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AN IMPACT OF IRRIGATION OF SELECTED VARIETIES ON HIGHBUSH BLUEBERRY CROP

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Abstract

The paperwork includes estimate of irrigation on yield effect of highbush blueberry. The research was conducted in 2014-2016, on a small plantation located in Przyczyna Górna, in the Wschowski county, in the Lubuskie Province. The plantation's area was 800 m^2.

The article presents an analysis of five varieties of highbush blueberry: Patriot, Duke, Chandler, Elliott and Bluecrop. The frequency of irrigation and the amount of water supplied to the shrubs depended mainly on the distribution of atmospheric precipitation and the optimal humidity that the soil needs in growing blueberries. The need for irrigation was determined on the basis of soil water suction measurements using tensiometers. The shrubs were irrigated with a drip line with a spacing adjusted to the spacing of blueberry bushes.

The annual dose of water used for irrigation were from 144 mm to 303 mm. The research showed that the average crop increase amounted to 167%, because of irrigation. In 2015, which was a wet year, the increase was 140% and in the average year (2014) was 193%. It was not connected only with amount of precipitation, but with the distribution of precipitation at growing season. The best yield was noted for Chandler (32% of yield), Patriot and Bluecrop (20%).

Key words: highbush blueberry, drip irrigation, yield

INTRODUCTION

The highbush blueberry is the youngest plant cultivated in plantations. Its cultivation started at the beginning of 20th century, when its specific soil needs were discovered (Wach 1999, 2003). For many years the interest in highbush blueberry in Poland has been high and it is still growing. An important factor of the interest in this plant is the search for new sources of agricultural income. As Kozaczyk *et al.* (2017) reports the need to increase production effects leads to cultivation of varieties of highbush blueberry, which are characterized by smaller plant sizes and denser plantings. Poland is the biggest producer (23% of yield) of highbush blueberry in the European Union and the third producer in the world, after the USA and Canada (ARR 2014). The highbush blueberry in Poland occupies 6% of the area of berry plants, the highest score after strawberries and currants (32%) and raspberries (23%). The area of highbush blueberry cultivation increased from 1000 ha (2004) to 7000 ha in 2013, and the production increased from 4 thousand tons to 13 thousand tons during this time. The reason for the increase in production is high profitability of cultivation and export possibilities, which accounts for 80-90% of the harvest.

The highbush blueberry needs to be cultivated on acid soil, which pH is between 3.5-4.5 (Pliszka 2002, Treder 1997). Too high pH limits plant's growth and when pH is 6.8 the bushes stop growing and wither. However, too high acidity of soils (under 3.5) results in chlorosis and discoloration of shrubs (Bryk 2013). The highbush blueberry should be cultivated on easily permeable (sandy and sandy-loamy soils) humus and moderately moist soils (Rusnak 2012). To improve soils properties for cultivating the highbush blueberry, it is necessary to apply appropriate measures such as acidification by sulphurisation, which should be carried out at least a year before the plantation starts. One should also remember to fertilize the plantation properly. In order to enrich soil with organic substance, before planting, one should add acidic peat, sawdust or ground pine bark into holes or mix the substances with soil (Bryk 2013). One of the main factors affecting the yield and profitability of cultivation is the precipitation and irrigation if precipitation is limited (Koszański *et al.* 2009a). Shallow roots of the plant are sensitive to short-term water shortages. The water shortage, uneven distribution of precipitation during the growing season limits the plant growth and is often the cause of low yields (Koszański *et al.* 2009a, 2009b). In this case, the only way to supplement water deficits in the soil and create optimal moisture conditions is to apply irrigation, which greatly affects the yield and quality of the crop (Przybyła and Gruca 1999, Lipiński 2015). As Liberacki *et al.* (2017) states the right selection of irrigation results in shorter working time and reduces expenditure per unit of production and increases work efficiency. To irrigate the highbush blueberry the best solution is to apply dropping system, because of the highest efficiency of using water for irrigation of fruit plants (Jeznach 2009). The location of the emitters is adjusted to the location of plants, and the amount of water depends on soil permeability. The necessity of irrigation is likely to increase because long-term forecasts indicate the decrease in precipitation and the increase in mean monthly air temperature. These factors increase evapotranspiration and frequency of occurrence and intensification of soil drought (Bąk and Łabędzki 2014a, b).

The aim of the research, conducted in the years 2014 – 2016, was to assess the production effects of irrigation of the high blueberry in different water conditions.

MATERIAL AND METHODS

The research was conducted in 2014-2016, on a small plantation located in Przyczyna Gorna, in the Wschowski County, in the Lubuskie Province. The area of plantation was 800 m^2 and there were brown soils and black lands, and their bonitation value corresponded to the second and third class. At the beginning, the pH was 6.0. One year before the foundation of the plantation, soil had been acidated by a sulphate. A dose was 12 [kg·100m^2] and changed pH to 4.0. In subsequent years, soil care consisted in mulching each plant with sawdust. The research was conducted on 77 shrubs, five varieties of the highbush blueberry: Patriot, Duke, Chandler, Elliott and Bluecrop. The first crop was in 2014. However, due to the lack of adequate protection of young shrubs against frost, a majority of plants withered. The care over the bushes, conducted in early spring, consisted in cutting and forming The distinction between flower buds and leaf buds was easier. After planting the plants, shoots longer than 50 cm were shortened by 25%, and the weak stems were cut out. Since the start of plantation, there have not been any problems with a negative impact of diseases and pest activities.

The high blueberry fertilization proposed by Schönthale *et al.* (2015) was carried out on the basis of indicative doses, i.e. visual assessment of plant growth and yield (Table 1). The optimal dose of nitrogen did not exceed 100 kg·ha^{-1}. Too intensive fertilization could result in a strong growth of plants, not the increase in yield and prolongation of vegetation and the weakening of resistance to frost. Nitrogen fertilized in the form of ammonium sulphate or ammonium nitrate. Fertilization, for each bush, took place in mid-April, and the next immediately after flowering and in June and July, immediately after the intensive fruit growth.

Fertilization of potassium and phosphorus had been carried out before the plantation started. Later, phosphate and potassium fertilizers were mixed and sown generally after harvesting fruit. In the paperwork the authors observed plant reaction of fertilizers used and decided to use Substral's ready fertilizer mixes.

It was noticed that the shrubs reacted well to it, and it was visible primarily after larger increments of young shoots. Organic fertilizer was also used as spreader.

The main objective of the research was the assessment of dropping system impact on the highbush blueberry crop. Plantation was irrigated in three variants (Tab.2).

Table 1. The approximate dose of macronutrients for highbush blueberries in Poland

The component	The dose [$kg \cdot ha^{-1}$]	Type of fertilizer
Nitrogen	30-50	ammonium sulphate, ammonium nitrate,urea
Potassium	50-75	potassium sulphate, potassium salt
Phosphorus	30-60	superphosphate, ammonium phosphate
Magnesium	20-80	magnesium sulfate

Source: based on Schönthale et al. (2015)

Table 2. Variants of irrigation of highbush blueberry

Variant	Irrigation through the dropping system	Total efficiency	Average hydration time	Irrigation dose
Variant A. (2014)	Yes	2.0 $dm^3 \cdot h^{-1}$	twice a day for 4 hours	11 mm
Variant B. (2015)	Yes	2.0 $dm^3 \cdot h^{-1}$	once a day for 4 hours	21 mm
Variant C. (2016) control one	No	-	-	-

The irrigation was conducted using drip lines with emitters located every 50 cm. The emitters were located on one side and in a distance of 10 cm from the bushes. The drip lines were placed under a layer of sawdust. The annual dose of irrigation water ranged from 144 mm to 303 mm. The advantages of this system included water saving and avoiding damage to plants, because the horizontal wetting radius was 15 cm. The dripping system was used from the second half of May to mid-September. These periods represented the beginning of the flowering of the shrubs and the end of fruit ripening. The irrigation depended on the amount of precipitation on the plantation, which is the best determinant of yield increase (Żarski *et al*. 2013). The determination of the dose of water and timing of the irrigation depended on soil humidity indicated by the Steinzner 8060 tensiometer, which had been placed in the soil at a depth of 20 cm. The water supply started, when tensiometer had indicated more than 100 hPa.

The experiment focused on the impact of the irrigation on fruits yield, as well as on yield efficiency of selected five varieties of the high blueberry.

Moreover, the experiment determined the quality and size as well as the color of harvested fruits of each variety.

The precipitation in the course of research from 2014 to 2016, for vegetation period (April-September) ranged from 297 mm (2015) to 456 mm (2016). The average precipitation for the years 2006-2016, according to Leszno station, ranged from 31 mm for April to 81 mm for July (Table 3) whereas mean air temperatures during the growing season were around 15.6 ^{O}C and were equal to the multiannual mean temperature for this period. The vegetation period in 2015 was defined as a dry, because the sum of precipitation (279 mm) was lower than the mean of a multi-year by 49 mm, with an average temperature of 15.4 ^{O}C. The vegetation period in 2016 was defined as a wet when the sum of precipitation (456 mm) was higher than the average of 109 mm and the temperature was 15.9^{O}C.

Table 3. Temperature (°C) and precipitation (mm) during the experiment against the mean values of the multi-year (2006 to 2016)

Month	Temperature (°C)				Precipitation (mm)			
	Mean monthly temperatures of 10 years	Mean monthly temperatures			Mean monthly sums of 10 years	Monthly precipitation		
		2014	2015	2016		2014	2015	2016
April	9.5	10.3	8.2	8.6	31	46	29	37
May	13.9	13.2	12.3	15.4	52	104	25	58
June	17.2	16.2	15.4	18.5	60	36	85	161
July	19.9	21.5	19.2	19.0	81	72	50	136
August	18.8	17.6	22.6	17.6	75	64	69	52
September	14.5	15.7	14.6	16.2	47	68	39	12
April-September	15.6	15.7	15.4	15.9	346	389	297	456

Source: based on data from the Institute of Meteorology and Water Management, Leszno station

RESULTS

The high blueberry yield began three years after planting the seedlings and it was different in terms of fruit weight harvested for each variety. The late harvest was the result of shrubs withering in the first year after planting. The impact on the distribution of shrubs on the plantation was significant. The variety, which proved the highest resistance to low temperatures, was the Patiot, from the initial number of 30 bushes 24 remained. Bluecrop also proved to be resistant to frost. The Chandler variety was found to be comparable with the Bluecrop variety.

It was found, that high blueberry yield depended on the amount of precipitation and the applied irrigation variant. The importance of irrigation was observed in 2016 when the plantation was not irrigated. The highest yields (1.43 $t \cdot ha^{-1}$) were obtained in 2014 when more frequent irrigation was applied.

Table 4. High blueberry fruit yield [$t \cdot ha^{-1}$] depending on the type of hydration variant used

Year	Variant of irrigation	Yield [$t \cdot ha^{-1}$]
2014	A	1.43
2015	B	1.04
2016	C (control one)	0.74

In the first year of fruiting, the weight of the harvest and the mass of individual fruit were the highest. The diameters of the fruit were larger, especially in the Chandler variety. Such good results in fruit size, obtained in 2014, were the result of application of optimal irrigation during the flowering period and berry ripening. Similar results of the irrigation applied were obtained by Smolarz (1997).

In 2016 the high blueberry yield was 0.74 $t \cdot ha^{-1}$, and in the other years it ranged from 1.04 $t \cdot ha^{-1}$ (2015) to 1.43 $t \cdot ha^{-1}$ (2014) (Tab.4). The mean yield increase, due to irrigation, was over 167%, in 2015 classified as dry 140% and 193% in the mild year 2014. The high blueberry yield as a result of irrigation was close to the mean annual yield, which was obtained on plantations in Poland, in fields without irrigation. The yield increase on the irrigated fields was over 6 $t \cdot ha^{-1}$ (132%) (Gruca 1997).

The yield in the three analyzed years was 3.2 $t \cdot ha^{-1}$. The variety with the best production was Chandler, and its yield was 1.04 $t \cdot ha^{-1}$ (32%). The Patriot, Bluecrop and Elliott variaties were similar (Tab.5).

Table 5. The high blueberry yield of each variety with a percentage share in the surveyed years 2014-2016

Variety	Yield [$t \cdot ha^{-1}$]	Percentage of harvest
Duke	0.34	11%
Patriot	0.65	20%
Chandler	1.04	32%
Bluecrop	0.63	20%
Elliott	0.55	17%

Plantation varieties had been planned in such a way that harvesting was possible from the beginning of July to September. The time of fruiting of each variety was different and took place on different dates. The Duke and Patriot varieties, early ripening ones (Pliszka, 2002), had been fruiting since the beginning of July and the Duke variety even since the end of June. Their fruiting time lasted three weeks. Another variety, Chandler, ripened at the turn of July and August. It fructified for six weeks. The Bluecrop was a medium ripening variety, and the fruiting time lasted three weeks. The Elliott variety ripened as the last one and fruited for four weeks until the first half of September.

In 2014, when the highest fruit yield was recorded, the Chandler variety produced the largest amount of fruit 0.48 $t \cdot ha^{-1}$. However, the poorest amount of fruit was the Duke (0.15 $t \cdot ha^{-1}$). Similar production effects were achieved in 2015 and 2016 when the Chandler variety also yielded best, and the Duke one worst (Fig. 1).

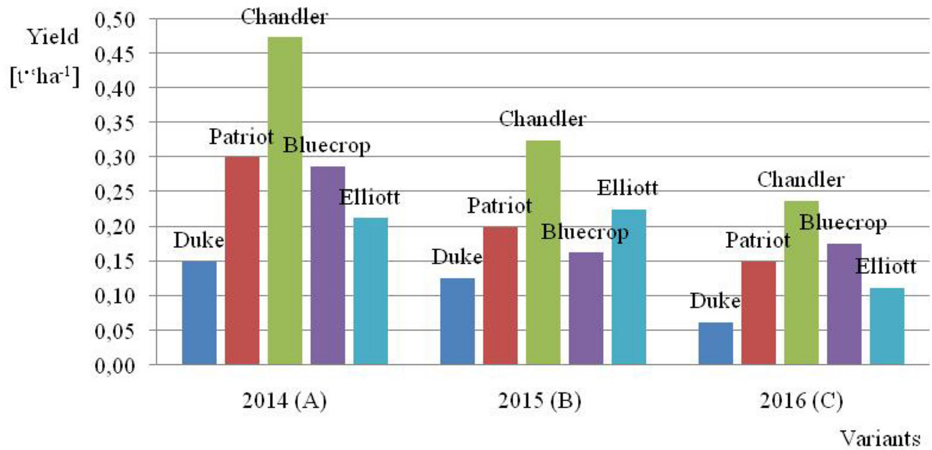

Figure 1. Highbush blueberry yield for each of the varieties analyzed in vegetative periods in the years 2014-2016

CONCLUSIONS

1. Irrigation of highbush blueberry in two growing seasons contributed to the increase in yield by 0.5 $t \cdot ha^{-1}$ on average, in relation to the vegetative period without irrigation.
2. The average yield increase due to irrigation was over 167%, in the mild year (2014) the increase was 193%, and in the dry year (2015) by 140%.

3. The Chandler variety yielded the best fruit, and its fruit yield was 1.04 t·ha^{-1} (32%). The Patriot and Bluecrop and Elliott varieties were comparable.

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