EFFECT OF FERTILIZATION ON SOIL pH AND GROWTH OF LOWBUSH BLUEBERRY (*Vaccinium angustifolium* Ait.)

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Abstract

Lowbush blueberry (*Vaccinium angustifolium* Ait.) has specific soil requirements, they do best when the pH_{KCl} of the soil is between 4.5 and 5.5. In the Department of Horticulture at the Estonian Agricultural University the trial work with lowbush blueberry began in 1999 to investigate the effects of fertilizers and elemental sulfur on soil pH. The aim of the research was to find out weather the suggested doses of fertilizers are sufficient to ensure necessary pH value for blueberry in the soil. Experimental fields were situated in different soils. Sulphur and mineral fertilizers ammonium sulfate + potassium sulfate + superphosphate were used in both fields. In one field complex fertilizers Kemira Cropcare 2-11-22 and Kemira Cropcare 6-14-23 were also used. Fertilizers were used according to the content of nutrients in the soil.

The results of the research showed that for changing soil pH from pH_{KCl} 6.0 to the suitable one for blueberry (below 5.5), it takes two years if using sulphur + fertilizers and it takes three years if to use only fertilizers. The results from second experimental field showed that if the pH_{KCl} of the soil is 5.5, then the acidity of the soil during two years is significantly changed by acidic mineral fertilizers and complex fertilizer, which has higher nitrogen content. In present experimental conditions there was a weak relation between soil pH and content of nutrients in blueberry leaves. Using sulfur and fertilizers influenced the growth of the plants. According to the research results we may say that concerning prevalent soils in Estonia the suggested doses of fertilizers for blueberry are sufficient to ensure necessary pH value in the soil.

Introduction

Lowbush blueberry (*Vaccinium angustifolium* Ait.) is a low-growing plant, 35 cm has been measured to be the height of the plant in natural habitats. Natural growing area for lowbush blueberry is situated in north-east of North America (Vander Kloet, 1988). Growing as half-cultivated plants together with other blueberry species *Vaccinium angustifolium* forms considerable amount of berry production in USA and Canada (Eck, 1989; Sibley, 1994).

The success of blueberry growing is greatly dependent on soil conditions. Most suitable soils are mentioned to be well aerated sandy-clay soils, which would be rich in organic matter and with light texture. The most important factor is considered to be the reaction of the soil; optimum is pH_{KCl} 4.5…5.5 (Vander Kloet, 1988; Paasisalo et al., 1994). In production fields with mineral soils sulfur is widely used to change soil's acidity in USA and Canada (Spiers, Braswell 1992). Soil's pH and texture should be taken into consideration when finding suitable amounts of sulfur (Hanson, Hancock, 1996).

Blueberry plants are very sensitive to excessive fertilization, but in production conditions optimal fertilization is needed in order to gain higher yields. If the soil pH is somewhat high (above 5.0), ammonium sulfate is the best fertilizer. Ammonium sulfate is acidy ant it tends to decrease soil pH (Hanson, Hancock, 1996; Lehmushovi et al., 2000).

The experimental work with blueberries in the Department of Horticulture at the Estonian Agricultural University began in 1997. Experiments have shown, that due to good winter-resistance species of lowbush and half-highbush blueberry could be perspective berry – cultures in Estonia (Starast et al., 1999; Karp et al., 2000). At the same time there is a lack of soils in Estonia, which would have suitable Ph. The aims of the present research were to find out:

- weather the suggested fertilizers and their doses are sufficient to ensure necessary pH value for blueberry growing;
- how fast the influence of mineral fertilizers and sulfur appears;
- the influence of mineral fertilizers and sulfur on vegetative growth of lowbush blueberry.

Material and methods

The blueberry experiment were carried out in Tartu County, South Estonia (hereafter Tartu experiment) and in island Saaremaa, West Estonia (hereafter Saaremaa experiment). Trial fields were established with one-year old lowbush blueberry (*Vaccinium angustifolium*

Ait.) seedlings in 1999. The gap between the plants was 0.8 m and the space between two rows was 1.0 m. Soil elemental contents was analyzed before plantation in 1999 (table 1).

Table 1. Soil elemental content in Taru and Saaremaa trials before plantation in 1999.

Location, year, treatment	pH_{KCl}	P mg/kg	K mg/kg	Ca mg/kg	Mg mg/kg	% Org. matter
Island Saaremaa	6,0	8	0	1300	280	2,6
Tartu County	5,9	176	288	1706	110	4,7

Variants of fertilization in Tartu experiment:

1. without sulphur and fertilizers (control);
2. ammonium sulfate 5 g/m^2 + potassium sulfate 10 g/m^2+ superphosphate 17 g/m^2;
3. Sulphur 100g/m^2;
4. Sulphur 100g/m^2 + ammonium sulfate 5 g/m^2 + potassium sulfate 10 g/m^2+ superphosphate 17 g/m^2
5. Sulphur 100g/m^2 + complex fertilizer (N-11%; P-5%; K-18% + microelements) 20 g/m^2.

Referred fertilization scheme was used in spring 2000. In spring 2001 only ammonium sulfate was used with dose 12 g/m^2 in variants, where ammonium sulfate was also used in last year (variants 2 and 4). In 2002 fertilizers were not used, because soil analysis showed that P and K levels in the soil were high.

Variants of fertilization in Saaremaa experiment:

1. without sulphur and fertilizers (control)
2. ammonium sulfate 12 g/m^2 + potassium sulfate 15 g/m^2+ superphosphate 20 g/ m^2
3. Kemira Cropcare 2-11-22 - (N 2%, P 5%, K 18%, + microelements) 20 g/m^2
4. Kemira Cropcare 6-14-23 - (N6%, P 6%, K 19%, + microelements) 20 g/m^2
5. Sulphur 100g/m^2
6. Sulphur 100g/m^2 + ammonium sulfate 12 g/m^2 + potassium sulfate 15 g/m^2+ superphosphate 20 g/ m^2
7. Sulphur 100g/m^{2}S+Kemira Cropcare 2-11-22 20 g/m^2
8. Sulphur 100g/m^{2}S+Kemira Cropcare 6-14-23 20 g/m^2

According to previous variants fertilization was carried out in spring 2001 and 2002.

Powdery elemental sulphur (S 100%) was used in the experiments. The doses of fertilizers were estimated using suggested amounts given by Finnish scientists Lehmuhovi et al. (1999) and Paasisalo (1994) , and for doses of sulphur amounts suggested by Hanson and

Hancock (1996) according to soil's texture, acidity and content of nutrients. pH_{KCl} of the soil samples, from the depth of 0-20 cm was measured with Evikon pH Meter E 6115 in September 2002.

In the autumn (2002), height of blueberry plants was measured and number of long shoots (longer than 15 cm) was counted.

The nutrient content of blueberry leaves was measured at the beginning of harvesting period (August 2002) using N- tester Spad 400, Minolta.

Data were analyzed by ANOVA table and regression analyze. Significant (LSD 95%) differences from the control were marked by asterisk (*) in figures.

Results

At the time of planting the average pH_{KCl} of the soil in the experimental area in Tartu was 6.0 and it did not change significantly during first summer after fertilization (Fig. 1). By autumn in the second year (2001) the reaction of the soil had significantly changed in variants, where sulphur was used together with acidic or complex fertilizers (variants 4 and 5). Sulphur powder without fertilizers had no effect.

The influence of sulphur appeared in third year. The reaction of the soil had raised to the level which was appropriate for blueberries in variants where sulphur and fertilizers together with sulphur was used (variants 3,4,5).

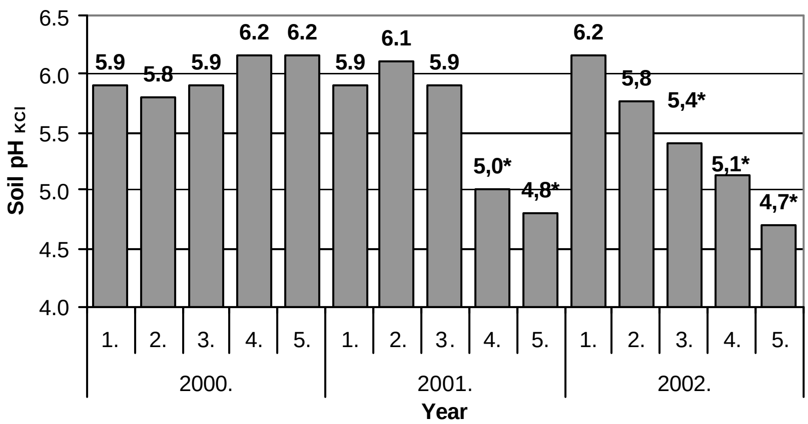

Figure 1. pH_{KCL} of the soil depending on fertilization in spring 2000 in Tartu experiment.

1- Control; 2- Ammonium sulfate + potassium sulfate + superphosphate; 3- Sulfur;

4- Sulfur + complete fertilizer; 5- sulfur + ammonium sulfate + potassium sulfate + superphosphate

*significant difference 95%

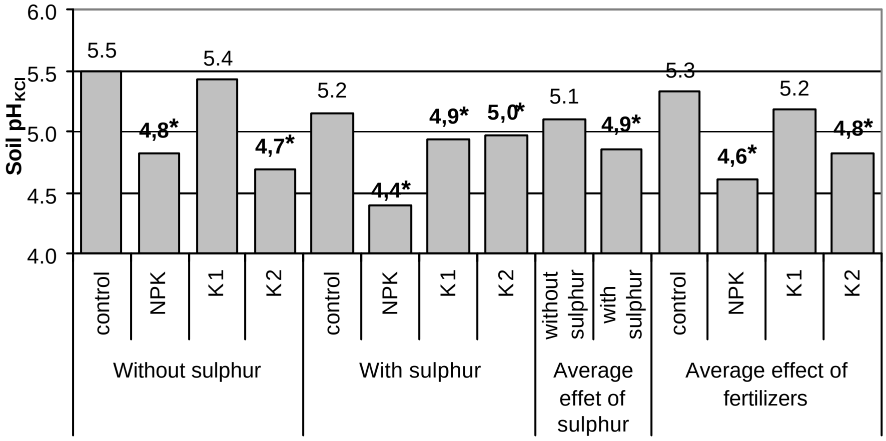

Figure 2. pH_{KCL} of the soil depending on fertilization in spring 2002 in Saaremaa experiment.
NPK - ammonium sulfate + potassium sulfate+ superphosphate; K1 - Kemira Cropcare 2-11-22; K2 - Kemira Cropcare 6-14-23
*significant difference 95%

The acidity of the soil in Saaremaa before establishing plantation was pH_{KCl} 5.9 (Table 1). pH_{KCl} was a bit lower than in Tartu, but still remained outside the recommended values for blueberries. In this experiment significant influence of sulphur and fertilization appeared already in second year after fertilization (Fig. 2). In 2002 the reaction of the soil had significantly changed as a result of acidic fertilizers and Kemira Cropcare 6-14-23, which is richer in nitrogen. The average effect of these fertilizers was also significant. Together with sulphur another complex fertilizer also had significant effect. As an average of the experiment, the acidity of the soil in variant without sulphur was 5.1, in variant with sulfur the soil was more acidic, having pH_{KCl} value 4.9.

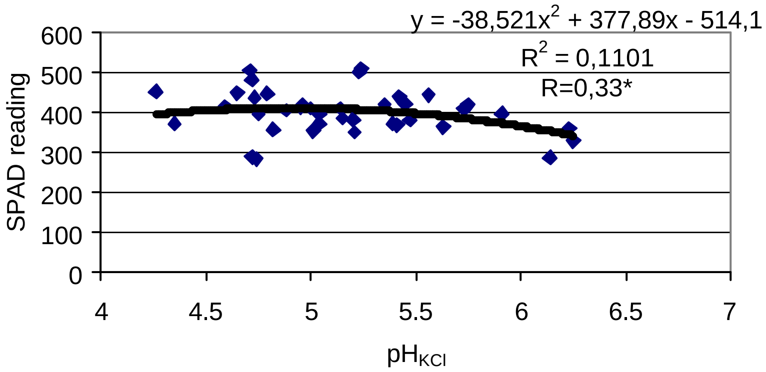

Figure 3. Nutrient content of blueberry leaves depending on soil's pH_{KCl} value in August 2002.

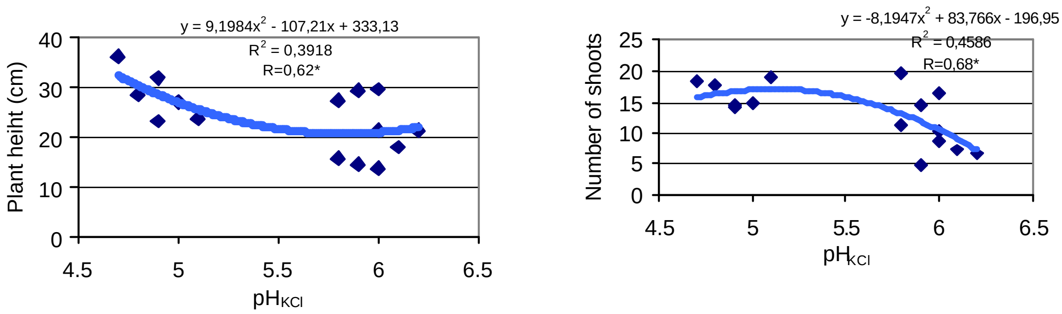

Figure 4. Growth of blueberry plants depending on soil's pH_{KCl} value in 2002.

The influence of soil reaction on assimilation of nutrients by blueberry plants was relatively low, only 11% (Figure 3). In our experiment there was a weak relationship between pH of the soil and nutrient content of blueberry leaves, which indicates that assimilation of nutrients by the plants is influenced by soil acidity, but not much. At the same time relationship between growth of the plants and reaction of the soil was stronger (Figure 4). Thus we may conclude that in given pH interval plants do not suffer from lack of nutrients, but growth of the plants is better with more acidic soil, which also has been fertilized.

Discussion

Plantation of lowbush blueberry will give yield 3…4 years after establishing. During first growing years it is important to create optimal conditions for vegetative growth of plants to ensure high yield in future. The reaction of the soil is considered to be very important. Optimal acidity for growing media of blueberries is found to be pH_{KCl} 4.5…5.5 (Vander Kloet, 1988; Paasisalo et al., 1994). Spiers (1984) made experiments with rabbitey blueberry and claimed pH 3.9…6.1 to be the best for ensuring good growth and high yield. To regulate acidity of the soil, sulphur or physiologically acidic fertilizers are recommended (Hanson, Hancock, 1996). Spiers and Braswell (1992) have explained that in soils with low acidity using acidic fertilizers is not enough to reach the desired pH value. In present experiments added sulphur did not change the reaction of the soil in first year after fertilization. Elemental sulphur dissolves poorly in the water and therefore its effect appears slowly. Hanson and Hancock (1996) have also mentioned in their work that sulphur needs time to have an effect and therefore they recommend to give sulphur the year before establishing blueberry plantation. The influence of sulphur and fertilizers in current experiment appeared in second and third year.

The results of the research showed also that after establishing blueberry plantation, ammonium sulfate + potassium sulfate + superphosphate or Kemira Cropcare 6-14-23 are suitable for changing soil's pH. High amounts of fertilizers are not needed, doses which are worked out and recommended by Finnish scientists, are sufficient for blueberries in Estonia. Fertilization after establishing the plantation increases growth of blueberry plants and thus creates good preconditions for gaining high yields.

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