therefore, we can state the following: despite the significant weather and climate differences in the regions, where the introductory experiments were conducted, the formation of a cultivated berry bush cover is going in two ways: 1) through the horizontal development of the crowns of parent plants, this is determined by plagiotropic growth of the sprouts, and 2) as a result of the emergence of partial shrubs from the buds on the rhizomes. However, it should be noted that the authors found the partial bushes of 5-year-old plants, whereas in our experiment their emergence was recorded, though in a very small amount, even in the first vegetative season after planting. Such a significant time difference is probably caused by harsher climatic conditions of the Volga-Vyatka region of Russia than that of the northern part of Belarus (in winter the temperature in the Volga-Vyatsky region can drop to –54 °C). In this regard, it is logical to assume that in the process of introduction of *V. angustifolium*, the rate of formation of a berry bush cover, which degree of development largely determines the yield of berries, can significantly vary depending on weather and climatic conditions of a particular region.

The most important economic indicator, that being the yield of berries, and the early beginning of commercial fruiting of *V. angustifolium* (the third year after planting) should be noted. This sets lowbush blueberry apart from other introduced species from North America – *V. macrocarpon* and *V. corymbosum*. Their plantations can be exploited only in the fifth and sixth or seventh years respectively (Gladkova 1974). Also note that unlike lowbush blueberry the successful cultivation of marsh cranberry and highbush blueberry is possible only if there is an artificial watering system, which leads to a rise in the cost of berry production.

According to the studies of Hepler and Yarborough (1991), who studied the yield of berries of 100 selected lowbush blueberry clones in the natural habitat, this indicator varied from 300 to 17,000 kg/ha, with an average value of 7,726 kg/ha, depending on the conditions of the year. In our experiment, the peak of the average yield of berries from a bush of 26 forms (clones) was 1,293 g (Figure 7) or, with the adopted planting scheme (1.5 m × 1.0 m), projected yields of 8,620 kg/ha. The comparison presented above, in our opinion, very convincingly testifies to the prospect of introducing lowbush blueberry to the cutover raised-bog peat deposits in northern Belarus. The same conclusion can be made comparing the yield of lowbush blueberry with that of native berry species of the *Ericaceae* family. Therefore, according to research of Grimashevich (2002), the yield of bilberry (*V. myrtillus*) in Belarus is 150–400 kg/ha, that of cranberry (*O. palustris*) is 800 kg/ha, and the yield of swamp blueberry (*V. uliginosum*) are estimated at 1,200–1,400 kg/ha. All these facts give us grounds to disagree with the opinion of Rupasova and Jakovlev (2011), presented at the beginning of the section "Discussion and conclusions" of this article, about the comparatively low production parameters of lowbush blueberry.

A sharp decrease in the yield of berries from a bush in 2016 resulted from a change in the age structure of the sprouts that form the crown – older sprouts (more than three years old), characterized by a decrease in the generative potential, and began to predominate. This fact illustrates when it is time to conduct regeneration pruning that is necessary to preserve high yields in following years. As can be seen from Figure 7, it should be implemented 7 growing seasons after planting.

The exceedance of the highest yield (typical for particular forms) over the average one was recorded in 2011 and 2012 by 1.7 times, in 2013 by 1.8 times, in 2014 by 1.7 times, in 2015 by 1.6 times, and in 2016 by 1.7 times (Figure 7). We interpret these facts as the evidence of the possibility and necessity of selective improvement of the range of clones by the intraspecific selection technique.

As Egoshina et al. (2017) noted, there was no record of any extinction of lowbush blueberry plants under the influence of the negative temperatures during the winter period; there was not even freezing of them, which was possibly due to the stability of the negative temperatures of a winter period in the Volga–Vyatsky region of Russia.

According to the data of Konovalchuk (2014), who conducted the research in Ukraine, over the whole period of observation (2006–2014) lowbush blueberry was not damaged in winter. In our opinion, this result can be explained by very mild winters of that country.

The results that we obtained differ from that of Konovalchuk (2014). The plants of almost all studied forms of lowbush blueberry are more or less exposed to the damage resulting from low temperatures of a winter period. However, it is important to emphasize that the degree of damage is not critical in the vast majority of cases. According to our method used to evaluate winter-hardiness, which was also tested on other berry species of the *Ericaceae* family, lowbush blueberry has proven to be a highly winter-hardy or winter-hardy species. The main reason for the freezing, in our opinion, is the discrepancy between the regime of mineral fertilization and the acclimation process. As a result, lowbush blueberry, which is highly sensitive on sphagnum peat to mineral fertilizing, meets winter "unprepared" or, otherwise, with unripe (non-lignified) apical accretion. At the same time, the adverse influence of the alternation of freezing and thawing on the plants cannot be excluded; it becomes especially damaging if the amplitude of negative and positive temperatures is increased. It is possible that a really sharp change of positive temperature to negative one at the beginning of winter has the following impact: the plants do not readjust in time. In our future work we shall pay the closest attention to these and other aspects of winter weather changes, as well as to the reaction of lowbush blueberry to late spring frosts.

We studied 26 forms of *V. angustifolium*. Using them as the example, the formation process of the canopy was studied from 2009 to 2016, the dynamics of the yield of berries from the years 2011 to 2016 was established, as well as the reaction to the temperature regime of a winter period from 2009 to 2013. In our opinion, a considerable amount of information was obtained. The results of its analysis suggest that the successful introduction of lowbush blueberry in Belarusian Lakeland is, basically, possible. The ecological-biological type of the studied species complies with the weather and climatic conditions of the region. This is illustrated by the following: 1) seven years after the planting a continuous berry bush cover form. This positively influences on the phytocenotic stability of a cultivated phytocenosis and to some extent on the yield of berries; this also significantly reduces the expenses caused by the weed control, minimizes the possibility of wind and water erosions, and reduces the risk of fire. 2) The yield of berries is comparable with the same indicator established for this species in the natural area (North America), and significantly exceeds the yield results of local representatives of the species *Ericaceae*. This can be interpreted as one of the confirmations of the economic benefits of cultivation of *V. angustifolium*. 3) Throughout the whole period of observation, the species proved to be highly winter-hardy or winter-hardy, which had a positive impact on the formation of plant cover and the yield of berries.

Therefore, the results of this study prove the possibility of industrial cultivation of blueberry in Northern Belarus basing on the cultivation of lowbush blueberry. A significant advantage of this species in comparison with other representatives of *Ericaceae* is the possibility of its cultivation without the use of artificial watering.

One of the most important factors that positively influences in the effectiveness of the introduction of *V. angustifolium* under the edaphic conditions of the cutover raised-bog peat deposits in northern Belarus is the need for mineral nutrition fertilization. It is important to select the plant forms which have the following characteristics: low-growing, possessing phenological rhythm adapted to that of environmental factors, and disease-resistant.

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