

**Estimation of growth and yielding of
highbush blueberry (*Vaccinium corymbosum* L.)
cultivated on soil developed from weakly loamy sand**

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ABSTRACT

In the years 1996 – 1999 an estimation of the growth and yielding of highbush blueberry cultivated on soil developed from weakly loamy sand was carried out. The study covered the initial years of fruit bearing (3-6 years after planting) of six cultivars of highbush blueberry: 'Bluecrop', 'Blueray', 'Darrow', 'Ivanhoe', 'Northland' and 'Spartan'. The strongest vegetative growth was characteristic for bushes of 'Northland' and 'Bluecrop' cultivars, while the weakest was found in 'Darrow' and 'Spartan'. 'Northland' proved to be the best yielding cultivar, although its fruits were the smallest. Berries of the 'Darrow' cultivar were the largest. In the study, the highest ranking was awarded to 'Bluecrop' (for growth, yielding, fruit size) and 'Northland' (for growth and yielding).

INTRODUCTION

Highbush blueberry (*Vaccinium corymbosum* L.) is one of the youngest orchard plants, and has highly specific requirements with respect to soil. Its cultivation is the most successful on light, humus, well aerated, acid and warm soils. Soil priming with sawdust, peat and bark, and mulching are especially recommended in blueberry cultivation on mineral soils with low humus content (Moore 1993). In the opinion of Pliszka (2002), the optimum pH_{KCl} of soil is from 3.8 to 4.5. In recent years, in Poland as well as abroad, there has been an increase in the acreage of highbush blueberry plantings. The world leader in the cultivation of the species is the USA, with 22,440 ha. Large areas of highbush blueberry plantations can be found in China – 10,000 ha, Canada – 4,397 ha, Chile – 2,500 ha, Argentina – 1,200 ha, and in Germany – over 1,000 ha (Banados 2006, Strik 2006). In Poland highbush blueberry is now grown on about 1,000 ha (Smolarz 2006).

The objective of the study was the estimation of highbush blueberry growth and yielding on production plantations under the climate and soil conditions of the Lublin region.

MATERIAL AND METHODS

In the years 1996 – 1999 a study on the growth and yielding of highbush blueberry was conducted on a plantation in Niemce near Lublin. The plantation was established in the spring of 1993, on a soil developed from weakly loamy sand. Two-year-old bushes of six highbush blueberry cultivars ('Bluecrop', 'Blueray', 'Darrow', 'Ivanhoe', 'Northland' and 'Spartan') were planted at 2×1 m spacing. The rows of plants were mulched with a layer of sawdust 60 cm wide and 15 cm deep. The inter-rows were covered with turf. Drip irrigation was applied at the plantation. The annual dose of irrigation water was $400 \text{ m}^3 \text{ ha}^{-1}$. The soil had a highly acid reaction (pH_{KCl} 3.8-4.5). Every year the plants were fertilised with ammonium sulphate at the dose of 60 kg N ha^{-1} split in three parts, and with potassium sulphate and magnesium sulphate at doses of $60 \text{ kg K}_2\text{O}$ and 10 kg MgO on the whole surface, respectively.

The determinations and measurements included the following:

- height of plants, number and total length of annual shoots measured in spring,
- time of ripening,
- level of commercial yield,
- weight and diameter of 100 fruits for berries from every harvest.

The study was conducted on 40 bushes in 4 replications, with 10 plants per replication.

The results were processed statistically using analysis of variance. The significance of differences was estimated with Tukey intervals of confidence at the level of significance $p = 0.05$.

RESULTS AND DISCUSSION

The climatic conditions prevailing during the experiments are presented in Table 1. The average annual air temperature of the coldest year, 1996, was 6.2°C, and it was lower by 1.2°C from the long-term average. In the final – and warmest – year of the study the temperature was higher by 0.5°C than the long-term average. In the years 1996 and 1999 the annual sums of precipitation exceeded 600 mm, but its distribution was varied. The highest amounts of precipitation were recorded in July 1997, June 1999 and in May 1996, when they exceeded the long-term average values by 200-250%. The smallest amounts of rainfall were observed in April and June 1996, June 1997, and in August of 1997 and 1999, when they amounted to approximately 50% of the long-term standard.

According to Hancock and Draper (1989), the height of the plants of cultivated highbush blueberry cultivars usually does not exceed 250 cm. According to Pomology, strongly growing cultivars include, among others, ‘Bluecrop’, ‘Blueray’, ‘Ivanhoe’ and ‘Spartan’ (Smolarz 2000). The growth size and strength of the bushes on the highbush blueberry plantation in the years 1996 – 1999 are presented in Table 2.

In the course of the study the height of the highbush blueberry bushes increased. The highest were the bushes of ‘Bluecrop’ and ‘Northland’ cultivars at 1.11 m, and the lowest were those of the ‘Darrow’ cultivar at 0.68 m. Under the conditions of the experiment, the strongest growth was characteristic of ‘Northland’ bushes, which produced the largest number of annual shoots with the highest total length (4.43 pcs bush⁻¹ and 3.48 m bush⁻¹, respectively).

The terms of highbush blueberry ripening in the years 1996 – 1999 are given in Table 3.

Highbush blueberry revealed a certain variability in the time of berry ripening within the period of the study, which was affected by the weather conditions. In the final and warmest year of the study, 1999, the highest air temperatures were recorded in June and July, which accelerated fruit ripening by as much as two weeks compared to the first and second years of the study.

Table 1. The air temperatures and amount of precipitation in Felin in years 1996 – 1999

Year	Month												Mean
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Mean monthly temperature (°C)	-6.9	-6.8	-3.0	7.3	15.5	16.5	16.4	17.7	9.6	8.4	5.5	-5.8	6.2
	-6.1	0.2	1.8	3.9	13.9	16.8	17.6	18.2	12.5	5.5	2.3	-2.0	7.1
	0.4	2.1	0.3	9.5	13.8	17.5	17.5	15.9	12.3	6.4	-3.3	-5.0	7.3
	-1.9	-3.2	2.8	8.8	11.6	18.5	20.0	17.3	14.7	7.2	0.3	-1.1	7.9
Mean for 1951-1995	-3.6	-2.9	1.1	7.4	13.0	16.4	17.9	17.2	12.9	7.9	2.5	-1.3	7.4
Amount of precipitation (mm)	10.4	26.9	24.6	15.4	115.5	28.0	80.2	90.3	83.3	57.0	62.1	14.8	608.5
	1.6	12.5	16.2	40.8	83.1	36.9	183.8	33.8	47.4	34.1	34.8	33.0	558.0
	19.6	23.3	22.5	63.9	49.6	61.5	84.0	100.8	59.7	62.6	30.7	16.7	594.9
	16.2	41.8	17.0	81.6	45.9	160.9	102.1	33.5	37.6	34.9	52.3	19.8	643.6
Mean for 1951-1995	22.5	24.5	25.4	39.1	57.2	65.9	73.6	71.1	51.4	40.5	38.7	32.2	542.1

Table 2. Height of one bush, number of annual shoots and total length of annual shoots of six highbush blueberry cultivars in years 1996 – 1999

Cultivar	Height of bush [m]			Number of annual shoots [pcs bush ⁻¹]						Total length of annual shoots [m bush ⁻¹]						
	1996	1997	1998	1999	1996	1997	1998	1999	1996	1997	1998	1999	1996	1997	1998	1999
'Bluecrop'	1.07	0.99	1.07	1.32	1.11	1.9	1.5	3.7	6.8	3.5	1.6	1.1	2.5	6.2	2.9	
'Blueray'	0.87	0.85	0.94	0.99	0.91	1.6	1.0	2.5	4.3	2.3	1.01	0.7	1.3	3.1	1.5	
'Darrow'	0.74	0.71	0.54	0.73	0.68	1.5	1.8	2.6	3.1	2.2	0.9	1.0	1.3	1.8	1.2	
'Ivanhoe'	0.88	0.96	0.93	1.19	0.99	0.5	0.9	2.9	4.6	2.2	0.4	0.5	1.9	4.0	1.7	
'Northland'	0.92	1.05	1.13	1.33	1.11	2.4	2.3	6.3	6.8	4.4	1.6	1.5	4.7	6.2	3.5	
'Spartan'	0.72	0.77	0.77	0.98	0.81	1.0	1.0	1.9	3.7	1.9	0.6	0.6	1.0	2.7	1.2	
Mean	0.87	0.89	0.90	1.10	0.94	1.5	1.4	3.3	4.9	2.8	1.0	0.9	2.1	4.0	2.0	
LSD _{0.05} cultivar				0.10	1.11						0.98					
years				0.07	0.82						0.72					
interaction				0.25	2.81						2.46					

Table 3. Date of fruit maturity of six highbush blueberry cultivars

Cultivar	Year							
	1996		1997		1998		1999	
'Bluecrop'	25.07	12.08	30.07	6.10	24.07	19.09	16.07	13.08
'Blueray'	23.07	8.08	30.07	20.08	15.07	20.08	12.07	2.08
'Darrow'	13.08	30.08	4.08	11.10	7.08	9.09	16.07	22.08
'Ivanhoe'	25.07	13.08	27.07	5.08	16.07	18.08	16.07	3.08
'Northland'	16.07	5.08	24.07	29.08	12.07	16.08	12.07	3.08
'Spartan'	25.07	9.08	23.07	2.09	15.07	7.08	13.07	5.08

Table 4. Average yield, weight of 100 fruits and fruit diameter of six highbush blueberry cultivars in years 1996-1999

Cultivar	Yield [kg bush ⁻¹]						Weight of 100 fruits [g]						Fruit diameter [mm]					
	1996	1997	1998	1999	Mean	1996	1997	1998	1999	Mean	1996	1997	1998	1999	Mean			
'Bluecrop'	0.37	3.06	2.14	1.59	1.79	204	164	171	181	180	18	15	16	17	17			
'Blueray'	0.27	1.34	1.98	1.27	1.21	169	171	170	177	172	17	15	16	16	16			
'Darrow'	0.08	1.00	1.12	0.73	0.73	233	213	219	243	227	20	17	17	18	18			
'Ivanhoe'	0.22	1.67	1.18	1.29	1.24	179	203	173	199	189	16	17	15	17	16			
'Northland'	0.83	2.68	2.40	2.62	2.13	163	146	148	171	157	16	14	15	16	15			
'Spartan'	0.19	1.00	0.81	0.94	0.73	190	174	190	198	188	17	16	16	17	17			
Mean	0.33	1.79	1.70	1.41	1.31	190	179	178	195	185	17	16	16	17	16			
LSD _{0.05}	cultivar						8.4						8.4					
	years						6.1						6.1					
	interaction						21.1						21.1					

Under the conditions of the experiment, the highest total yield of berries from the 3rd to the 6th year after planting characterised the ‘Northland’ cultivar – 42.64 t ha⁻¹, followed by ‘Bluecrop’ – 35.81 t ha⁻¹ (Fig. 1). Koziński (2006), in his studies on fertilisation and mulching of ‘Bluecrop’ highbush blueberry, obtained – for plants of similar age – a three year total yield above 90 t ha⁻¹ on soil mulched with sawdust and on soil mixed and mulched with sawdust at a nitrogen fertilisation rate of 60 kg ha⁻¹.

Under the climate and soil conditions of Poland, highbush blueberry grows and yields well, but the results reflecting its yielding are fairly varied (Chlebowska and Smolarz 1997, Smolarz 1997). In central Poland very good yields have been obtained – almost 10 kg per bush (Smolarz 2005). Young plants that enter the period of fructification produce low yields but are characterised by increasing productivity, reaching full fructification in the 6th-8th year after planting (Eynard et al. 1985). The study presented herein represents the period of entry into fructification of six highbush blueberry cultivars (Table 4).

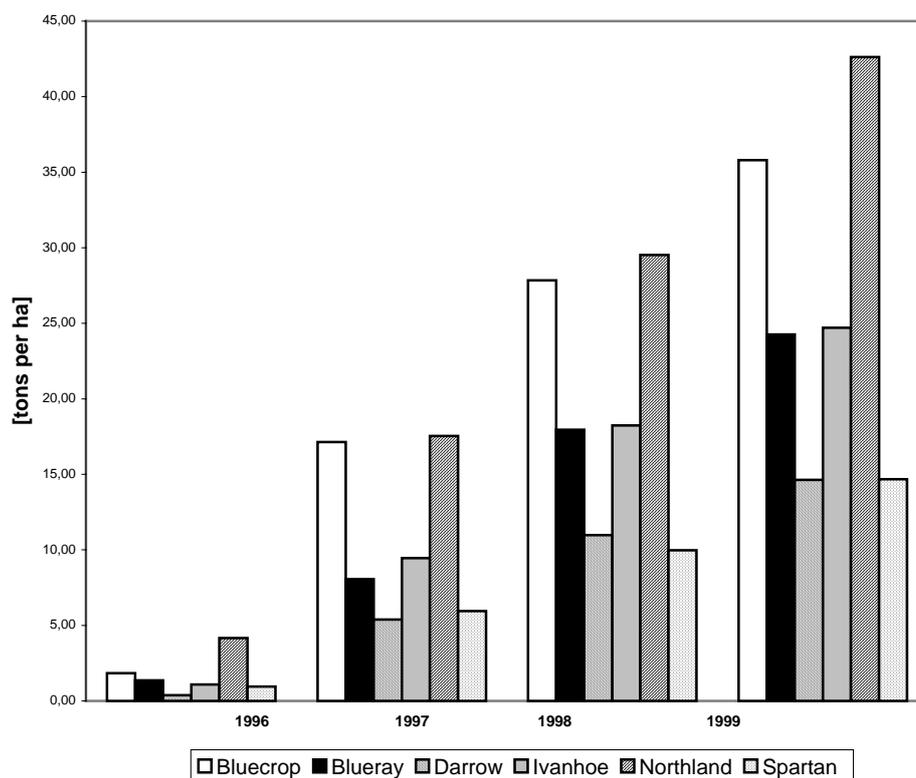


Fig. 1. Cumulative yield of six highbush blueberry cultivars in the years 1996 – 1999

Under the conditions of the experiment the yields of highbush blueberry varied from 0.33 kg bush⁻¹ in 1996 to 1.79 kg bush⁻¹ in 1997. In an estimation excluding the years of the study, the highest yield was produced by 'Northland' (2.13 kg bush⁻¹), and the lowest by 'Darrow' and 'Spartan' (0.73 kg bush⁻¹). The yielding of cultivars 'Bluecrop', 'Blueray', 'Northland' and 'Darrow' on the plantation in Niemce was higher, and that of 'Spartan' lower than those obtained in American studies (Nelson 1985). In certain experiments abroad, yields lower than those in Niemce were obtained for 'Northland' berries (Lareau 1985, Kaps and Odneal 1998), while in Norway the cultivar 'Northland' yielded at levels comparable to those obtained in the study presented herein (Øydvin and Øydvin 1999). Under Polish conditions yields of highbush blueberry have been obtained at levels that were both lower (Kawecki and Kopytowski 1991, Chlebowska and Smolarz 1997) and higher (Kropp et al. 1992) than in the study presented here.

High yields entail a reduction in the weight and size of a single fruit, which was demonstrated, with the example of nine highbush blueberry cultivars, by Siefker and Hancock (1986), and which was also observed in this experiment. The study showed that the largest berries were characteristic of 'Darrow', which is in agreement with all literature data (Eynard et al. 1985, Smolarz 1997, Małodobry et al. 2001). A decreasing order of hierarchy of cultivars favourable in terms of that feature included 'Bluecrop', 'Spartan', 'Ivanhoe' and 'Blueray'. The smallest fruits in the experiment were produced by 'Northland', which is also in agreement with the results of studies by other authors (Austin and Bondari 1989, Kaps and Odneal 1998).

CONCLUSIONS

1. Bushes of 'Northland' and 'Bluecrop' cultivars attained the largest sizes and were characterised by the strongest vegetative growth, while the growth of 'Darrow' and 'Spartan' cultivars was the weakest.
2. The fruits of 'Northland' started to ripen the earliest. Air temperatures in the summer months of 1999, higher than the long-term average, accelerated the ripening of berries of all the cultivars compared to the first and second years of the study.
3. 'Northland' proved to be the highest yielding, but it produced the smallest fruits. 'Bluecrop' also produced good yields, while the lowest yielding were 'Darrow' and 'Spartan' cultivars.
4. The highest values of fruit weight and diameter were characteristic of the berries of 'Darrow'. Also good in that respect were 'Spartan', 'Ivanhoe' and 'Bluecrop' cultivars.
5. In the study, the best overall were 'Bluecrop' (growth, yielding, berry size) and 'Northland' (growth, yielding) cultivars.

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OCENA WZROSTU I PLONOWANIA BORÓWKI WYSOKIEJ (*VACCINIUM CORYMBOSUM* L.) UPRAWIANEJ NA GLEBIE WYTWORZONEJ Z PIASKU SŁABOGLINIASTEGO

Streszczenie: W latach 1996 – 1999 przeprowadzono ocenę wzrostu i plonowania borówki wysokiej uprawianej na glebie wytworzonej z piasku słabogliniastego. Badania obejmowały pierwsze lata owocowania (3-6 rok po posadzeniu) sześciu odmian borówki wysokiej: ‘Bluecrop’, ‘Blueray’, ‘Darrow’, ‘Ivanhoe’, ‘Northland’ i ‘Spartan’. Najsilniejszym wzrostem wegetatywnym charakteryzowały się krzewy odmian ‘Northland’ i ‘Bluecrop’, zaś naj słabszym ‘Darrow’ i ‘Spartan’. Najplenniejsza okazała się odmiana ‘Northland’ chociaż jej owoce były najmniejsze. Jagody odmiany ‘Darrow’ były największe. W badaniach najkorzystniej oceniono odmianę ‘Bluecrop’ (wzrost, plonowanie, wielkość owoców) i ‘Northland’ (wzrost, plonowanie).

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