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Variability in yield of the lowbush blueberry clones growing in modified soil

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Abstract. In Latvia blueberry plantations are represented by approximately 486 ha in 2018, and about 44% of blueberry plantations are established in cutover peat bogs and approximately 40 ha of them are grown lowbush blueberry (*Vaccinium angustifolium* Ait.). In Latvia, lowbush blueberries are not grown on modified mineral soil (peat on the top of mineral soil). Ten lowbush blueberry clone were sampled from a commercial field to estimate potential productivity. The experiment was done at the Faculty of Agriculture, Latvia University of Life Sciences and Technologies. The plantation was established in peat (pH 3.8), which was covered in a layer of about 40 cm on mineral soil, rooted cuttings were planted in 2012, at a distance of 0.5×0.9 m, if necessary, the plantation was watered. The yield was estimated for a five year period, from 2015–2019. Significant differences in yield were found both by years and between clones. Over a five-year period, yields between clones ranged from 0.18 kg (2017) to 4.79 kg (2019) per bush. The high coefficient of variation (from 24.6 to 84.9%) indicate differences in yield between clones, with only 4 clones being below 30%. The average yield of clones by years was higher in 2019 (2.24 kg per bush), the lowest in 2017 (1.12 kg per bush). The results indicate variability on yield between the clones included in the experiment and year.

Key words: yield, one berry weigth, *Vaccinium angustifolium* Ait.

INTRODUCTION

Lowbush blueberry *Vaccinium angustifolium* Ait. (in some literature noted as a wild blueberry or Canadian blueberry) has a clonal growth habit; it is a prostrate shrub that spreads trough an underground network of rhizomes (Bell et al., 2010). In Europe this plant is relative new to cultivating (Hjalmarsson, 2006) due to its low climatic requirements.

Individual genotypes of lowbush blueberry exhibit significant differences in berry yield. In a several year study, Hepler & Yaraborough (1991) determined that the mean yield of 100 blueberry clones was 7.7 t ha^{-1} (yield ranged from 0.4 to 17 t ha^{-1}). In a three year study, Estonian researcher (Starast et al., 2007) determined that the yield of lowbush blueberry was from 1.3 to 5.5 t ha^{-1} depended significantly on soil pH.

Common cultivation practice in the U.S. and Canada has demonstrated that lowbush blueberry yields are maximized when the crops are grown in a two or three-year cropping cycle, with alternating vegetative and fruiting (yield) years (DeGomez, 1988).

According to data from the Rural Support Service, in Latvia blueberry plantations reaches approximately 486 ha in 2018 (Latvian Agriculture, 2019). According to the data of the Latvian Fruit Growers' Association (personal communication), about 44% of blueberry plantations are established in cutover peat bogs and approximately 40 ha of them are grown lowbush blueberry (*Vaccinium angustifolium* Ait.).

In Latvia there is a lack of information about lowbush blueberry yield. Currently berries are harvested by hand (at least the first berries intended for fresh consumption), then a hand-rake is used. The aim of this study was to determine the productivity of ten lowbush blueberries clones over a five-year period.

MATERIALS AND METHODS

Growing Conditions and Plant Material

The experiment was done at the Faculty of Agriculture, Latvia University of Life Sciences and Technologies (LLU) in Jelgava (56° 39' 47.1" N, 23° 45' 13.6"). The plantation was established in peat (pH 3.8) on top of mineral soil (about 40 cm). Rooted cuttings were planted in spring, 2012, at a distance of 0.5×0.9 m. The plant material for the root cuttings were selected from a commercial plantation grown from seedlings. Ten lowbush blueberry clones were evaluated (without replications).

The yield was estimated for a 5 year period, from 2015–2019. The crop was picked by hand two to three times (picking depended on berry mature, but the first pick was done when the approximately 75% of the berries were mature). Yield (kg per bush) and yield quality was determined during the experiment. A sample of 50 mature berries was weighed on each harvest date and used to calculate the average berry weight over the season. Cumulative yield over a five-year period for each clone was also calculated.

Plants were fertilized with 25 g m^{-2} granular fertilizer 12N–8P–16K (NH_4 7%, NO_3 5%, P_2O_5 8%, K_2O 16% + Mg 1.4%, S 10%, B 0.02%, Fe 0.06%, Zn 0.01%) one time per season (at the beginning of bloom). Five to six honey bee colonies were located near the experimental field, which provided the pollination of the clones. Netting was placed over the plants to exclude birds. If necessary, the plantation was watered. Lowbush blueberry clones were grown without pruning six year after planting, but in the spring of 2017 a half of the dormant bushes were pruned to assess new shoot formation (yield differences pruned/unpruned were not recorded).

Environmental conditions

The data of air temperature in the trial sites were recorded by data logger (MicroLite USB and EasyLog EL-USB-2-LCD+). The data were recorded in digital format every hour.

Air temperature differed between years (Fig. 1). In 2015 and 2017, the air temperature was similar, only November 2015 was characterized by a higher temperature (+10 °C in 2015 vs. +3.8 °C in 2017). In January, 2016 the air temperature was stable below 0 degrees, but in May sharp fluctuations in air temperature were observed. Meteorological conditions was unfavourable in 2017, where the vegetation period was characterized by lower temperatures during the study period and increased precipitation (data not shown) in August and September. The vegetation periods of 2018 and 2019 the air temperature was higher and drier than average.

Statistical analysis

Descriptive statistics were used for mathematical data processing, coefficient of variation was calculated, ANOVA and Tukey test were done to determined significance (*P* = 0.05) of differences. Different letters in figures and tables indicate significant differencies.

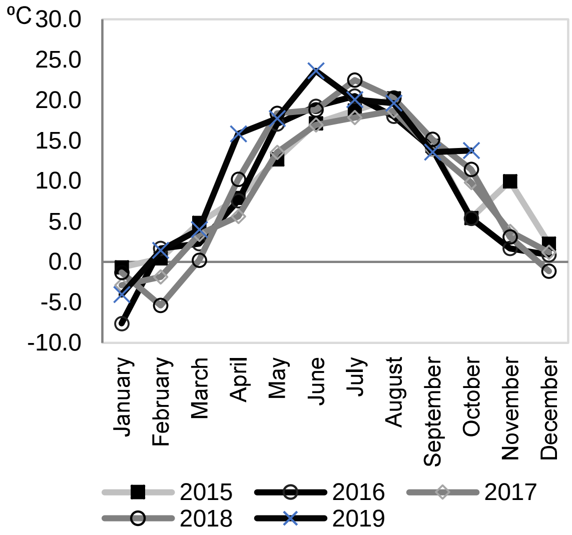

Figure 1. Monthly average air temperature during the experimental period.

RESULTS AND DISCUSSION

The year 2015 was characterized by fluctuating air temperature, which affected the ripening process of the berries. In this year the berries were picked only twice with an interval of 3 weeks of difference (1st time - on July 22, 2nd time - on August 6). May 2016 was characterized by high air temperature and large temperature fluctuations. The first berries were harvested on July 18, harvested 3 times with an interval of 8 to 10 days. In 2017, meteorological conditions affected the phenological development of plants - flower bud break occur later, flowering was also later in the season. The berries were harvested only once - on August 18, 2017. In 2018 the flowering period was characterized by an unusually high air temperature (average air temperature in May was 18.4 °C, in the period from 18 to 23 May the air temperature exceeded 30 degrees) and low rainfall (drought). The berries were harvested twice with a 14 day intervals (1st time on 13 July, 2nd time on 27 July). In 2019 the phenological development occur early, and also characterized by fluctuating air temperature. In 2019, the berry was harvested twice with an interval of 12 days (July 12 and July 24), but the last harvest for clone 1.1. was also done third time - on September 7, 2019.

Over a five-year period, yields between ten lowbush blueberry clones ranged from 0.18 kg (clone no. 2.4., 2017) to 4.79 kg (clone no. 1.1., 2019) per bush. Clone no. 2.5. showed the most stable yield in all years of the study, which is also indicated by the coefficient of variation (24.7%). Also clones no. 1.4., 1.5. and 2.1. showed relatively less yield fluctuations during the study period (coefficient of variation are from 27.1 to 29.3%). Only one (clone no. 1.1.) of the ten clones included in the experiment was characterized by large yield fluctuations, which is also shown by the very high (84.9%) coefficient of variation (Table 1).

Table 1. Average yield (kg per bush) of lowbush blueberry clones and coefficient of variation

Clone number	Average yield 2015	2016	2017	2018	2019	Average in five year period	Coefficient of variation (%)
1.1.	1.03	2.38	0.59	1.19	4.79	1.99 ab	84.9
1.2.	1.27	2.77	0.97	1.87	0.52	1.48 a	59.1
1.3.	1.45	2.32	1.10	1.23	1.84	1.58 a	31.4
1.4.	1.26	1.88	1.15	1.25	2.04	1.51 a	27.1
1.5.	2.25	1.37	1.85	2.48	3.05	2.20 ab	28.8
2.1.	0.72	1.48	1.17	0.86	1.39	1.12 a	29.3
2.2.	1.05	1.76	0.50	1.17	1.39	1.17 a	39.5
2.3.	0.72	1.60	0.54	1.60	1.39	1.17 a	43.3
2.4.	0.70	1.49	0.18	1.52	1.50	1.07 a	56.8
2.5.	2.59	2.74	2.87	3.71	4.50	3.28 b	24.7

Significant differences in yield were found between years ($P = 0.002$) and clones ($P < 0.05$). The clone factor ($\eta^2\% = 46.40$) had the highest effect on lowbush blueberry yield, also significant was the whole year's weather factor ($\eta^2\% = 19.68$).

The average yield of the ten lowbush blueberry clones was 1.66 kg per bush with a high coefficient of variation (57.87%). Yield ranged from 1.09 kg per bush in 2017 to 2.24 kg per bush in 2019 (Fig. 2). The results indicate a relatively small variability between the clones included in the experiment.

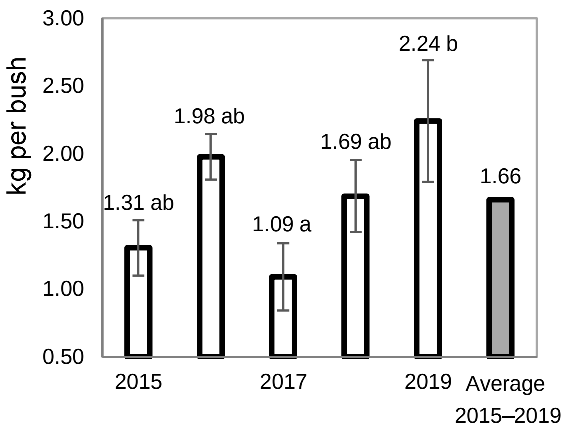

Figure 2. Mean yield of ten lowbush clones in trial by year. Bars represent standard error of the mean.

The mean berry weight of lowbush blueberry cones ranged from 0.5 to 0.6 g (clones no. 1.1, 1.3, 1.5., 2.4. and 2.5.) and from 0.8 to 0.9 g (clones no. 1.2., 1.4., 2.1., 2.2. and 2.3) with a coefficient of variation of 26.82% that indicate sufficient factor stability.

The most productive clone in the five-year period was clone no. 2.5, where its cumulative yield during the experiment was 16.41 kg from the bush. The lower cumulative yield were obtained from clones no. 2.4., 2.1., 2.3., and 2.2. (Fig. 3). The average cumulative yield was 8.30 kg per bush.

Recalculating the yield from one bush to one hectare (assuming that 22,000 plants are planted per 1 ha) potentially yield could be 28.7 t ha^{-1} in the third year after planting, and 49.3 t ha^{-1} in the seventh growing year (or 36.52 t ha^{-1} in average). The sdisparity between the average yield reported in literature (Hepler & Yaraborough, 1991; Albert et al., 2011) and the high yields obtained in this study may be due to the differences in pollination and irrigation. In this study the blueberry clones were subjected to a high density of bees for pollination. As mentioned in literature 25–60% of lowbush blueberry yields are affected by pollinators (Drummond, 2019), Wood (1969) determinate that lowbush blueberries can set up to 40% of their blossoms in field condition with native pollinators and 70% when supplemented with honeybees. Moisture is necessary for flower bud development and for increasing the weight of the berries, but proved that the lowbush lowbush blueberry has adapt to growth under limited moisture conditions (Glass et al., 2005).

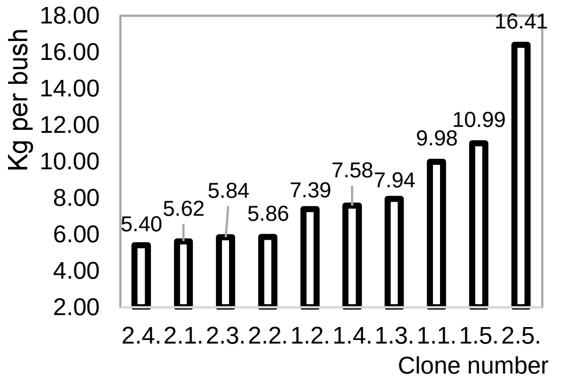

Figure 3. The cumulative yield of lowbush blueberry clones over a five-year period.

In total, all clones formed a 0.5–0.6 m high shrub, with a large number of shoots (on average 8 to 40 annual shoots per bush - data not show in this article). Only three clones (Table 2) formed rhizomes, confirming the recent information indicates in literature that seedlings and micropropagated lowbush blueberries become established and spread faster than rooted cuttings (Morrison et al., 2000). Half of the evaluated lowbush blueberry clones were characterized by berries that were blue with surface wax, half - with black berries without visible surface wax (Table 2).

Table 2. Fruit characteristics of the ten lowbush blueberry clones

Parameters	Spread by rhizomes	Berry colour		Yield potential (kg per bush)		
		dark blue with surface wax	black without visible surface wax	low (< 1.5)	moderate (1.5–2)	high (> 2)
Clone no.	1.4	1.1	1.4	1.2	1.4	1.1
	2.2	1.2	2.1	2.1	1.3	1.5
	2.5	1.3	2.2	2.2		2.5
		1.5	2.3	2.3		
		2.5	2.4	2.4		

As mentioned in the literature (Bernard & Joubes, 2013; Samuels et al., 2008), the surface wax of the berry outer layer is the first protective barrier against abiotic and biotic stresses (protects the berry from drying out, extreme temperatures, UV radiation, pathogenic attack, etc.). Study in Latvia have shown (Klavins et al., 2019) that the surface wax composition varies between blueberry species and even cultivars, which may also affect the firmness and shelf life of the berries, etc. According to the observations in this experiment we hypothesize that for clone no. 2.3, the layer of surface wax could be significantly thinner than compared to the other clones. As mentioned Chu et al. (2018), the existence of natural wax help maintained the firmness of fruit and in delaying its softening.

CONCLUSIONS

The yield of lowbush blueberries fluctuate from year to year and are mainly influenced by the clone factor. The potential yield from evaluated clones can be very high and now there is a basic information about the lowbush blueberry yield potential in

Latvia conditions. Research should be continued, including investigating the effects of weather, mulch, fertilization and irrigation on the lowbush blueberry productivity.

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