DETERMINATION OF NITROGEN EFFICIENCY BY HALF-HIGH BLUEBERRY CULTIVAR 'CHIPPEWA'

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Abstract. *Nitrogen management is quite complicated due to it mobility, transformations, vegetative growth and reproductive development, berry biochemical content etc. The nitrogen management for blueberries was chosen as a main topic for experiment set up in Valmiera district in 2012 where plantation was established 2 years ago. Experimental plots with blueberry cultivar 'Chippewa' were arranged on gently slope. Original topsoil's reaction was pH KCl 6.41, organic matter content 20 g kg^{-1}. Five experimental plots each of them consisting from 8 bushes was set up. Soil reaction was determined potentiometrically, organic matter in mineral soil according to the Tyurin's method, in organic materials – by dry combustion, total nitrogen using Kjeldahl method. Samples of leaves from each experimental plot were taken during the vegetation for NPK and Fe, Mn, B nutrition diagnosis. Research showed that different nitrogen fertiliser applications significantly influenced Mn concentration in the leaves; however the impact on yield was not significant.*

Key words: *fertilisation, nitrogen forms, blueberry cultivation, soil properties.*

INTRODUCTION

Mineral nutrition studies for high-bush blueberries in Latvia are at a very early stage. In our country, high-bush blueberries are grown in acidic mineral soils and peat bogs. Blueberries are grown in many regions around the world using differently modified soils, having different texture, pH, organic matter content and other soil properties. Therefore, we are not able to use the exact North American fertiliser technology recommendations for all blueberry plants because soil and climate conditions differ significantly. Therefore it is very important to make intensive regional and also local scientific research on blueberry soil and climate requirements, as well as on fertilisation technology [1].

Until now, in Latvia there are very few publications about the influence of nitrogen fertilisation on blueberry growth and development. Therefore, the aim of the current research was to compare the growing rates of nitrogen fertilisers on productivity of blueberries, as well as chemical composition of berries and plant leaves.

MATERIALS AND METHODS

The site and soil characteristics

The research was carried out in a highbush blueberry plantation (established on a 10% north–south slope in 2010) at the farm Abullaci, Valmiera district in 2012-2014. Predominant soil – Endoabruptic Luvisol (Amphisiltic, Aric, Cutanic) (World Reference Base for soil Resources, 2014), fine sandy loam/very fine sandy loam, developed on moraine [2],[3]. The original topsoil reaction – pH H_2O 6.96 and pH KCl 6.41; organic matter content – 20 g kg^{-1}. Before establishing the plantation, substantial improvement (change) of soil properties was done. In 2010, the bushes were planted in rows, deep cultivated, and mixed with acid (pH KCl 3.0±0.3) sphagnum peat. Each year, the same kind of peat was used as a mulch to cover a 5 cm layer on the soil surface between the bushes. During summer, 0.8 m wide strips along the bushes were kept free from vegetation, but grasses were sown and periodically mown in interrow spaces. The experiment layout consisted from five treatments in four replications. Plots were located in different positions on slope, representing one cultivar of highbush blueberries. Each plot consisted of eight fully developed bushes arranged in one row.

In October – November 2012-2014, soil sampling was done in each plot and at two depths: 0-20 cm, 20-40 cm. The following analytical methods were used: pH – potentiometrically in a 1*M* KCl suspension; organic matter for mineral part of soil – using Tyurin's method, for organic part of soil – by dry combustion; total nitrogen – by Kjeldahl method; plant available phosphorus and potassium for mineral part of soil – by Egner–

Riehm method; for organic part of soil – total concentration after ashing of sample. Two modifications for organic matter and PK analysis were used because soil was conditioned by peat and some part of rows under bushes dominated by mineral soil, another – by organic soil.

Plant material

Plant leaf samples were collected from each plot two times per season: on early July – from previous-year shoots, and on late July – from the new shoots. Samples of the most recently fully expanded leaves that were free from disease or other damages were collected, and each sample consisted of 10 leaves from each of the eight plants. Total nitrogen was determined using Kjeldahl method; total phosphorus and potassium were analyzed after ashing – colorimetrically and by flame photometry respectively. The levels of iron and manganese were estimated by atomic absorption spectrophotometer (Perkin Elmer AAnalyst 700, acetylene-air flame), boron was analyzed colorimetrically by hinalizarine in sulphuric acid medium.

Berries material

Nitrate content was determinated using GOST method 29270-95 p.5 in the Institute of Food Safety, Animal Health and Environment "BIOR".

RESULTS AND DISCUSSION

Productivity of blueberries

The measurements of blueberry yield in experimental plots were started in 2013. The first commercial yield in the plantings where experiment was established was obtained in 2012. The average yield of cultivar 'Chippewa' grown in Latvia in 2008-2012 was around 7-11 t ha^{-1} annually. Nitrogen fertilisation influenced berry yield and data for 2013 and 2014 is shown in Figure 1.

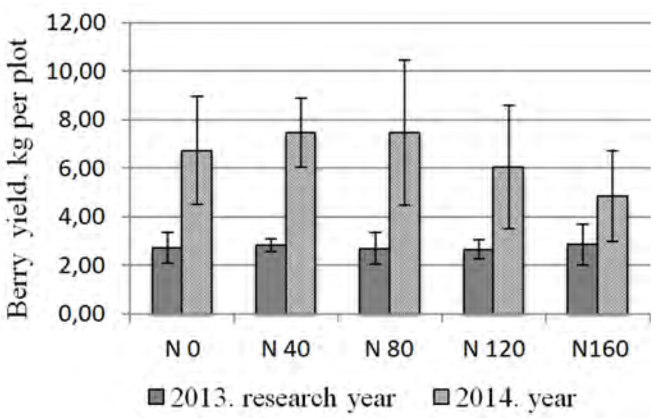

Fig. 1. **Productivity of blueberries in experimental plots in 2013 and 2014.**

There was small yield difference among treatments in 2013, because experiments with fertiliser application were started recently – in 2012. The next year harvest showed more marked variations; although these were no significant in terms of experimental statistics, they indicated only some trend. Here N 80 kg ha^{-1} was more effective for berry production but increased rates of applied nitrogen resulted in yield decrease.

N–NO$_3$ in blueberries

Some restrictions are set up for nitrogen application for field and horticultural crops in Latvia. For example, for small berries the maximum annual amount of nitrogen application shall not exceed 130 kg ha^{-1} N. If plantation is established in organic soils – even les. Limitation of nitrogen use is set up due for two reasons – food safety and environmental risk reduction. Therefore some control measures was performed to verify abovementioned risks. Nitrate concentration in berries was tested in the treatment where the highest nitrogen rate – 160 kg ha^{-1} N was used. Analytical results affirmed that N–NO$_3$ concentration not exceed 36 mg kg^{-1} in all replicates that is acceptable for the use of berries for fresh consumption or for processing.

Plant nutrient uptake

Many authors caring out experiments with blueberry fertilisation concluded that this crop does not tolerate high salt concentration in growth media. Over fertilisation can result even in plant's death [4]. This is one of the reasons why fertigation is widely used – systematic supply of nutrients in small concentrations. Using this method variability of nitrogen supply might be performed depending on crop conditions. If the plant grows and develops well, nitrogen application can be reduced or stopped. This will provide the reasonable use of fertiliser resources, to avoid the potential risk of nutrient leaching and also to provide the high yield potential with good quality of berries. As author's shows, special attention should be paid on nitrogen optimization [5],[6].

Some methods should be developed for quick monitoring of plant nutrient supply in crops. Plant nutrient concentration in leaves (or in new shoots) could be the reasonable parameter for plant nutrition diagnosis. Therefore concentration of total nitrogen, phosphorous, potassium as well as iron, manganese and boron were tested in the blueberry leaves in 2014 (Fig 2 and Fig. 3).

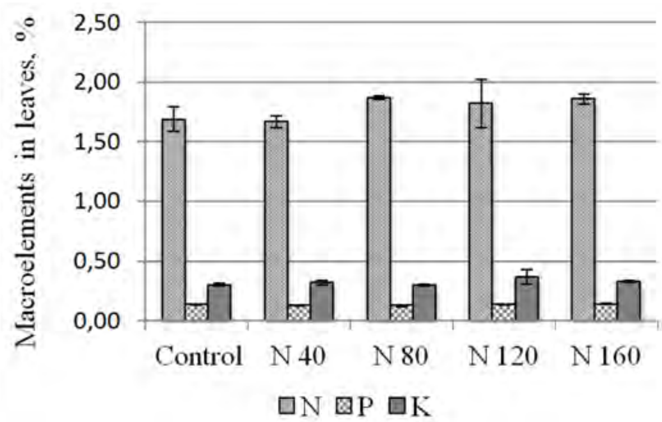

Fig. 2. **NPK concentration in blueberry leaves (dry matter, %).**

There were small differences among the treatments in NPK concentrations in blueberry leaves. Using such data it is not possible to monitor the plant nutrient status in crops. Literature data reports the following reference values for vegetative parts of blueberries: 1.7-2.0% of N, 0.2-0.3% of P, and 0.45-0.7% of K [7],[8]. Compared with that, the nitrogen supply in experimental plants was 1.6-2.05%, phosphorus 0.12-0.14% but potassium 0.29-0.44%.

Generally, in leaves samples the concentration of iron and boron were optimal but manganese was high (Fig. 3).

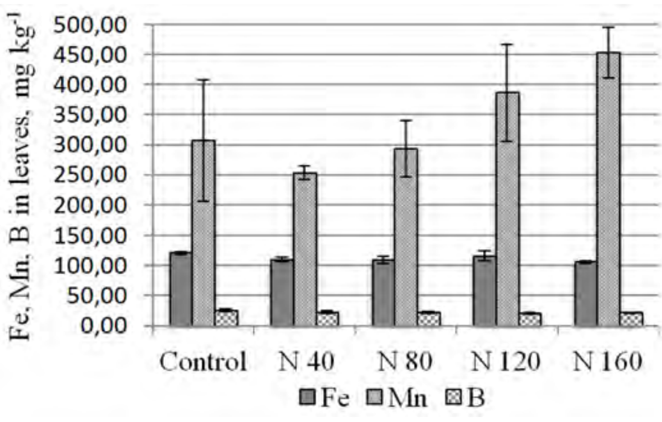

Fig. 3. **Fe, Mn and B concentration in blueberry leaves (dry matter, mg kg^{-1}).**

It is reported that the optimal level of manganese in leaves for blueberry growth is 40-100 mg kg^{-1}. Also data are found that toxic influence of manganese for blueberries occurs when Mn concentration in leaves exceeds 450 mg kg^{-1} [7],[8].

In Latvia the nitrogen deficiency for blueberry plantations is reported in both: cultivating crops in mineral soils and in peatlands. It was confirmed by collecting of leaf examples from commercial plantations and concluded that insufficient N supply may be one of the major factors limiting blueberry yield. In this research done in 2007-2009 was found the plant nutrient scarcity in blueberry plantations. The main problems were the deficiency of N and B, as well as the abundance of Mn. These results indicated that only 39% of all soil parameters in blueberry plantations in Latvian were in the optimal level. It should be noted that the lowest macro- and micronutrient concentrations of blueberry plantation in the soil was comparable to the concentration of nutrients in poor forest soils, thereby pointing to the deficiency of the fertiliser use. Such scarcity could heavily reduce the blueberry yield in Latvia. Although high-bush blueberries like wild blueberries can be considered as typical calcifuges plants as they grow well in nutrient poor soils with low pH, wild blueberries had particularly high K, Fe and Mn intake efficiency and accumulation in leaves. This phenomenon can be seen as a wild plant potential physiological adaptation mechanism in arid soils. However, this mechanism does not exist for cultivated blueberries [1].

Soil properties

Many abiotic factors have a significant impact on blueberry yield including soil properties and soil management [9]. In experimental site soil investigation (morphological observations, sampling) showed that soil cover was not homogenous. In this case soil under bushes originally was (and still is) a typical mineral soil. Soil developed on moraine originally was slightly acid and therefore before planting of blueberries was modified by deep ploughing and peat additions. As the peat mineralisation occurs, every second or third year new peat additions are done. Therefore soil conditions within the plantations are rather heterogeneous – low density, high organic matter and acid soil in strips with bushes and unchanged typical mineral soil between rows. This situation has some priorities, because bushes can utilise plant nutrients found in moraine subsoil which chemically are more rich compared with conditions when blueberries are grown in peatlands.

CONCLUSIONS

Our study is being developed and based on already obtained data we can concluded that productivity of blueberry cultivar ‘Chippewa’ in the first years after using a certain scheme of fertilization (control and low nitrogen norms) is only insignificatly lower. The highest yield was obtained using treatment N 80. Further increase of nitrogen fertilizer did not resulted in the desired results, on the contrary yield reduction was observed (N 120 and N 160).

It is possible that selecting a different cultivar, could cause significant decreases in yield. In our study, chosen cultivar has been established as an interspecific hybrid (*Vaccinium corymbosum* x *V. angustifolim*). It adapts quite well and it is able to produce yield in a certain period of time even without nitrogen fertilizer.

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