EVALUATION OF WINTER HARDINESS AND PRODUCTIVITY OF FIVE HIGHBUSH BLUEBERRIES CULTIVARS IN LATVIA

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Abstract

Winter hardiness is very important for introducing and commercial cultivation of blueberries in North Europe. Winter survival in the field is influenced by multiple factors that are influenced by uncontrollable environmental parameters. In the years 2006-2008, in eight farms were surveyed in different fruit-growing areas of Latvia, which produce highbush blueberries. We were interested in the plants physiological conditions (winter hardiness) after the winter, yields and the growth conditions. All study sites were evaluated by 6-year-old plant of highbush blueberry cultivars 'Polaris', 'Chippewa', 'Patriot', 'Northblue' and 'Duke'. After the year 2006/2007, the highest winter hardiness was observed for 'Polaris', 'Chippewa', 'Northblue' and 'Patriot'. The lowest winter hardiness was observed in 'Duke'. December 2007, January and February 2008 changing weather conditions did not do significant damage in plantations. 'Patriot' and 'Chippewa' had the highest average yield (kg per bush) throughout the production period, cultivar 'Northblue' had the lowest yield. On the other hand, 'Northblue' had the highest 100 berry weight. Cultivar 'Patriot' had the largest berry size - most of the berries had a diameter of 15 - 16 mm.

Key words: *Vaccinium corymbosum* L., weather condition, yield, berry weight.

Introduction

Blueberry is one of the richest sources of polyphenolic antioxidant compounds that have important role in human health. In the last few years, consumer demand for components that protect health and delay the onset of disabilities associated with chronic and degenerative diseases has given producers a significant opportunity to obtain higher prices for blueberries than they could get if blueberries were sold merely as food (Giongo et al., 2006).

In commercial agriculture the major blueberry-producing species are lowbush and highbush blueberries. Highbush blueberries (*Vaccinium corymbosum* L.) are native to North America (latitudes 40 to 45 ºN, Latvia is located in latitudes 55 to 58 ºN), upright, 2 m tall, crown-forming shrub. Fruit ranging 3 – 20 mm are blue-black berries with many seeds. More than 50 cultivars of highbush blueberry have been developed in North America, primarily based on selections for commercially valuable fruit characteristics and seasonality. Lowbush blueberry (*Vaccinium angustifolium* Ait.) is native to eastern and central Canada and the north-eastern United States.

Highbush blueberry cold hardiness varies tremendously among types and cultivars. Highbush and lowbush blueberries generally are hardy to at least - 2 ºC, although some cultivars are tenderer. Winter injury usually is not a problem in western Oregon and Washington (USA). However, if a severe cold spell occurs early, before plants are fully dormant, winter injury may occur (Hancock et al., 1987). Winter hardiness of blueberry species and cultivars is very important for introducing and commercial cultivation in North Europe (Haffner and Vestrheim, 1994). Winter survival in the field is influenced by multiple factors that are influenced by uncontrollable environmental parameters (Hummel et al., 1982). For example such as fall-timing of growth cessation, freezing tolerance at the cold acclimation state, the tolerance to fluctuation of temperature in late winter and early spring, chilling requirement, wind desiccation, snow cover etc. and thus may exhibit annual variation (Fowler and Gusta, 1979; Fear et al., 1985).

Depending on which tissues have been injured and the degree of injury, symptoms of "delayed winter injury" may not appear until late spring or early summer. Shoots may bloom, leaf out, and even begin setting fruit before suddenly collapsing and dying over one or two-day period. Sudden collapse usually is related to the onset of hot weather, which increases the demand for water by the developing shoots and fruit. Injured vascular tissues are unable to supply the needed water and nutrients, and the shoot collapses (Biermann et al., 1979).

Cultivars of northern highbush blueberries require the greatest number of winter chilling hours, and therefore most suitable for areas with long cold winters (Trehane, 2004). Highbush blueberry plants damage usually occurs when temperatures fall to around - 29 ºC, well-acclimated canes can withstand an extreme of - 40 ºC.

Half-highbush blueberries (*Vaccinium×covilleanum)* 'Northblue' survive -30 ºC, 'Nortcountry' -35 ºC and they need 800 chilling hours (Gough, 1994). Dangerous time for blueberry plants is spring with the flowers receiving the frost damage (Hicklenton et al., 2002).

Critical temperatures and spring frost damage of blueberry have been well studied in the world; however, there are few studies about influence of temperature fluctuations on blueberry growth, development and productivity. Distance to the Atlantic Ocean, Baltic Sea and Gulf of Riga and the large-scale terrain are major factors that determine regional differences in climate in Latvia. Away from the Atlantic Ocean and the Baltic Sea, marine climate features decline and the growing conditions have signs of continentality. Frequent cyclones from west influence the winter character in Latvia and arisen a high air temperature fluctuation (daily from + 5 ºC to -10 ºC or more).

The aim of the study was to define the five highbush blueberry cultivars winter hardiness and productivity in Latvia.

Materials and Methods

In the years 2006-2008 was evaluated the situation in eight farms of different fruit-growing areas of Latvia that produce highbush blueberries. We were interested the plants physiological conditions (winter hardiness) after the winter, fruit productivity and quality.

Studies for plant physiological conditions, productivity and yield quality characteristics taken in the LUA, Faculty of Agriculture Institute of Agrobiotechnology teaching-research base in Jelgava, as well as part of the studies carried out in the farms from western (region of Jelgava and Tukums), eastern (region of Aluksne and Preili), central (region of Valmiera) part in Latvia and district of Riga six-year-old plants of highbush blueberry cultivars 'Polaris', 'Chippewa', 'Patriot', 'Northblue' and 'Duke' were evaluated in all study sites.

Short characteristics of cultivars:

'Chippewa'- midseason, berry: medium size, very light blue color, medium firm, good flavour;

'Duke' – early season, berry: large size, medium blue color, firm, good flavour;

'Northblue' – early midseason, berry: medium size, dark blue color, medium firm, fair acid flavour;

'Patriot' – early season, berry: large size, medium blue color, firm, excellent flavour;

'Polaris' - early season, berry: medium size, light blue color, firm, excellent flavour (Hancock and Hanson, 2001).

In spring (from the beginning of May to the end of June), winter hardiness was estimated using a ten-point scale (0 point – a plant is dead, 1 point – very low winter hardiness, all branches damaged up to the soil level, 9 point – very high winter hardiness, branches not damaged).

The air temperature was determinate by using State agency Latvian Environment, geology and meteorology agency's data in different areas of Latvia.

Taking into account the climatic conditions of the years 2006/2007 it was impossible to correctly register the blueberry yields in 2007. The highbush blueberry fruit ripen gradually, so the yield was picked five times from the end of July 2008 to the end of August 2008. The yield was harvested by hand and at the same time was established 100 fruit weight (g) and fruit was grouped by size group (< 12, 12-14, 15-16, 17-18, < 19 mm). We observed 3 individual plants of every cultivar in every fruit-growing area.

All measurements were made in three replications. The calculation of standard division was used in same objective.

Results and Discussion

The first seven months in 2006 passed with insufficient precipitation for blueberries. There was a particularly scarce amount of precipitation in July, only 24% of the norm for Latvia. The insufficient amount of precipitation caused losses in all agriculture in Latvia (Table 1).

Table 1

Temperature and Precipitation Values Compared with the Long Term Average in 2006-2007*

Month	Average daily air temperature, °C			Precipitation, mm		
	2006	2007	Long term average	2006	2007	Long term average
January	- 5.2	0.3	- 4.8	15	99	40
February	- 5.9	- 8.2	- 5.2	23	27	30
March	- 3.0	4.4	- 1.0	30	27	31
April	4.8	5.1	4.5	29	28	41
May	12.0	12.6	13.0	40	57	48
June	17.0	18.3	15.0	37	60	62
July	20.0	16.6	17.0	19	111	80
August	17.0	18.0	15.5	89	79	80
September	14.0	11.9	11.0	43	81	72
October	8.0	7.1	6.0	75	91	62
November	4.0	1.2	2.0	73	78	61
December	4.3	1.7	- 2.5	68	41	50

*Source: Latvian Agency of the Environment, Geology and Meteorology.

The fluctuation of temperature in November and December, 2006 and January and February, 2007 (Table 2) influenced the frost resistance of highbush blueberry.

Table 2

The Air Temperature in Different Fruit Growing Areas of Latvia (from November 2006 to April 2008, °C)*

Monthh	Western Part		District of Riga		Central Part		Eastern Part	
	min	max	min	max	min	max	min	max
Nov.06	-12.9	11.1	-6.4	10.0	-11.8	8.8	-10.6	7.6
Dec.06	-6.4	11.6	-2.7	11.0	-10.2	8.8	-8.1	9.7
Jan.07	-20.3	10.7	-13.3	10.2	-18.8	4.0	-18.7	8.8
Feb.07	-29.7	4.2	-21.4	3.4	-25.9	0.9	-27.1	0.6
Mar.07	-5.2	18.0	-1.9	16.5	-3.6	16.9	-3.9	16.8
Apr.07	-5.0	23.9	-2.3	21.7	-4.1	21.3	-7.7	22.1
Mai.07	-3.6	29.4	-0.3	28.3	-4.3	22.1	-5.2	29.0
Jun.07	2.8	27.5	8.8	26.1	8.1	25.4	5.9	26.2
Jul.07	6.0	28.1	9.2	25.7	9.1	25.2	7.4	25.4
Aug.07	2.1	30.1	4.9	27.5	5.0	30.1	4.4	30.1
Sep.07	0.6	22.5	4.8	20.0	1.5	22.5	1.2	21.9
Okt.07	-5.5	18.1	-1.9	15.7	-3.0	17.2	-3.1	16.6
Nov.07	-6.6	11.4	-3.9	10.0	-8.5	9.2	-9.9	8.9
Dec.07	-9.1	8.6	-5.6	6.8	-8.7	6.2	-9.3	5.6
Jan.08	-14.3	7.3	-15.2	5.5	-18.8	4.7	-18.4	4.2
Feb.08	-12.4	9.4	-6.6	9.8	-12.0	6.7	-14.0	5.9
Mar.08	-9.4	15.5	-6.3	15.2	-11.0	11.2	-10.0	11.6
Apr.08	-3.3	22.8	-0.6	22.7	-1.4	22.0	-3.1	21.6

*Source: Latvian Agency of the Environment, Geology and Meteorology.

Likewise, the minimum air temperature for December of the year 2006 was unusually high (+11.6 °C in western part). During the warmest days of the month it reached even 8 to 10 °C in some locations which is typical for September. As a result, the plants did not have the deep rest period and flower buds of the high-bush blueberries were swollen to the degree which is usually observed at the start of May (the flower buds of the high-bush blueberries are usually swollen when the average temperature of the air is above 10 °C, but the vegetation

period starts when the average temperature of the air is above 4.7 ºC (Gough, 1994). In turn, the minimum temperature January 2007 in western part fall till - 20.3 ºC, and February 2007 - 29.7 ºC (respectively in eastern part - 18.7 and - 27.1 ºC, central part - 18.8 and - 25.9 ºC but district of Riga – 13.3 and – 21.4 ºC). Winter of 2007/2008 was more suitable for growing highbush blueberries and more typical for Latvia.

All surveyed plantations of highbush blueberries were affected by frost in the winter 2006/2007 (Table 3). The new plantations, planted in 2006, were particularly affected in the eastern part of Latvia and many plants died. In six farms, plantations were renewed, but other two enterprises have decided not to replant cultivars 'Duke'. After the winter of 2006/2007, the highest winter hardiness was observed for 'Polaris' in farm by district of Riga (8 points), but lowest winter hardiness was in central part only 4 points. In all of parts 'Chippewa' was observed even result (4.2 points in district of Riga to 5.5 points western and central parts of Latvia). 'Northblue' the highest winter hardiness was in central part (6.5 points). The 'Patriot' highest winter hardiness was in district of Riga 5.5 points, but in all other part 'Patriot' winter hardiness was lowest (from 3.2 in eastern part to 4.2 points in central part). The lowest winter hardiness was observed for 'Duke' in eastern part 0.5 points to 1.8 points in district of Riga.

Only single highbush blueberry branches were damaged by frost (cultivars 'Chippewa' in western part and district of Riga, and cultivars 'Duke' in eastern part), performed in 2008 (Table 3). Highbush blueberries crops damage from spring frost in western and eastern part, when the temperature dropped.

Table 3

Winter-hardiness of the High-bush Blueberry Plantations in the Fruit Growing Areas of Latvia 2007 – 2008

Variety	Western Part		District of Riga		Central Part		Eastern Part	
	2007	2008	2007	2008	2007	2008	2007	2008
'Polaris'	4.5	8.7	8.0	9.0	4.0	9.0	5.5	8.5
'Chippewa'	5.5	7.5	4.2	8.0	5.5	8.7	5.0	8.0
'Patriot'	3.5	8.5	5.5	8.3	4.2	9.0	3.2	8.3
'Northblue'	4.0	8.3	4.0	9.0	4.0	9.0	6.5	8.0
'Duke'	1.5	8.7	1.8	9.0	1.2	8.6	0.5	7.7
Standard deviation	1.48	0.5	2.27	0.48	1.57	0.19	2.36	0.31

The highest winter hardiness of all fruit-growing areas was observed in plantations of farms in district of Riga. Different cultivars of the highbush blueberries are grown in the different fruit-growing areas of Latvia. The highest cultivar diversity was observed in the western and central parts of Latvia and in the District of Riga. The selection of cultivars was more limited in the eastern part.

Only at the end of June 2007 it was possible to determine highbush blueberry plants for winter damage. In all the surveyed farms from the adverse weather highbush blueberries were damaged very minimally, some plantations were seen frost injury (suffered fruit slips), this was due to low air temperatures in June (in western part minimum temperature was + 2.8 ºC) and July (in western part minimum temperature was + 6.0 ºC).

In 2008 blueberries began to bloom in the 1st decade at the end of May - June, while production started in July 2nd and 3rd decade beginning in Latvia. In all areas of most fruit varieties grown are 'Patriot', 'Polaris', 'Chippewa', 'Northblue' and 'Duke'. There is no unity among growers about the best cultivars - each grower considered another cultivars as the best one, because each growers has different goals. In Latvia, unlike blueberry cultivars, grown in the United States, where the crop is ripening more or less simultaneously, highbush blueberry berries harvest is a very laborious process, since berries develop gradually, they must be collected on average of 3-4 times a season, but, for example, the cultivars 'Chippewa' is to be collected up to 6 times (Gough, 1994). We harvested all cultivars five times in a season ('Patriot', 'Polaris', 'Northblue'), except 'Chippewa'. 'Chippewa', which were six times a season.

Taking into account the climatic conditions of the years 2006 and 2007 and winter damage of the highbush blueberries, it was impossible to correctly register the yield in 2007, especially for 'Duke'.

In 2008, assessing the average yield per cultivars in the production period, the highest yield (kg per bush) cultivars showed 'Patriot' - with a yield 4.08 (standard deviation ± 0.47) kg per bush and 'Chippewa'- 3.68 kg per bush, while the lowest yield was cultivars 'Northblue' 1.44 kg per bush (Table 4). The average yield was 2.68 kg per bush.

Table 4

Average Yield and 100 Berries Weight of the Highbush Blueberry Cultivars

Cultivars	Average yield (kg per bush)	100 berries weight, kg
Patriot	4.08±0.47	0.21±0.023
Polaris	2.44±0.85	0.22±0.026
Northblue	1.44±0.36	0.20±0.032
Chippewa	3.68±0.56	0.19±0.01

The 100 berries weight ranged from 0.19 to 0.22 kg (Table 4). During the harvest and its quality performance record, the heaviest 100 berries were from the cultivar 'Northblue' 0.22 kg.

The evaluation of the berry size, most of the berries had a diameter of 15 - 16 mm cultivar 'Patriot'; it is 52%. Cultivar 'Northblue' 34% of the berry had a diameter of 17 - 18 mm and 31% of 15 – 16 mm. Cultivars 'Chippewa' most of berries had a diameter of 12 - 14 mm (Fig.1.).

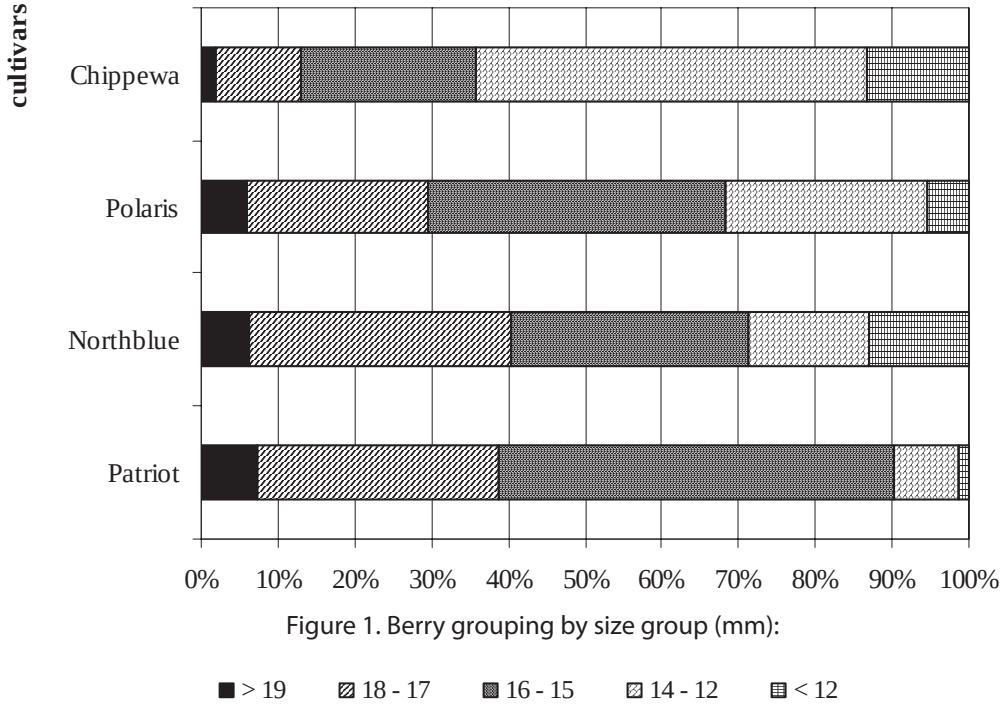

Figure 1. Berry grouping by size group (mm):

Observations, made on blueberry cultivars winter hardiness and yield production, showed that temperature has a major impact on blueberry growth, development and yield formation. In Latvia's climatic conditions blueberries were harvested several times (3 - 6 times, depending on variety).

Although research indicates that the maximum cold hardiness is associated with drought stress in some woody species, blueberry plants should not be allowed to become drought stressed, either during the growing season or after the plants are dormant, in regions with low annual rainfall, irrigate deeply before the soil freezes to provide enough moisture to supply the blueberries during the winter (Byres and More, 1987).

Conclusions

After the year 2006/2007, the highest winter hardiness was observed for 'Polaris' (4 to 8), 'Chippewa' (4.2 to 5.5), 'Northblue' (4 to 6.5) and 'Patriot' (3.2 to 5.5 points). The lowest winter hardiness was observed in 'Duke' (0.5 to 1.8 points).

'Patriot' and 'Chippewa' had the highest average yield (kg per bush) throughout the production period - 4.08 and 3.68 kg per bush, respectively, and cultivar 'Northblue' had the lowest yield.

Cultivar 'Northblue' had the highest 100 berry weight – 0.22 kg and cultivar 'Patriot' had the largest berry size - most of the berries had a diameter of 15 - 16 mm.

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