Research on the Growth of Shoots in Irrigated Blueberry Cultivation (*Vaccinium corymbosum* L.)

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Abstract

Given the importance and special qualities of blueberries for the human diet, the goal is to extend and develop these cultivations in Romania. The goal of this research is to improve certain aspects of the cultivation technology and water consumption for blueberry crops in the field, to monitor the effectiveness. Research were conducted on the field of experiments situated at the Monariu farm, in the town of Ulmeni, Maramureş County, on a soil with moderate acid reaction, made of 8 blocks randomized in 3 repetitions, each of the 24 plots having 10 shrubs, planted on ridges at a distance of 1 m, with a distance of 3 m between rows. Irrigation was carried out using an irrigation system supported by a water source from a well and an energy source of 220 V from the electrical power network; water is stored in two buffer tanks and then taken up through a supply line by a pump and distributed to the water main, then through joints to the zonal pipes from which, through nozzles, the watering of each shrub takes place by the dripping method. From conducted measurements, with drought conditions, following the procedure provided in the research project and graduations of studied factors, it appears that in the vegetation period there is an average growth of sprouts of Hannah's Choice variety, ranging from 23.4 to 50.4 cm for one year old sprouts, 18.8 to 40 cm for two years old sprouts and 9.0 to 21.2 cm for three years old sprouts. For Elliott variety, the average growth of one year old sprouts ranges from 17.2 to 36.6 cm, 11.4 to 25.1 for two years old sprouts and 8.3 to 18.2 for three years old sprouts. From observations we can conclude that there is a faster growth of sprouts from Hannah's variety compared to sprouts from Elliott variety and that in both cases there is a higher growth of one year old sprouts compared to the growth of two and three years old sprouts.

Keywords: *highbush blueberry, irrigation, fertilization.*

INTRODUCTION

Spontaneous blueberry is spread between parallels 45° and 71° in Asia, Europe and North America, where it grows at a high altitude, even in alpine areas, on acid soils. Highbush blueberry (*Vaccinium corymbosum*) is included in the *Ericaceae* family, the *Vaccinium* genus and is native from North America where it was cultivated on approximately 10000 ha until the end of 1970 (BÎSTROVA et al., 1968).

Worldwide, countries with the highest blueberry production are United States of America, Canada and Germany. Cultivation of highbush blueberry in Europe started in 1925, in Holland and Germany, then expanded in many other countries on the entire continent, including in Romania (MITRE, 2001).

The first blueberry crops in Romania were established in 1968, at Bîlceşti, Campulung-Muscel, where they conducted research for 30 years to prove that highbush blueberry can be successfully

cultivated in the pedoclimatic conditions of our country (BĂDESCU, 2007).

Blueberry fruits have special qualities in human nutrition, especially for their pharmaceutical action due to anthocyanin, which helps in the functioning of blood microcirculation, in retinal vascular protection, acts as an adjuvant in treatment of type II diabetes, it is antidiuretic, anti-inflammatory and antiseptic, protects the body against radiation and helps rejuvenating cells can cancer prevention. Cultivated blueberries is mainly represented by varieties with a high bush (1-3 m), obtained from *V. Corymbosum* L. species, native from North America. For the formation of blueberry varieties also contributed the *V. Lamarckii* Camp. (lowbush blueberry) species, native also from America. In crops it was introduced only in 1889, in USA, when Dr. Friedrich W. Coville started its systematic propagation (MIHĂIESCU, 2007).

Blueberry requires an average rainfall of over 700 mm annually. However, it was observed that blueberry might be affected in years when rainfall is over 800-850 mm, so crop irrigation must be done with moderate quantities of water. Irrigation is performed on small intervals and is associated with mulching the soil (PÂRVU, 2002). Blueberry generally suffers when periods of over 8-10 days without rain occur, during the growth and ripening of fruits when it requires a high consumption of water. From research conducted at Bîlcești after 2001, it was revealed the positive effect of irrigations. In a field of experiments with three irrigation variants, in 2004, the highest production of 33 t/ha was obtained by using irrigation with the dripping method (BĂDESCU, 2007).

Irrigation is recommended in the growth period of sprouts and fruits, 3-5 weeks before fruit harvesting and in the fruit bud differentiation period (MITREA, 2001).

Worldwide, the most used irrigation methods are by dripping with dripping tubes or with individual dropper on each plant, these being connected to fertigation systems. In this way, with the application of the watering norm are also applied fertilizers specific to the phenophase function.

Irrigation of blueberry crops is made by dripping and watering duration depends on the watering norm, distance between pipes, distance between droppers and flow of a dropper (LUCA and NAGY, 1999).

For blueberry, starting from April until August, some places until September, plants must be irrigated, maintaining a constant moisture, preventing the water from making a puddle. Excessive irrigation results in rotting of the roots. Besides irrigation and mulching, it is necessary to ensure a balanced fertilization, especially with nitrogen without which leaves turn yellow, bluish and dry, lack of potassium causes necrotic spots on leaves and lack of phosphorous cause's redness of the stems. Sulfur deficiency causes chlorosis of young leaves and blocking iron in the soil has serious consequences on plants. Because of deficiencies and blocking of iron, blueberry shrubs can wither within a year. Soil acidity is very important, a pH of 4.5-5.5 is required; otherwise, acidification is performed with the addition of acidic peat, sulfur and aluminum sulfate. In order to maintain a high acidity are used acidic fertilizers, such as ammonium sulfate. If the pH is below 3.5, aluminum and manganese become soluble and very toxic for the plant, roots become thick, stop growing and die, and if the pH is over 5.2, nitrogen is converted from the useful ammonium acid form to the nitrate form, and chlorosis causes an iron deficiency in the plant, leaves turn yellow, photosynthesis is inhibited and the plant dies (KORCAK, 1989).

The goal of the research was to pursue some aspects of the cultivation technology of highbush blueberry, using drip irrigation, irrigation efficiency, differentiated and comparative, on the studied blueberry varieties.

MATERIALS AND METHODS

Research was conducted on the field of experiments located in the Tohat-Ulmeni farm, Maraureș County.

Geographic coordinates of the farm are between 47°29'43.51" and 47°29'45.87" north latitude and 23°17'59.19" and 23°18'14" east longitude (Fig. 1).

The farm was established in 2011, on a soil with a moderate acidic reaction, having a pH of 5.5; with a high percentage of clay and little organic matter, a poor productive soil, so for the establishment of the crops was added river gravel to correct texture and acidic peat (5l/plant) for input of organic matter and for maintaining the pH necessary for the crop. Surface of the farm is 0.837 ha (Fig. 2).

Fig. 1. The experimental farm in Tohat – Ulmeni.

Fig. 2. The Tohat - Ulmeni farm project.

R	B ₁ B ₂		B ₃ B ₄		B ₅ B ₆		B ₇	B ₈
R ₁	a ₁ b ₁ c ₁	a ₁ b ₁ c ₂	a ₁ b ₂ c ₁	a ₁ b ₂ c ₂	a ₂ b ₁ c ₁	a ₂ b ₁ c ₂	a ₂ b ₂ c ₁	a ₂ b ₂ c ₂
R ₂	a ₂ b ₂ c ₂	a ₂ b ₂ c ₁	a ₂ b ₁ c ₂	a ₂ b ₁ c ₁	a ₁ b ₁ c ₂	a ₁ b ₁ c ₁	a ₁ b ₂ c ₂	a ₁ b ₂ c ₁
R ₃	a ₁ b ₂ c ₁	a ₁ b ₂ c ₂	a ₁ b ₁ c ₁	a ₁ b ₁ c ₂	a ₂ b ₁ c ₁	a ₂ b ₁ c ₂	a ₂ b ₂ c ₁	a ₂ b ₂ c ₂

Fig. 3. The structure of field experiments.

The field of experiments is made of 8 blocks randomized in 3 repetitions, each of the 24 plots having 10 shrubs, planted on ridges at a distance of 1 m, with a distance of 3 m between rows. The total number of shrubs on the field of experiments is 240.

Factors included in the study are: A-water with two graduations, a₁-basic irrigation, a₂-basic and supplementary irrigation; B-fertilizer, with two graduations, b₁-basic fertilization, b₂- basic and supplementary fertilization; C-variety, c₁-Elliott and c₂ Hannah's Choice. Surface of the field of experiments is 854 m² (Fig. 3).

The significance of each plot are:

R_1B_1, R_2B_6, R_3B_3	$a_1b_1c_1$	Basic irrigation and fertilization for Elliott
R_3B_1, R_1B_3, R_2B_8	$a_1b_2c_1$	Basic irrigation, basic and supplementary fertilization for Elliott
R_1B_5, R_2B_4, R_3B_5	$a_2b_1c_1$	Basic and supplementary irrigation, basic fertilization for Elliott
R_2B_2, R_1B_7, R_3B_7	$a_2b_2c_1$	Basic and supplementary irrigation, basic and supplementary fertilization for Elliott
R_1B_2, R_2B_5, R_3B_4	$a_1b_1c_2$	Basic irrigation and fertilization for Hannah's Choice
R_1B_4, R_2B_7, R_3B_2	$a_1b_2c_2$	Basic irrigation, basic and supplementary fertilization for Hannah's Choice
R_1B_6, R_2B_3, R_3B_6	$a_2b_1c_2$	Basic and supplementary irrigation, basic fertilization for Hannah's Choice
R_1B_8, R_2B_1, R_3B_8	$a_2b_2c_2$	Basic and supplementary irrigation, basic and supplementary fertilization for Hannah's Choice

Thermal regime of the Tohat Ulmeni area, Maramureş County, from January to June 2014 is presented in a table (Tab. 1). By comparing the mean values on decades with the normal values, specific to the period between 1961 and 1993, we can observe that weather was very hot and excessively hot.

Rainfall for the field of experiments in Tohat Ulmeni area from January to June 2014, show that the weather was very and excessive (Tab.2).

Studied soils are Hannah's Choice and Elliott. Hannah's Choice is an early variety, produces large and medium sized fruits, dark blue in color, with a good scar, with excellent dimensions and firm, the riper ones being bigger than the ripening ones from the same bunch. Following the studies conducted from 1996 to 2001, it was observed that fruit weight varied between 1.9 g in the first harvest to 1.6 g in the third harvest. 50% of fruits are ripe around 25th of June. Hannah's Choice

Tab. 1. The average temperature (°C) of Tohat – Ulmeni aires in January – June 2014.

Month	January	February	March	April	May	June
First decade	4,0	2,8	5,7	9,1	11,9	17,3
Second decade	2,8	5,4	6,1	9,1	12,5	17,4
Third decade	-1,38	4,1	9,0	14,0	10,9	16,3
Average monthly	5,45	12,32	20,84	32,17	35,30	51,04
Normal	-2,40	0,20	5,50	10,70	15,20	18,20
Departure	7,85	12,12	15,34	21,47	20,10	32,84
Characterization	Very hot	Excessively hot	Excessively hot	Excessively hot	Excessively hot	Excessively hot

Tab. 2. Rainfall for the field of experiments.

Precipitation (mm) in 2014 Tohat Ulmeni						
Month	January	February	March	April	May	June
First decade	0,3	1,5	3,0	1,0	1,8	0,5
Second decade	2,8	6,5	3,8	1,5	7,8	4,8
Third decade	3,58	0,7	3,1	1,6	3,8	6,7
Average monthly	6,65	8,66	9,80	4,13	13,32	11,98
Normal	63,4	46,2	49,7	67	86,8	104,7
Departure	-56,75	-37,54	-39,90	-62,87	-73,48	-92,72
Characterization	excessively dry	very dry	very dry	excessively dry	excessively dry	excessively dry

crops were very profitable in New Jersey, but with variable crops, weak to moderate in Michigan, Oregon and North Carolina (MARK *et al.*, 2005).

Elliott is a variety of American blueberry that has spread throughout Europe. It is part of the late ripening varieties, at the end of August. Elliott variety forms a vigorous bush, vertical and robust, of great height which can reach up to 2 m. This variety is different from the others by its resistance to low temperatures and by its extremely high productivity until late September, obtaining productions between 12 tons and 50 tons per hectare. Elliott requires careful and proper trimming. The fruit is medium sized, light blue, of good quality. It ripens in mid-August to mid-September. Fruits are sour, with very small scars and are arranged in compact bouquets. Providing a cross pollination will increase the speed of ripening, so 70-80% of the fruits will ripe at once making possible an automated harvesting.

The irrigation system of Tohat-Ulmeni farm is supported by a water source from a well and an energy source of 220 V from the electrical power network. Water input and its storage in the two buffer tanks is conducted as follows: water is taken up from the superior aquifer layer situated at a depth of 6-7 m below the natural elevation of the field through a strainer equipped with rubber retention membrane and protected with metal sieve.

Water entrain is made with a surface pump with the power of 1.1 kW and a flow of 4.5 m³/h at a pressure of 3 bars, equipped with mechanical

pressure controller and expansion tank. Water is then transported through a PN 6 polyethylene pipe with the diameter of 32 mm to the two storage tanks made of stainless steel, each having a capacity of 7 m³.

Distance on which the water is transported from the source to the tanks is 140 m. Pumping, filtration and fertilizer dosing are done as follows: water from the buffer tanks is taken up through a supply pipe by the pump, which is identical to the pump that takes water from the source. Its operation is controlled by an electronic pressure controller with protection function when water is missing from the system. Water passes then through a filter with discs to stop suspensions of up to 150 microns by mechanical filtering. From the filter water passes through the Dozatron fertilizer dispenser. This dispenser allows precise dosing of hydro soluble fertilizers in to the water for irrigation in the percentage established by setting. The dispenser is coupled in series on the hydraulic path and is equipped with an internal bypass when not working.

In order to ensure efficient water distribution to the plants, the irrigation system was dimensioned based on the characteristics of the dripping tube and on the characteristics of the pump (Fig.4.).

Control of the operation of the irrigation system is performed through a command panel that allows programming watering on each area based on a pre-established program. From the control panel actuates the electro valves locate on the

Fig. 4. The irrigation system in Tohat - Ulmeni.

hydraulic path through copper wires. Watering is done sequentially, separately on each area.

To establish the watering norm, soil sample is taken from the root area and moisture is measured. Daily amount of water is determined depending on the root volume and the retention capacity in the soil. The root has a diameter of approximately 60 cm. Water retention capacity in the soil is different depending on soil texture.

In the existing climatic conditions, taking into account soil moisture, irrigation was done starting from April, five times a week, one hour a day, then according to phenophase, daily, 2 liters and 4 liters per nozzle, at a pressure of 1-3 bars, one hour a day, and if the temperature exceeded 38 °C, irrigation was done for about 2 hours a day.

Fertilization consists of a basic fertilization which was made at the establishment of the crop by intake of organic matter, garden mould in the amount of 5 liters/plant and acidic peat 5 liters/plant. The amount of fertilizer needed by a plant is determined by soil texture and nutrient reserves in the soil. Blueberry needs nitrogen in the form of ammonium, phosphorous and potassium and also microelements. As shown in research from Bilcești, best results are obtained when fertilizing with ammonium sulfate, substance that we use also for the supplementary fertilization of the field of experiments; the amount used was 4.6 g/plant and it is applied through the irrigation system once a month. Irrigation was done in rainless periods when soil moisture decreased reaching critical level.

In the first two years fertilization was done by using the irrigation system with NPK 20-5-10, for a growth rate of 1-2 g/plant. In the third year, together with ammonium sulfate were applied microelements of Mg, Cu, Bo and Ca which are very important for the formation and development of fruits. In this year phosphorous and potassium have an important role during flowering, development and fruit ripening.

Observations took into account the growth of one year old sprouts, two and three year old shrubs of blueberry from April to August 2014 for the two varieties. Sprout growth were measured with a linear meter in April at the entry into vegetation and at the end of August, for the 10 shrubs on each plot.

RESULTS AND DISCUSSION

In determining the average values of growths in the field of experiments, there were chosen samples of 10 shrubs per plot. Obtained averages, standard deviation and standard deviation of the most probable value are considered values of the entire population of the Tohat farm.

From the conducted measurements, with drought conditions, following the procedure provided in the research project and graduation of the studied factors, it appears that in the vegetation period there is an average growth of sprouts of Hannah's Choice variety, ranging from 23.4 to 50.4 cm for one year old sprouts, 18.8 to 40 cm for two years old sprouts and 9.0 to 21.2 cm for three years old sprouts (Tab. 3).

For Elliott variety, the average growth of one year old sprouts ranges from 17.2 to 36.6 cm, 11.4 to 25.1 for two years old sprouts and 8.3 to 18.2 for three years old sprouts (Tab. 4).

Also, we can observe that for both varieties that were studied, the variants that have benefited of irrigation and basic fertilization with supplements yielded the best results in terms of average sprout growth.

CONCLUSIONS

Research conducted in the field of experiments shows that:

- minimum average growths were recorded for 3 years old sprouts of shrubs from plots with basic irrigation and basic fertilization of Elliott variety, with a value ranging from 8.3 to 11.1 cm and the maximum value of average growths is ranging from 42.1 to 50.4 cm for one year old sprouts of shrubs from plots with basic irrigation and fertilization and supplementary fertilization of Hannah's Choice variety.
- generally, growths are higher for one year old sprouts compared to two and three years old sprouts, both for Hannah's Choice and Elliott varieties.
- standard deviations of most probable values are on average of 1 cm for sprouts from Hannah's Choice variety and 0.6 for Elliott variety.
- the mean square error of a single observation, namely the standard deviation of one year old sprouts, due to nonlinear growths and higher values, was higher than the standard deviation of two years old sprouts.

Tab. 3. Average growth of sprouts from April to August 2014, Hannah's Choice variety, standard deviation of a value and standard deviation of the most probable value.

Fertilization regime	Irrigation regime	Sprout Age [year]	Plot	Mean value of growth [cm]	s_0	s
Basic fertilization	Basic irrigation	1	R2B5	28,0	5,281	1,760
			R3B4	23,6	1,778	0,593
			R1B2	23,4	1,350	0,450
		2	R2B5	18,8	2,946	0,982
			R3B4	22,2	1,724	0,575
			R1B2	19,0	3,321	1,107
	Basic irrigation with supplement	3	R2B5	9,2	1,533	0,511
			R3B4	9,0	2,198	0,733
			R1B2	11,8	1,639	0,546
		1	R1B6	36,4	6,161	2,054
			R2B3	30,7	3,626	1,209
			R3B6	30,4	2,761	0,920
Basic fertilization with supplement	Basic irrigation	2	R1B6	24,4	3,536	1,179
			R2B3	28,9	4,487	1,496
			R3B6	24,7	3,435	1,145
		3	R1B6	12,0	1,668	0,556
			R2B3	11,7	2,444	0,815
			R3B6	15,3	0,073	0,024
	Basic irrigation with supplement	1	R1B4	42,0	2,187	0,729
			R3B2	35,4	3,933	1,311
			R2B7	35,1	3,778	1,259
		2	R1B4	28,2	5,034	1,678
			R3B2	33,3	3,305	1,102
			R2B7	28,5	4,579	1,526
Basic fertilization with supplement	Basic irrigation	3	R1B4	13,8	2,340	0,780
			R3B2	13,5	1,233	0,411
			R2B7	17,7	2,194	0,731
	Basic irrigation with supplement	1	R1B8	50,4	4,480	1,493
			R2B1	42,5	6,927	2,309
			R3B8	42,1	6,377	2,126
		2	R1B8	33,8	2,602	0,867
			R2B1	40,0	3,402	1,134
			R3B8	34,2	1,871	0,624
	Basic irrigation	3	R1B8	16,6	1,966	0,655
			R2B1	16,2	1,050	0,350
			R3B8	21,2	2,567	0,856

Tab. 4. Average growth of sprouts from April to August 2014, Elliott variety, standard deviation of a value and standard deviation of the most probable value

Fertilization regime	Irrigation regime	Sprout Age [year]	Plot	Mean value of growth [cm]	s_0	s
Basic fertilization	Basic irrigation	1	R1B1	22,2	2,181	0,727
			R2B6	17,2	1,848	0,616
			R3B3	18,2	2,919	0,973
		2	R1B1	11,4	0,990	0,330
			R2B6	15,2	1,888	0,629
			R3B3	12,4	2,319	0,773
		3	R1B1	8,3	0,843	0,281
			R2B6	8,5	1,701	0,567
			R3B3	11,1	2,100	0,700
	Basic irrigation with supplement	1	R1B5	25,5	2,998	0,999
			R2B4	19,8	2,372	0,791
			R3B5	20,9	2,541	0,847
		2	R1B5	13,1	2,090	0,697
			R2B4	17,5	1,841	0,614
			R3B5	14,3	0,913	0,304
		3	R1B5	9,5	1,458	0,486
			R2B4	9,7	0,619	0,206
			R3B5	12,7	1,410	0,470
Basic fertilization with supplement	Basic irrigation	1	R3B1	30,0	4,961	1,654
			R1B3	23,2	2,055	0,685
			R2B8	24,6	2,191	0,730
		2	R3B1	15,4	1,967	0,656
			R1B3	20,5	3,668	1,223
			R2B8	16,7	3,668	1,223
		3	R3B1	11,1	0,689	0,230
			R1B3	11,4	1,005	0,335
			R2B8	14,9	1,649	0,550
	Basic irrigation with supplement	1	R2B2	36,6	3,221	1,074
			R1B7	28,4	1,898	0,633
			R3B7	30,0	1,522	0,507
		2	R2B2	18,8	1,317	0,439
			R1B7	25,1	1,823	0,608
			R3B7	20,5	4,238	1,413
		3	R2B2	13,6	0,985	0,328
			R1B7	13,9	0,765	0,255
			R3B7	18,2	2,115	0,705

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