EFFICIENCY OF PHOSPHOROUS AND POTASSIUM FERTILIZERS IN SEA BUCKTHORN CULTIVATING

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ABSTRACT. Efficiency of phosphorous and potassium fertilizers in sea buckthorn cultivating. *At the Polli Horticultural Institute in South-Estonia an experiment was established in 2000 on light-texture loam soil, pH 5.7, with 95 mg phosphorous, 139 mg potassium, 933 mg calcium and 69 mg magnesium per kg/soil. Control variant was left without fertilizing. P and K were used pre-planting (ploughing depth) fertilizers for stockpile (P_2O_5 and K_2O, both 500 kg/ha). In the following four variants the fertilizers were given in early spring, after one year on the grass surface: P_2O_5 and K_2O, both 200 kg/ha, P_2O_5 and K_2O, both 100 kg/ha, P_2O_5 – 200 kg/ha, and K_2O – 200 kg/ha. This is the first experiment in sea buckthorn fertilizing in Estonia. The growth of trees was not affected when the trees were fertilized with PK. However, the yield of fruits (botanically small juicy stone fruits, like berries) was 30% smaller when PK was used as stock-fertilizer or given in every second year P_2O_5 and K_2O both 200 kg/ha. The conclusion is that PK fertilizing is not needed in fertile soils. Sea buckthorn can be cultivated in moved grass land.*

Keywords: Hippophäe rhamnoides*, PK-fertilizers, growth, yield.*

Introduction

Sea buckthorn (*Hippophäe rhamnoides)* with its valuable and widespread medicative fruits has claimed for long time in Eurasia and in America. The wild species of sea buckthorn have slender need for soil nutrients, but they like moisture and light. They adapt easily to extream conditions (Luetjohann, 2001). There are different opinions on the demands of the crop. It is thought, that sea buckthorn's need towards nutrients, especially phosphorus, is even more fastidious than other fruit cultures have (Bukštoenov *et al*., 1978). It is a wind pollinating plant with male and female flowers on separate trees. Flowers are without petals and are rarely noticeable. Roots are fragile and equipped with nitrogen assimilating rootknobs. Horizontal roots of sea buckthorn are mostly 30 cm below the surface, but some roots are very close to surface. Scientists are on consensus, that sea buckthorn prefers light air-rich soil, which is probably needed for better nitrogen assimilation in rootknobs, where actinomycetales reside. Most of the scientists are in position, that thanks to nitrogen use from air, sea buckthorn does not need nitrogen fertilizer. However, it is still recommended to young plants as a start-fertilizer. More problematic is sea buckthorn's need for phosphorous and potassium fertilizer. As mentioned, sea buckthorn thrives better on light soil, which has usually less nutrients than heavy clay soil. Therefore we can assume that sea buckthorn needs phosphorous and potassium fertilizers, but the need towards fertilizer depends on soils natural fertility.

In Estonia, widespread plantations have been built in past ten years, but cultivation technology in local circumstances has not been researched so far.

The goal of this study was to examine the effect of phosphorous and potassium fertilizers on sea buckthorn's growth and yield, when grown on medium fertile loam and to give an evaluation on cultivation technology used.

This investigation includes the results of the first five year, where phosphorous and potassium fertilizers effect on young sea buckthorn plants' growth dynamics and crop formation, until trees reach their full age, are evalued.

Material and methods

Experimental plantation of the sea buckthorn to study PK-fertilizer effect was established at the Polli Horticultural Institute in spring, 2000. soil was light-texture sandy loam. The cultivar was 'Botanicheskaya'. 50–70 cm high one year old plants were planted 4×2 m apart, into little 25 cm deep planting holes on farmed soil. For 6 female plants, 1 male plant was planted. Male plants were planted to east-west directed row ends and in the middle. Experimental trees were planted over the rows, fertilization variants were isolated from each another with defensive rows, which were not fertilized. Before planting the trees, the only fertilized variant was pre-planting-stock-fertilizers variant. Experiment was carried out according to the scheme:

1. unfertilized (control)
2. P_2O_5 500 + K_2O 500, as pre-planting-stock-fertilizer

3. P_2O_5 200 + K_2O 200
4. P_2O_5 500 + K_2O 100
5. P_2O_5 200
6. K_2O 200

Fertilizers in variants 3–6 were given in early spring 2001 and 2003 onto the grass surface. The experiment was repeated in triplets, 3 plants in every test plot. In every autumn the trunk diameter was measured at 20 cm from the ground, also tree height, and crown diameter were measured. From the measurement results the trees yearly growth was estimated and their measures in the end of experiment leg. The credibility of test results was assessed with dispersion analysis: with 95% substantial differences.

In the year of plantation the test-plantations were cultivated in spring 2001, the mix of species *Festuca pratensis*, *Festuca rubra*, *Lolium perenne*, *Poa pratensis* was sown. Rowgaps were mowed 2–3 times in month, in rowgaps tractor-mower and in tree rows lawn-mower were used. Trees were designed with one trunk (height ca 40 cm). Crown of trees was not pruned, only broken and dryed branches were cut off.

The weather conditions were different in the test period. Local look-out data showed that precipitation amount and mean air temperature in four years of experiment in vegetation period were similar to district's mean data. 2002 summer was droughty, especially poor of rain were May and August.

Results and discussion

Before the experiment, the unfertilized soil contained 1.6% of humus and pH = 5.7, with the content of 95 mg phosphorus, 139 mg potassium, 933 mg calcium, and 69 mg magnesium per kg of soil. Inserting to the soil the pre-planting stock-fertilizer P_2O_5 500 + K_2O 500 caused the content of phosphorus (P) rise to 114 mg and potassium (K) to 213 mg per 1 kg of soil. There is little information about the optimal content of P and K, that should be used to grow sea buckthorn. According to Russian scientists (Gatin, 1963, Bukstoenov *et al.*, 1978), for the normal growth of sea buckthorn, the soil should contain at least 87 mg of P per 1 kg of soil. References to the optimal K content in soil to grow sea buckthorn could not be found. German scientists (Kramer *et al.*, 1973) claim, that for fruit trees the optimal soil content of P = 30–65 mg/kg and K = 83–125 mg/kg, when grown on light soil. Switzerland's scientists (Heller *et al.*, 1993) say, that for apple trees grown on medium weight soil, the sufficient P = 40–80 mg/kg and K = 120–200 mg/kg. When taking these data into account we can say that the unfertilized soil's P and K content is optimal or even higher than optimal, but for stock-fertilized soil they are high. In spring 2000, the planted one-year-old sea buckthorn plants rooted well and their growth was moderate. In autumn the height of unfertilized trees was 111 cm and trunk diameter was 1.5 cm, for fertilized trees the height was 94–123 cm and trunk diameter was 1.1–1.5 cm. Intensive growth took place one year after the plantation, when the height of trees increased 84–96 cm and trunk diameter gained 1.0–1.5 cm. Fertilizing did not seem to have an effect on height of trees, but trunk diameter did increase periodically more for fertilized trees compared to unfertilized trees (Table 1).

Table 1. Growth of sea buckthorn plants, cultivar 'Botanicheskaya', in the experiment of PK-fertilizing

Variant	Trunk diameter, autumn 2000 cm	Yearly increase of trunk diameter, cm				Height of trees, autumn 2000, cm	Yearly increase of tree height, cm			
		2001	2002	2003	2004		2001	2002	2003	2004
Nonfertilized (control)	15	1.1	1.0	1.6	0.8	111	84	32	31	32
$P_2O_5$500+K_2O500 as stockfertilizers	1.5	1.0	0.9	1.2*	0.8	123	84	34	58*	27
$P_2O_5$200+K_2O200	1.5	1.4*	1.1	1.5	1.1*	114	86	28	37	36
$P_2O_5$100+K_2O100	1.4	1.4*	1.1	1.7	0.9	107	96*	26	29	31
$P_2O_5$200	1.4	1.5*	0.8	1.6	0.9	103	87	26	31	53
K_2O200	1.1	1.4*	0.8	1.8	1.2*	94	86	10*	52	52
PD 95%		0.23	0.21	0.15	0.22		10.3	19.4	19.1	29.4

Following year's vegetation period was arid. The speed of growth declined, due to unsufficient moisture in soil, also due to beginning of fruit bearing. Growth in height decreased dramatically. Since 2002 the growth in height of unfertilized trees was stabile: 31–32 cm/year, fertilized trees showed less stability: 10–58 cm/year. The trunk diameter increase was not very much affected by fertilization. The beginning of fruit bearing and weather conditions had only little influence on the growth differences. Abundant yield' of berries in 2004 probably affected the increase of trunk diameter. The fastest increase of diameter (1.2–1.8 cm) was in 2003, when the precipitations in growth period was homogeneous and sufficient for the normal growth of sea buckthorn. Fertilization did not have any specific effect on the increase of trunk diameter. In autumn on the fifth growth year, the unfertilized trees were 2.9 m high with 6.0 cm trunk diameter (Table 2). The fertilized trees were alike, not depending on ways of fertilizing or combination of fertilizers. Only crown of trees was wider and also volume of crown in the variant of P_2O_5 200 + K_2O 200.

Results show, that P and K fertilizers on the middle fertile soil don't affect substantially the growth of young sea buckthorn trees. The growth is more affected by weather, especially by precipitation on vegetation period.

After the third year of plantation the tree started to bear fruit. On the third and fourth years the yield was relatively small (1.0–4.7 kg per tree), but on the fifth year it was bigger (14.6–22.4 kg per tree), from what we can ensue that sea buckthorn reached its full age of fruit bearing on the fifth year after planting. The yields of fertilized and unfertilized trees differed on the fifth year, which was reflected in the sum of yield 2002–2004 also (Table 2). The three year summarized yield of unfertilized trees was 28.0 kg, where 2004 year's yield was 22.4 kg. Similar yields where observed with those fertilization variants, where PK fertilizers were given over the year P_2O_5 500 + K_2O 100 or separately P_2O_5 200 + K_2O 200. The yield in variants with bigger amounts PK fertilizers was ca 30% smaller compared to unfertilized trees. It can be concluded (from the result of the first stage of experiment) that sea buckthorn, grown on the middle productive soil, does not need PK fertilizers at least until reaching full age of crop bearing. Thus, sea buckthorn could be grown as organic gardening crop.

From the experience of the maintenance of plantation, it can be claimed that sea buckthorn grows well on grass sod. Mowing grass does not damage the horizontal roots, and root runners are cut away. Crop gathering conditions are far more better on grass sod compared to muddy soil.

Table 2. Measurements of the trees (cultivar 'Botanicheskaya') in the 5th year and yield 2002–2004

Variant	Trunk diameter, cm	Tree height, m	Crown width, m	Crown volume, m^3	Yield (kg) per tree 2002	2003	2004	Kokku 2002–2004
Nonfertilized (control)	6.0	2.9	1.9	4.7	3.0	2.6	22.4	28.0
$P_2O_5$500+K_2O500 as stockfertilizers	5.2	2.7	1.8	4.0	2.5	2.9	14.6*	20.0*
$P_2O_5$200+K_2O200	6.4	2.9	2.2	6.5*	3.0	1.7	14.7*	19.4*
$P_2O_5$100+K_2O100	6.3	2.9	2.0	5.2	3.9	3.7	19.0	26.6
$P_2O_5$200	6.0	2.9	1.9	4.9	4.7	2.9	21.8	29.4
K_2O200	6.2	2.9	2.0	5.4	3.7	1.0	22.0	26.7
PD 95%	0.88	0.29	0.31	1.77	2.51	1.64	5.70	7.62

The competition for moisture and nutrients in soil between grass and sea buckthorn can be minimized by frequent mowing of grass. The biggest drawback is the thickening of soil, which leads to poorer aeration, but it is not enough to disturb the growth and yield of sea buckthorn. Sea buckthorn grows satisfactorily in natural areas and bears fruit without fertilization or cultivation. It is important to choose the right place for plantation. Light sandy soils are with good aeration, but relatively poor in nutrients and affectable by drought. Heavier clay soil has more nutrients and can hold water, but it is with poor aeration and is unappropriate. Therefore it should be recommended to use nutrient rich claysand or light sandclay soil, which have good balance in moisture, air and nutrient regimes for establishing plantation of sea buckthorn. The need for nitrogen is ensured by air nitrogen and no N fertilization is needed (Trofimov, 1970; Tjurikov, 1988; Luetjohann, 2000; Fischer, Albrecht, 2002). Nutrient rich heavy and thick clay soil does not suit for sea buckthorn, because trees tend to die (Pantelejeva, 1970) or grow slow to short age (Trofimov, 1970). Fertilizing on heavy clay soil does not give good result also (Mochalov, 1973). Sea buckthorn can grow on clay soil on the banks and close to sea (Bukstoenov *et al.*, 1978). The main limiting factor on sea buckthorn growth is aeration of soil and N feeding of trees.

In literature it has been reported that sea buckthorn grows best between pH = 6.0–7.0, but as seen, it succeeds quite well on soil which pH is 5.7. The pH is not the dictating factor when growing sea buckthorn (Li, 2002).

The need for PK fertilizers depends on soil's natural fertility, conducted experiments show that relative need for phosphorus is bigger (Gatin, 1963; Bukstoenov *et al.*, 1978; Li, 2002) and positive effect with P fertilizers has been gained on nutrient poor soils (Singh, 2003). When soil is sufficiently fertile, then PK fertilizers don't have a positive effect, in many cases their effect has been little or short termed even on nutrient poor clay soil.

Better results have been gained with organic fertilizers, especially when using it together with mineral fertilizers (Gatin, 1963; Mochalov, 1973; Bukstoenov *et al.*, 1978). As well as degrading organical fertilizers and nutrients unleashed, the soil got air rich, which is vital to sea buckthorn.

Summary and conclusions

In the Polli Horticultural Institute the experiment with sea buckthorn was established on light-texture sandy loam. From the first five year of the experiment it was clear that on middle weight soil, which contained 95 mg/kg P and 139 mg/kg K, there is no need for PK fertilizers. In five years the trees grew 2.9 m high, with the trunk diameter of 6.0 cm. Trees started to bear fruit on the third year after the plantation, on the fifth year the yield per tree was 22.4 kg and summarized yield for three years was 28.0 kg. The growth into height (84 cm/year) was fastest on the year after the plantation and then it decreased and was stabile (31–32 cm per year). The trunk diameter increased 0.8–1.6 cm per year. It was more intensive in warmer and rich of precipitations years. PK fertilizers induced the increase of trunk diameter only after the planting year. In general they didn't affect the increase of trunk diameter and growth in height. Trees with strong fertilization (P_2O_5 200 + K_2O 200) that had somewhat wider crown, had also a larger volume of crown. On that fertilization and pre-planting stockfertilizer backdrop, the yield was 30% smaller than unfertilized trees.

Sea buckthorn grows well and bears fruit on middle fertile soils, which nutrient, moisture and air regimes are well balanced. On these soils PK fertilizers are not needed and sea buckthorn can be grown as organic gardening crop. Due to sea buckthorn's biological peculiarity the grass sod is most fitting for plantation.

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