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Adaptation of the main elements of the technology of cultivation of highbush blueberry (*Vaccinium Corymbosum L.*) in the conditions of Southeast Kazakhstan

Gulfaridat Amanovna Kampitova, Laura Serikkanovna Yerbolova, Togzhan Kadylbekovna Yegizbaeva, Balnur Erbolovna Alimbekova, Dinara Seidazimova

Kazakh National Agrarian University,
050010, The Republic of Kazakhstan, Almaty, Medeu district, Abai Avenue, 8

Abstract

The article shows the results of studying adaptation of the main elements of the technology of cultivating highbush blueberry (*Vaccinium Corymbosum L.)* in the conditions of South-Eastern Kazakhstan. Its morphological characteristic has been given; the characteristics of bushes' growth and development against the background of climatic conditions in the studied area, phenological phases of blueberry development have been studied depending on the applied cultivation technology. The composition of root layer of soil, the optimum amount of peat to be used, and age of planting material for creating productive plantations of highbush blueberry in the conditions of a foothill zone of the Almaty region have been determined. Based on the research, it has been established that the edaphoclimatic conditions of the foothill zone of the Almaty region are favorable for growing Bluecrop variety of blueberry. To ensure more productive planting of blueberry, it is recommended to use 2-year-old planting material obtained in vitro, after adaptation in the ex vitro conditions. The plants planted into the peat and into the peat with the use of foil have great potential for productivity. To create the optimum soil conditions with pH ranging between 3.8 and 4.8, blueberry plants are to be planted into holes with the use of 15 kg of peat.

Keywords: highbush blueberry, berries, adaptation, technology, South-East of Kazakhstan, productivity.

INTRODUCTION

Blueberry is one of the world's leading small-fruit crops. It is not only interesting for its biology, ecology, geography and history, but also for its great practical importance [1]. Blueberries contain a lot of vitamins, have high nutritional value, and in Western countries they are touted as the "elixir of youth". From the literature it is known that along with the usual set of vitamins and minerals, blueberries are rich in organic acids, phenolic compounds, which perform important physiological functions in human body [2,3].

Experience of foreign scientists [4,5] proves that blueberry is highly profitable, as it has a short payback period. When 2-year-old seedlings are used for laying plantations, the yield of berries planted in the 2x1.5 m pattern on the 3 or 4-th year may reach 4-5 t/ha, or more. Abroad, the cost of 1 kg of berries ranged between US$6-7 and US$10-12.

Blueberry is the only crop widely spread in Europe and America, which has not yet been introduced in Kazakhstan, but may quite successfully adapt to the conditions of our country. In this regard, employees of the Horticulture and Nuts Production Department of NAO KazNAU study the introduction of highbush blueberry in the conditions of Southeastern Kazakhstan. The climatic conditions of Southeastern Kazakhstan are not too different from the optimum conditions for the blueberry crops in the regions, which allows obtaining high yields in the future by adapting the technology and selecting proper varieties.

Increased interest to cultivation of highbush blueberry among farmers and private agricultural producers, and high consumer demand in domestic and foreign markets stimulated studies of adapting progressive technologies of blueberry cultivation in the conditions of Kazakhstan.

Our study is aimed at adapting the basic elements of technology of blueberry cultivation in the conditions of Southeastern Kazakhstan.

METHODS

In 2017, in order to adapt the main elements of highbush blueberry cultivation technology in the conditions of Southeastern Kazakhstan, experiments were laid in the foothill area of the Almaty region.

The region of the experimental field in the village of Kaynar is located in the arid front montane area in the North-Eastern part of the Karasai district of the Almaty region, at the altitude of about 700 m above the sea level, and occupies the piedmont plain characterized by sharply continental climate, low humidity, lots of sunshine, and short but quite cold winter.

The average temperature in the hottest month, July, is plus 22-24ºC, and in the coldest month, January, - minus 6-10 °C. The sum of positive temperatures is 3,450-3,750ºC. Spring frosts cease in the III decade of April, and the autumn frosts resume in the III decade of September - early October. The average duration of frost-free period is 140-170 days. The annual amount of precipitation is 350-600 mm. During the warm period, 120-300 mm of precipitation fall. The steady snow cover is formed in late November - early December, and remains for 85-100 days.

Snow depth reaches 20-35 cm. The hydrothermal coefficient is 0.7-1.0.

Relative air humidity varied significantly throughout the vegetation period. Moisture content in the air was higher than the many years' average indicators by 17.04-23.02%, depending on the vegetation months.

The soil in the experimental plots is dark chestnut, medium loamy with fully developed terrain clearly differentiated into genetic horizons. Top soil contains 2.9-3.01% of humus; 0.17-0.19% of total nitrogen; 0.20% of total phosphorus, and 2.2% of potassium. The content of mobile phosphorus in the topsoil is 23-32 mg per 1 kg of soil, of potassium - 355-360 mg/per 1 kg of soil. The sum of absorbed alkali or the cation exchange capacity is 20-21 mEq per 100 g of soil. Reaction of soil solution is slightly alkaline (pH 7.3-7.4). Soil bulk density is 1.1-1.2 kg/cm^3, the least moisture capacity is 26.6 %.

The object of the study is highbush blueberry species *Vaccinium corymbosum* L – the Bluecrop variety, which has become the standard. It has been breed in the United States by crossing GM-37 (Jersey x Pioneer) x CU (Stanley x June), J. Darrow, J. Klark, F. Coville, O. Freeman. It is suitable for manual and mechanized harvesting. It is used fresh and may be processed or frozen. The yield is 4 to 9 kg per bush, depending on age. It ripens in early August - from the third decade of July to the end of August - beginning of September: the fruiting period is prolonged. Berries of the second harvest are stringer, suitable for mechanical harvesting. High frost resistance - 28...-34^0. Bluecrop is least prone to changes in soil acidity – it is not so responsive to chlorosis, wilting, reduced productivity - the plants do not wither at the slightest changes. It tolerates droughts, but poorly overcomes raw damp climate, as it is susceptible to shoots' diseases. High frost resistance and resistance to freezing of buds during resumed frost are the unquestionable advantages of this variety [6].

For studying the adaptive nature of the technology of blueberry cultivation, phenological stage, survival rate and morphological characteristics of plants growth were taken into account. The methodological basis of the research was the "Program and methods of studying varieties of fruit, berries and nut crops" [7].

Soil was prepared for planting not only in accordance with the existing recommendations, but also with regard to the peculiarities of blueberry.

RESULTS

For the vegetation cycle, blueberry requires the sum of active temperatures of about 2,500^0, and the duration of the vegetation season should be 160-165 days [8].

On average, the vegetation period in Kazakhstan lasts for about 190-230 days (160-210 days with fluctuations), the frost-free period lasts on the average for 158 days. By the results of the studies, the duration of the growing season in the foothill area of the Almaty region was about 193-201 days, and was favorable for growth and development of highbush blueberry. The growing season started on April 4 to 9.

In 2017, the weather conditions featured heavy precipitation in the spring. From April to June, there was heavy rainfall. However, July and August featured the absence of rain throughout the month. In September, the amount of precipitation was not significantly different from the many-years observations.

In general, weather conditions during the vegetation period (April to September) in 2017 were relatively favorable for blueberry cultivation. Studying the climatic conditions had shown the real possibility of growing blueberries in the test area, where the sum of positive temperatures and the duration of the growing period were efficient for the complete cycle of vegetation. During the blueberry vegetation season, by means of taking agrotechnical measures (watering, fertilizing, inter-row cultivation, etc.), the negative impact of unfavorable weather conditions on the growth and development of blueberry plants decreased.

Highbush blueberry is very demanding to soil, and this is a serious obstacle to its spreading [8]. The crop grows best on light, well aerated and warmed acid soils with the humus content not less than 3.5%, preferably 7% and higher [4]. The optimum soil acidity pH is in the range between 3.8 and 4.8. The plants growing on soils with acidity lower than 5.1 have a tendency to chlorosis.

In this regard, studies were performed in 2017 in the conditions of the foothill zone of the Almaty region in order to determine the optimum soil conditions for growing blueberry. The experimental plot was planted with annual blueberry plants of Bluecrop variety obtained *in vitro*. Variants were studied for creating the root layer: 1) 10 liters of peat (reference); 2) peat+zeolite; 3) peat+foil (the use the foil for maintaining soil acidity); and 4) peat+sawdust. The ratio was 1:1 (5 gallons of peat 5 gallons of zeolite, peat and sawdust, respectively). Since the plants were annual, the pits were made 40 cm deep and 40 cm wide. Experiment layout was 1,5x1 m. The experiment was repeated three times, 5 plants in each repetition.

As a result of this work, the effect of various root layers on the vegetative growth and development of blueberry, and on the survival rate were studied. On the experimental plot, 60 plants were planted in each variant. Seedlings were 15-17 cm high, the root system was not much developed, as they had been grown in a cassette. Studies performed after planting showed the survival rate between 37% and 60%, at the end of the growing season - between 23% and 53%. We assumed that in the conditions of rainy spring and moderate-hot first half of the summer, the plants started growing and developing, but temperature stresses first caused stagnation, and then death of most plants. These results suggest that for productive planting of blueberry, the use of a 2-year old planting material obtained *in vitro* and adapted in the *ex vitro* conditions is recommended (Figure 1).

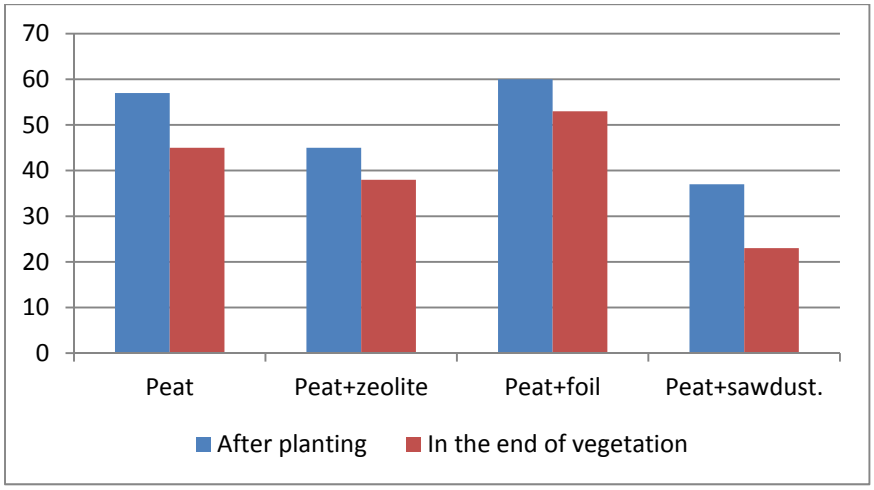

Figure 1 - Blueberry survival rate in % (2017)

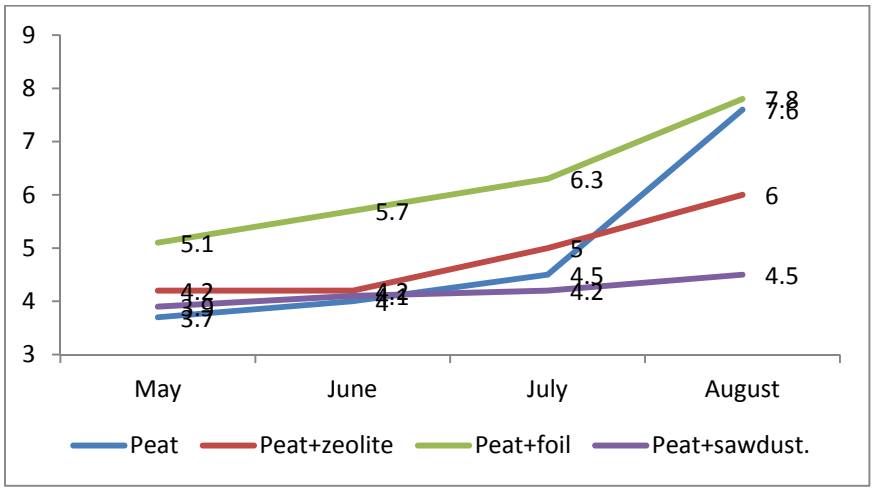

Figure 2 - Dynamics of annual shoots growth, cm

Table 1 - The influence of various root layers on the vegetative growth and development of annual plants of highbush blueberry (Bluecrop variety, 2017)

Experiment variants	Plant height, cm	Annual increments		Radical shoots		Leaf coverage		
		number, PCs	length, cm	number, PCs	length, cm	number of leaves, PCs/plant	Average leaf area cm^2	Leaves area cm^2/plant
Peat (reference)	34.0	5.6	7.6	4.3	7.1	50.4	13.3	670.3
Peat+zeolite	27.8	3.4	6.0	3.0	8.0	34.5	13.5	465.8
Peat+foil	32.6	4.2	7.8	8.0	9.2	47.2	15.1	712.7
Peat+sawdust.	21.7	2.3	4.5	1.0	6.0	27.6	12.3	339.5
m %	***7.86***		***15.4***		***8.12***			
Least significant difference$_{095}$	***6.44***		***2.82***		***1.73***			

Table 2 - Vegetative growth of biennial blueberry plants depending on the amount of peat, (2017)

Experiment variants	Survival rate, %		Plant height, cm	Annual increments		Radical shoots	
	after planting	at the end of vegetation		number, pcs	length, cm	number, pcs	length, cm
Peat 15 kg (reference)	100	96	65.8	15.9	16.1	3.2	19.4
Peat 10 kg	97	84	61.0	15.6	14.3	2.85	18.6
Peat 7 kg	90	68	56.9	14.2	12.3	2.62	18.3
m %			***3.72***		***8.82***		***4.71***
Least significant difference$_{095}$			***6.43***		***3.55***		***2.49***

Biometric observations had shown that blueberry planted into peat and into peat with the use of foil for preserving soil acidity showed good vegetative growth (Table 1). The height of plants by the end of the vegetation season in these variants reached 34.0 and 32.6 cm, while the height of the plants that were planted into pit+zeolite and peat+sawdust was 27.8 cm and 21.7 cm, which was 18.3% and 36.2% less than in the reference variant.

The average length of annual increments in the reference variant was 7.6 cm; also good growth was observed in the variant with peat+foil (7.8 cm), poor increase in annual growth was registered in the variants with peat+zeolite (6.0 cm) and peat+sawdust (4.5 cm). The same trend was observed in the development of radical shoots. The number of radical shoots on the average for the variants ranged between 1.0 and 8.0 per bush. High shoot-forming ability was observed in the variants with peat (reference) and peat+foil (Table 1).

The best indicators of vegetative mass formation were observed in the reference variant and in the variant with foil. The annual growth increments on blueberry plants on the average had 7-12 leaves. In accordance with this indicator, the nature of blueberry plant foliage coverage is determined (Table 1). In our studies, the highest number of leaves was formed on the plants that were planted into peat with the use of foil, and in the reference variant; on the average, a single plant had 50.4 and 40.7 leaves, which was 712.7 and 670.3 cm^2 of the leaf blade area. In the variants with peat+zeolite and peat+sawdust, the leaf area on a single plant was by 30.5% and 49.3% lower than in the reference variant.

The growth of shoots was monitored; as a result, intensive growth of annual increment started at the end of June - middle of the 3rd decade of July, and lasted for 21-25 days, then the growth slowed down to the 2nd decade of August. The most dynamic growth was observed in the reference variant and in the variant with peat+foil (Figure 2).

During the study of the growth of the aboveground mass, blueberry bushes in different variants showed a noticeable difference. Given that the main yield was formed on the annual increments, the plants that were planted into peat and peat with foil, were the most promising in terms of productivity.

The mechanical composition of the soil in the experimental site was medium clay loam with the bulk density of 1.1 to 1.2 kg/cm^3, and good permeability and sufficient moisture content. During blueberry testing, its increased requirements to soil acidity and humidity due to the biological characteristics of the species were taken into account. In the experimental plot, soil pH was close to neutral (7.3-7.4). To increase acidity, soil was mulched with rotten sawdust in the layer of 10-15 cm, peat, and acidic fertilizers were introduced in the form of powder sulfur, aqueous solution of ammonium sulfate, and potassium sulfate. One of the important goals of the study was creating optimum soil condition, where pH ranged between 3.8 and 4.8. Soil acidity was measured by a pH meter immediately after planting, after introduction of the fertilizer, and at the end of the vegetation season. pH varied depending on the variants of the experiment. The best values favorable for blueberry were observed in the reference variant and in the variant where foil was used (3.9 to 5.0). In the variants where peat was used with zeolite and sawdust, pH ranged between 4.0 and 5.2. Similar studies with the aim of determining the optimum amount of peat for creating favorable root layer were performed with biennial plants in the same experimental plot. The object of the study was the Bluecrop variety. Planting material was obtained by the *in vitro* method. 3 variants were studied: 1) peat - 10 l (reference); 2) peat - 15 l; and 3) peat - 7 l. The experiment layout was 1,5x1 m. The experiment was repeated three times, 5 plants in each repetition. The best results were obtained in the variants with peat 15 kg, pH ranged between 3.5 and 4.8. It should be noted that the level of soil acidity in other variants where the amount of peat was lower did not significantly exceed the permissible level, and ranged between 3.9 and 5.1. Observation of the changes that occurred in blueberry plants revealed the positive influence of fertilizers on the growth and development of blueberry bushes: the level of leaves' chlorosis significantly decreased; the bushes acquired more powerful habit. Based on the observations and the use of machinery, certain peculiarities of the studied variety were revealed: weak fibrous root system needed sufficient soil moisture and good aeration throughout the vegetation period, which confirmed the opinion of other scientists [9, 10, 11]. Therefore, during the vegetation period, the space between the rows was processed with a cultivator to the depth of 20 cm, and plants were mounded and weeded. The moisture content requirements of the cultivation technology were ensured during the dry season by means of drip irrigation every 10-14 days.

The favorable edaphoclimatic conditions of the foothill zone of the Almaty region had a positive effect on the survival rate, growth and development of biennial blueberry plants (Table 2). Accounting for determining the survival rate after planting showed the 100% survival rate of plants that were planted into peat 15 kg at the beginning of the vegetation season, 97% and 90% in variants with 10 and 7 kg, respectively. At the end of the vegetation season, a slight loss of plants was observed in all variants. In the first year after planting, blueberry plants' height in the reference variant reached 65.8 cm, which was the evidence of proper amount of peat for growing. The highest rates of the annual increments (16.1 cm) and radical shoots' formation (19.4 cm) were in the reference variant, where the amount of peat used was 15 kg. The lowest rates of growth and development were observed in the blueberry plants in only 7 kg of peat.

CONCLUSION

Blueberry is a valuable berry crop for our country for its unique healing properties and the inherent economic potential. And for developing recommendations for the technology of blueberry cultivation in Kazakhstan, it is necessary to comprehensively explore and identify the favorable growing conditions by adapting various technologies, since blueberry is very demanding to soil

acidity. Our research was aimed at studying the influence of the root layer on the growth and development of blueberry plants.

Based on the research, it has been established that the edaphoclimatic conditions of the foothill zone of the Almaty region are favorable for growing Bluecrop variety of high blueberry. To ensure more productive planting of blueberry, it is recommended to use 2-year-old planting material obtained *in vitro*, after adaptation in the *ex vitro* conditions. Biometric observations had shown that the blueberries planted into peat and into peat with the use of foil for preserving soil acidity showed good vegetative growth, by the end of the vegetation season plant height in these variants reached 34.0 and 32.6 cm, the average length of annual growth was 7.6 cm and 7.8 cm. Intensive growth of annual increments started between the end of June and the middle of the 3rd decade of July, and lasted for 21-25 days, then the growth slowed down until the 2nd decade of August, the most dynamic growth was noted in the reference variant and in the variant with peat+foil. Given that the main yield was formed on the annual increments, the plants that were planted into peat and into peat with foil, were most promising in terms of productivity. To create the optimum soil conditions with pH ranging between 3.8 and 4.8, blueberry plants are to be planted into holes with the use of 15 kg of peat.

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