

Berry Cultivation in Cutover Peatlands in Estonia: Agricultural and Economical Aspects

KAIRE VAHEJÕE¹, TAIRI ALBERT², MERRIT NOORMETS², KADRI KARP², TAIMI PAAL³, MARGE STARAST² AND RANDO VÄRNIK¹

¹Institute of Economics and Social Sciences, Estonian University of Life Sciences, Kreutzwaldi 1, Tartu 51014, Estonia

²Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Kreutzwaldi 1, Tartu 51014, Estonia

³Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Kreutzwaldi 5, Tartu, 51014, Estonia

Vahejõe, K., Albert, T., Noormets, M., Karp, K., Paal, T., Starast, M. and Värnik, R. 2010. Berry Cultivation in Cutover Peatlands in Estonia: Agricultural and Economical Aspects. *Baltic Forestry* 16 (2): 264–272.

Abstract

The aim of the study is to examine if lowbush blueberry (*Vaccinium angustifolium*) cultivation on cutover peatlands is as profitable as half-highbush blueberry (*Vaccinium angustifolium* x *Vaccinium corumbosum*) and strawberry (*Fragaria* x *ananassa*) cultivation on mineral soil. In addition it is examined if, due to land use changes, the abandoned peat excavation areas can be turned into a profitable land resource. Current experiments tested the suitability of a former pine bog area abandoned after peat mining for the cultivation of lowbush blueberry. Wild berry cultivation on those fields is rather a new agricultural branch and growers need efficient producing technologies. As data about the nutrient needs of blueberry on cutover peat fields are still lacking, a fertilizing trial was carried out. In the fertilization study the yield was used as an agrotechnical indicator to evaluate the viability of peat soils usage. A benefit-cost ratio analysis was used to assess the profitability of blueberry cultivation. A questionnaire survey was conducted to gather data on the costs for establishing a plantation, its maintenance, harvesting and marketing costs. It was found that on cutover peat land the fertilized blueberries produced 200 to 535 g berries per plant. The economic analysis showed that the benefit-cost ratio for lowbush blueberry on cutover peat areas was 227 %. The benefit-cost ratio for half-highbush blueberry and strawberry cultivation on the mineral soil was significantly lower at 116% and 43%, respectively. The highest profit came from lowbush blueberry and was 6,299 EUR ha⁻¹, whereas the lowest was for strawberry at 2,117 EUR ha⁻¹ from cultivation on mineral soil. The profit from half-highbush blueberry cultivation on mineral soil was 4,855 EUR ha⁻¹. Finally, it can be concluded that lowbush blueberry cultivation allows to put cutover peat lands into use, and lowbush blueberry production on those areas is economically profitable.

Key words: *Vaccinium angustifolium*, land use, land abandonment, peat mining, fertilization, yield, economic analyses, benefit-cost ratio

Introduction

Estonian economic and agricultural situation has undergone major changes during the last ten to fifteen years. The period from the end of the Soviet regime till Estonian entrance to the European Union in May 2004 can be handled as a process of transition from the liberal economic policy of the 1990s to the EU Common Agricultural Policy (CAP). During these years several peat production companies went bankrupt and ended their activities. At present there are 20,000 ha cutover peat lands that are exploited by 60 different enterprises (Oru and Paal 2007). Ilomets (2003) estimated that the drained peatland areas in Estonia, including bogs, fens and transitional bogs covered a total area of 1,033, 000 ha. The same author reports that about 70% of Estonian peatlands are drained or influenced by drainage to such an extent

that they no longer allow peat accumulation (Ilomets et al. 1995). Damaged by human areas are mostly not rehabilitated and therefore, due to a large carbon store in peat, are converted from a carbon store to a CO₂ emission source. The CAP pre-accession program, SAPARD (Special Accession Program for Agriculture and Rural Development), was launched in Estonia and several subsidies were available for local farmers. Some of these were used for the development and continuation of berry cultivation.

In Estonia, lowbush blueberry is developing into a promising horticultural crop for small berry growers and efforts have been made to maintain lowbush blueberry in the different regions of the country. In 2005 the Estonian Agricultural Registers and Information Board (ARIB) collected more than 66 ha of submitted supports for blueberry plantations, each of which did not exceed an average of 0.8 ha in size. Blueberry

cultivation areas have increased rapidly (Noormets et al. 2003). As in North America, mineral soils as well as poorly decomposed peat soils are used for blueberry cultivation in Estonia. A number of experiments has been conducted to recultivate opencast peat pits with different plant species (Heinsalu et al. 1992). However, neither of them has shown major success over time in terms of profitability returns, due to high water levels, the poorly decomposed uppermost layer and the variable environment of the rhizosphere of peatlands (Tamoshaitiene et al. 1997). One possibility to use such abandoned areas is to recultivate them with species that are stress tolerant and whose natural growth habitat is similar to peatland plants. Therefore, it is reasonable to investigate the possibility of the recultivation of opencast peat pits with acidophilic ericaceous species. Some *Vaccinium* species have previously been used for cultivation on peat soils (Abolins and Gurtaja 2006, Stackevičiene et al. 1997, Noormets et al. 2003, Yakolev 2000).

Lowbush blueberry is a tetraploid, woody perennial plant and its root mass is high, accounting for 80–85% of the total dry mass of the plant (Kloet 1988). The bulk of the root system is located in the upper 10 cm topsoil layer. The organs of sexual reproduction are situated in the top of aerial shoots, which produce numerous pendulous, racemose inflorescences of variable length (Kloet 1988). Individual pendulous flowers are complete and pentacyclic with an urceolate perianth configuration. When fertilization occurs the plant produces true, fleshy berries whose colour ranges from light blue to black. The intensity of the colour depends on the wax layer and the surface colour is related to the quality of the berry (Kalt et al. 1995). The growth habitats of the species are soils poor in mineral nutrients and with a soil pH of 4.5 to 5.5 (Kloet 1988). The growth of both *Vaccinium* species is dependent on native mycorrhiza, which secure plant nutrient uptake (Eccher et al. 2006) that, in its turn, depend on cultural practice (Starast et al. 2006), primary nitrogen, phosphorus (Read and Stribley 1973, Stribley and Read 1974, Read and Kerley 1998) and iron (Mitchell and Read 1981, Shaw et al. 1990).

Based on previously cited literature we claim that it is possible to use the cutover peatlands as berry cultivation. Lowbush blueberry is suitable for this purpose, as it tolerates the specific pedoecological conditions of opencast peat pits. Due to land use changes, the abandoned peat excavation areas can be turned into profitable land resources. This knowledge is especially important for the Baltic States, where plenty of abandoned peat fields are standing for decades without vegetation (Orru and Paal 2007). The task of the current research is to explain fertilizer needs and

cultivating profitability of lowbush blueberry on depleted peat fields. The cost-effectiveness of lowbush blueberry cultivation on Estonian cutover peat areas will be compared to that of half-highbush blueberry and the most popular berry crop, strawberry, in mineral soil.

Materials and methods

Experimental sites and soil conditions

In the current study, the term “peat area” refers to area that was abandoned after peat production without recultivation. The peat field is divided into smaller areas by drainage ditches measuring 1.5 m deep and 300 m long. An average peat field is 20 m x 300 m, with a flat and even surface without natural plant cover.

Experiment I (Exp. I) was conducted during 1999 to 2001 in the southern region of Estonia – in country Tartu (58° 22' N, 26° 43' E), Sapi-Lulli bog. The experimental plantation was established in 1992. The second experiment (Exp. II) was conducted during 2004 to 2006 in the northwestern part of Estonia – in the county Harjumaa (59° 6' N, 25° 22' E) in Ardu bog. The plantation was established in 2000. According to the WRB soil classification, the soil of the both experimental areas belongs to the *Fibri-Dystric Histosol* soils subgroups of.

Experimental set-up

The gap between the rows was 1 m and plant-to-plant spacing was the same. Top dressing was applied only locally around the root system once in early spring every year. Only in Exp. I the influence of a water-soluble foliar fertilizer (N 1.4, Ca 1.8 kg ha⁻¹) in a 0.5% solution was also tested. Lime (CaO + MgO, 67–71%) was used only in Exp. II in early spring in the planting year (2000) at a rate of 100g m⁻². In the control variant, plants did not receive fertilizers. Experimental design was a randomized complete block in 3 replications and 15 plants per plot (21 m²). The amounts of fertilizers are expressed as nutrients applied in kg ha⁻¹ (Table 1).

Sampling and soil chemical analyses

For the current investigation the soil sampling was done in May in 1999 for Exp. I, and in 2004 for Exp. II (Table 2). Soils were described by digging pits and samples for soil analysis were taken from upper peat layer (0–20cm) and air-dried in 3 replications. Dry matter content was determined by drying samples at 105 °C to a constant weight. Soil samples were analysed for organic C according to the Tjurin method (Chemical analysis of soils 1998). For direct estimation of organic matter content the loss-on-ignition (LOI)

Table 1. The used fertilizing treatments on experimental areas on cutover peat land plantations of lowbush blueberry

Experimental area and treatments	Nutrients given per hectare (kg)				
	N	P	K	Ca	Mg
Experiment I (1999–2001)					
Control	-	-	-	-	-
NPK1	0.6	19	46	-	-
NPK1+FF	2	19	46	1.8	-
NPK2	23	29	58	-	-
NPK2+FF	24.4	29	58	1.8	-
FF	1.4	-	-	1.8	-
Experiment II (2004–2006)					
Control	-	-	-	-	-
NPK1	8	20	72	16	10
NPK1+L	8	20	72	16	10
NPK2	6	6	19	4	12
NPK2+L	6	6	19	4	12
NPK3	14	5	21	-	5.6
NPK3+L	14	5	21	-	5.6

FF – Foliar fertilizing with water-soluble fertilizer (N1.4, Ca1.8 kg ha⁻¹) in a 0.5% solution

L – Lime (CaO + MgO) was used only in Exp. II in early spring in the planting year (2000) at a rate of 1000 kg ha⁻¹

Table 2. Nutrient content of the peat soil in different experimental plantations of lowbush blueberry

Experimental area	N _{org} %	P mg kg ⁻¹	K mg kg ⁻¹	Ca mg kg ⁻¹	Mg mg kg ⁻¹	Total C %	Ash %	pH
Experiment I	0.99	33	111	3641	436	42.8	3.6	2.8-4.0
Experiment II	1.06	56	292	1424	422	40.5	4.8	2.2

method was used (Methods of Soil analysis, 1996). The Kjeldahl method was used for the determination of N_{org} (Procedures of soil analysis, 1995). Available P, K, Ca and Mg were analysed according to the Mehlich-3 method (Soil analysis, 1998). The pH was measured from the soil suspension with 1M KCl (1:2.5 w/w) (Procedures of soil analysis, 1995).

Berries were picked once during the season and yield was measured in Exp. I from 1999 to 2001 and in Exp. II from 2004 to 2006. The yield from a single blueberry bush was weighed and expressed as g plant⁻¹ (in 3 replications and 15 plants per plot).

Statistical analysis

To study the influence of fertilizer on the yield, data were analysed by two-way analysis of variance; with the factors being A – years and B – fertilization. The means separated by the least significant difference (LSD) test and differences at P=0.05 considered statistically significant. The mean values to be com-

pared are followed by the same letter if they are not significantly different (Figure 1, 2).

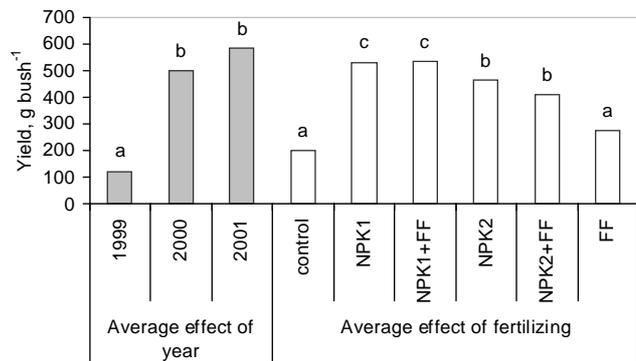


Figure 1. The yield of lowbush blueberry plants in experiment I influenced by year and fertilization. Explanations of fertilizing treatments are in Table 1. The means followed by different letters of the same colour are significantly different at P≤0.05

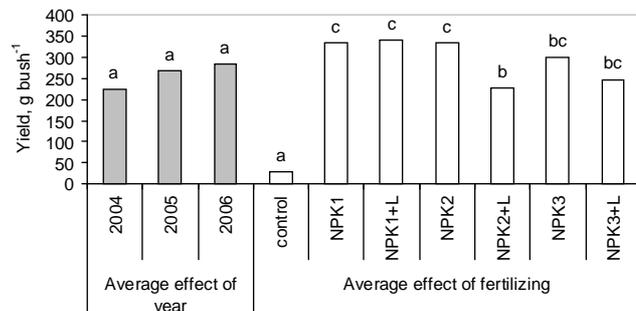


Figure 2. The yield of lowbush blueberry plants in experiment II influenced by year and fertilization. Explanations of fertilizing treatments are in Table 1. The means followed by different letters of the same colour are significantly different at P≤0.05

Meteorological conditions

The experimental year 1999 was characterized by a warmer spring than usual, accompanied by a precipitation deficit in July and August (Table 3). Moreover, in the September of 1999, the average temperature was particularly warm for this region. A warm and long fall with an unexpectedly high amount of precipitation in July characterized the year 2000. In July 2001, recorded temperatures were extremely high, as was the amount of precipitation in April and in summer (June to August). In 2004 May was colder than usual. In the middle of the month, during the lowbush blueberry blooming severe night frosts occurred. The second part of summer (August, September) was cooler, accompanied with lower precipitation amounts. The summers in 2005 and 2006 (June to September) were extremely warm and had low amounts of precipitation.

Table 3. Weather conditions in 1999 to 2006 as compared to the same figures of many years (1966-1998) in Estonia

Year	Month						
	IV	V	VI	VII	VIII	IX	X
	Total precipitation (mm)						
1999	29	26	56	21	36	43	52
2000	23	52	62	118	72	62	71
2001	52	49	86	111	127	58	79
2002	20	15	81	45	22	21	41
2003	37	105	59	88	109	18	39
2004	18	30	80	266	57	103	91
2005	22	114	54	22	92	59	38
2006	14	34	47	13	84	37	66
1966-1998	35	55	66	72	79	66	56
	Average air temperature (°C)						
1999	8	8	19	19	13	18	7
2000	12	14	18	20	19	13	11
2001	8	11	15	21	17	12	8
2002	12	20	17	25	26	15	4
2003	3	12	13	20	15	11	4
2004	5	10	13	16	17	13	7
2005	5	11	15	20	17	13	7
2006	6	12	16	19	17	14	8
1966-1998	4	12	15	17	16	10	6

The winter in 2006 was very frosty; at the end of January and the beginning of February the temperature was below -25 °C for an extended period of time.

Economic questionnaire

The aim of the questionnaire was to obtain economic data that would make it possible to determine the cost-effectiveness of strawberry and blueberry cultivation in Estonia. Farmers with plantations of 0.4–13 ha for strawberry and 0.5–2.5 ha for half-high blueberry and lowbush blueberry cultivation were included in the survey. Berry growers were sent fill-in forms on which they had to indicate all their expenses on establishing the plantation, harvesting and marketing. The present economic study is based on the mean data of 2004–2005, collected from the Estonian berry growers. The analysis was compiled on the basis of data from 32 strawberry and 6 blueberry growers.

Economic analysis

To confirm the hypothesis calculations were made regarding the production and experimental data of lowbush blueberry cultivation. The data obtained were compared with the respective data from the cultivation of other berries. The objective of the present analysis is to estimate the cost-effectiveness of lowbush blueberry cultivation based on the benefit-cost ratio. This kind of analyses has been used in the economic analysis of several other fruits (Gündogmus

2006, Demircan et al. 2006). The data submitted on the mean market price formed the basis for calculating the return on sales. Fixed costs have been calculated by dividing the establishment costs with plantation usage time. Maintenance costs, harvesting and marketing costs are included in the variable costs. Maintenance costs include the expenses on watering, fertilizing, weeding, pruning and chemicals. The production cost per kg was calculated by dividing the total cost of berry production per hectare by the berry yield per hectare. The profitability of berry cultivation has been calculated by dividing the profit from production by total expenses (fixed costs + variable expenses).

Results

Plant yield

In Exp. I, the yearly conditions influenced the yield significantly. In 2001 the yield was 79% higher than in 1999 (Figure 1). Among the fertilized variants, the lowest yield (275 g plant⁻¹) was recorded when only foliar fertilizer was applied. Compared with unfertilized plants, the fertilized plants in treatments NPK1 and NPK1+FF produced a 63% higher yield.

In Exp. II, the productiveness of four-, five- and six-year-old blueberries was equal (Figure 2). All fertilized blueberries produced a significantly higher yield, as compared with unfertilized plants. The plants in treatments NPK1, NPK1+L and NPK2 were more productive. Unfertilized plants produced an average of three years only 27 g berries per bush, but the yield from fertilized plants varied from 227 to 339 g plant⁻¹.

Economic analysis

According to the analysis the mean yield of half-highbush blueberry per hectare was 3,500 kg and that of strawberry 4,400 kg (kg ha⁻¹). As for lowbush blueberry, the mean yield from the bush – 363 g bush⁻¹ (Figure 1 and Figure 2) - of the 2–7 fertilization trial of 1999–2006 was equalized with the yield per hectare, which according to the 1m x 1m planting scheme, constitutes 3,630 kg ha⁻¹. The yield of blueberry plantations is not very high as the plantations are young and the crop capacity still low. Economic aspects of berry cultivation were summarized in Table 4.

In Estonia, most of the berries are sold fresh on the markets and in the shops, but many are also sold to the purchasing agents and industries. The survey showed that in 2004-2005 the price of strawberries was 54% lower than that of half-highbush blueberry and 36% lower than that of lowbush blueberry (Table 4). The survey showed that the selling price of blueberries was relatively low. A few half-highbush blueberry cultivators sold their products for 5 EUR kg⁻¹.

Table 4. Economic analysis of strawberry, half-highbush and lowbush blueberry

Cost and return components	Strawberry	Half-highbush blueberry in mineral soil	Lowbush blueberry on exhausted milled peat area
Yield (kg ha ⁻¹)	4400	2220	3630
Sale price (EUR kg ⁻¹)	1.6	3.5	2.5
Costs for establishing plantation (EUR ha ⁻¹)	7101	11805	8008
Plantation usage time (year)	4	30	30
Fixed costs (EUR ha ⁻¹)	1775	394	267
Variable costs (EUR ha ⁻¹)	3148	2521	2509
Total costs (EUR ha ⁻¹)	4923	2915	2776
Production cost (EUR kg ⁻¹)	1.12	1.3	0.76
Profit (EUR ha ⁻¹)	2117	4855	6299
Benefit-cost ratio (%)	43	166	227

For the berries sold on Estonian markets, the price of strawberries fluctuated the most. In 2005 the price of strawberries at the beginning of the season was on the average 7.67 EUR kg⁻¹, while in 2004 it was only 6.39 EUR kg⁻¹. Following the daily dynamics of the market price, it can be seen that the price changes very quickly (Figure 3). The lowest price during the harvest season in 2004 was 0.96 EUR kg⁻¹. The mean market price for strawberries in 2004 was 2.16 EUR kg⁻¹, and 2.38 EUR kg⁻¹ in 2005.

The market price of cultivated blueberries includes that of bilberries too. As the kilogram price of bilberry is lower than that of cultivated blueberry, bilberry prices lowered the mean price. Large differences in selling price are explained by the size of berries and

their quality, marketing opportunities, as well as the clientele. The price of cultivated blueberries remained in the same price bracket of 4.47–6.39 EUR kg⁻¹ in 2004–2005. There are, however, producers who sell blueberries at the same price or even cheaper than bilberries. The data from the survey showed that cultivated blueberries were also marketed at 1.92 EUR kg⁻¹. In 2004 one could buy bilberries for an average of 2.3–2.43 EUR kg⁻¹ at the market.

The total cost per hectare for lowbush blueberry growing on exhausted milled peat areas was 2776 EUR ha⁻¹, for half-highbush blueberry 2,915 EUR ha⁻¹ and the highest total cost in berry growing was calculated for strawberry grown on mineral soil - 4,923 EUR ha⁻¹. The calculations revealed that the production cost for strawberries was 1.12 EUR kg⁻¹, for half-highbush blueberries grown on mineral soil 1.3 EUR kg⁻¹, while the production cost for lowbush blueberries grown on exhausted milled peat areas, was significantly lower at 0.76 EUR kg⁻¹. As a result of the analysis it can be said that lowbush blueberry growing was the most profitable (6,299 EUR ha⁻¹) compared with strawberry growing; the profit per hectare was 3 times higher.

The benefit-cost ratio shows that in strawberry cultivation every euro spent returned 0.43 EUR, in half-highbush blueberry cultivation 1.66 EUR and in lowbush blueberry cultivation, which according to the analysis is the most profitable, 2.27 EUR.

Discussion

Plant yield

In the years of the experiments, the weather had an impact on the yield of blueberry plants only in Exp 1 in 1999. The very low yield was caused by the late night frosts that damaged the blooms. Fertilization had significant impact on the results of the experiments, but the liming had no significant effect. For blueberry cultivation, the optimal soil pH_{KCl} is 4.5–5.5 (Kloet 1988, Paasisalo et al. 1994). In experimental fields the soil was considerably more acidic; pH_{KCl} of 2.2–4.0. Lime was used with aim to change the soil pH to be more suitable for blueberries. The addition of lime, however, did not increase the yield – in some experimental variants, the use of lime even decreased productivity. As during the years of the experiments the previously used liming had no impact on pH (average pH of the test plot was 2.2), it did not impact the yield. From these we can assume that blueberries can grow on highly acidic soils and be productive, even though the soil pH is very low. In the blueberry cultivation the gypsum (with agricultural grade Ca=23.2%; S=18.6%) is also used to change the pH of the soil and its use increased the blueberry yield by 47% (Sanderson et al. 1996). The significant

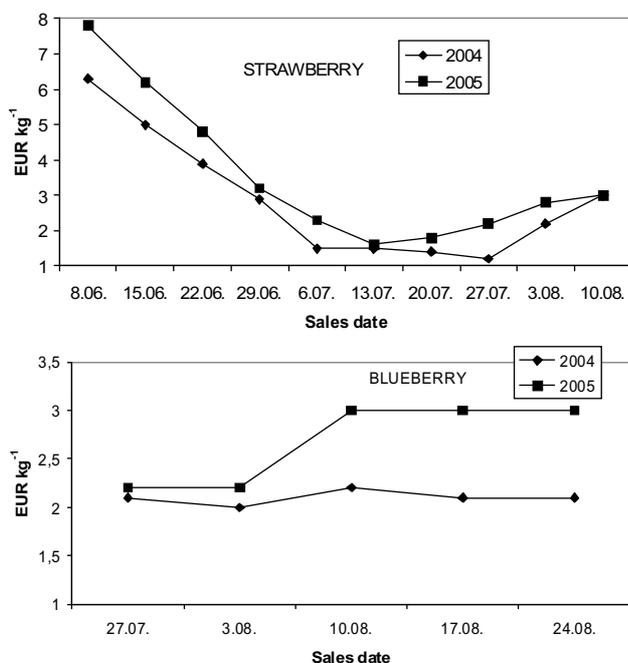


Figure 3. Price dynamics of berries, showing dependency on the marketing time in Estonia 2004–2005

effect appeared only in the beginning of the experiment and not in the following years. It can be concluded that in the future experiments it is necessary to study the effect of the repeated liming.

In a nutrient-poor environment, as in an ombrotrophic peat bog, fertilization plays an important role in the growth of plants. The fertilization increased the yield from 3 to 8 times. Only a few experiments have been conducted with blueberries in peat soil conditions. Necessity of fertilizing has come out even with trials on mineral soils, where nutrient elements composition is suitable for blueberry. A significant positive influence of NPK fertilization on yield was found in different places in Estonia, where the yield from bush was 41 to 336 g higher compared to the non-fertilized plants (Starast et al. 2007).

In Exp 1, where the fertilizers nitrogen contents differences were larger, the nitrogen had significant effect on the yield: the fertilizers with low nitrogen had significantly more positive impact on the yield. Moreover, smaller doses of nitrogen fertilization are preferred, due to the late autumn growth period. If fertilizers are applied too late, the uppermost parts of young shoots will be damaged by frost (Paal et al. 2004). The yield of the following year will thus be damaged as the flower buds develop in the upper part of shoots. Moreover, this study showed that the application of foliar fertilizers in the form of $\text{Ca}(\text{NO}_3)_2$ did not supply plants with enough nutrients for yield formation. Therefore, foliar fertilization on peat soils should be used as an additional source of nutrients rather than the main fertilizer application.

The results obtained showed that the local application of top dressings created favorable conditions for higher yields, despite the fact that the pH range in the experimental plots was significantly lower than the favorable pH range for the growth of lowbush blueberry.

Economic analysis

The economic analysis showed that among the cultures used for economic questionnaire survey, lowbush blueberry cultivation on exhausted milled peat areas turned out the most profitable. The differences in profitability were caused mainly by the specific pedoecological conditions of exhausted milled peat areas. This in turn was due to the different costs for establishment, and the differences in fixed and variable costs. In addition, the current market prices were in direct connection to profitability. The income from selling berries depends first and foremost on the yield, which is determined by the crop capacity of the cultivar grown, as well as climatic conditions and the technology used. The market price of strawberries changes very quickly. This can be explained by the fact that

at the beginning of the season the demand for strawberries is out of proportion with supply and this keeps the prices high. Within a few days the number of berry salesmen increases and the price of berries decreases. Blueberry is a comparatively new crop and, due to the competition-free market the price remains relatively stable throughout the marketing period. The consumer survey that covered 449 respondents showed that blueberry was a new crop and many consumers were not aware such berries existed and therefore did not ask for the berries at the market. At the same time the consumers liked the new and good taste of the berries and they would like to consume more.

The analysis showed that plantation establishment costs constitute the biggest share of the total costs. To calculate the fixed cost, the establishment cost was divided by plantation usage time. Based on earlier studies on strawberry plantations and questionnaire responses, costs were calculated for a 4-year period. The survey research showed that producers do indeed re-establish strawberry plantations every four years. Moreover, the earlier experimental works have shown that strawberry cultivation is economically profitable for 4–5 years (Värnik et al. 2000b). The plantation usage time of blueberry plantations is set at 30 years, although literature sources claim that the predicted life expectancy of blueberry plantations can extend to over 60 years (Hiirsalmi 1989). Estonia lacks long-term blueberry cultivation experience, therefore usage over a long time could not be surveyed. Half-highbush blueberry plantation establishing costs were 32% higher than those of lowbush blueberry.

The big difference in foundation cost derives from the different growing technologies applied. 90% of Estonian producers grow strawberries on dual rows with plastic mulch. This is the reason why the current study focuses mainly on this production technique. The experiments conducted in strawberry cultivation in Estonia have shown that this technique suits the growing conditions in Estonia (Moor et al. 2004). Half-highbush blueberry is produced on peat beds in mineral soil that have been covered with plastic mulch. The experiments carried out in Estonia show that this technology best suits Estonian conditions (Starast et al. 2002). Lowbush blueberry is grown on mill-peat areas where mulches are not used. The usage of plastic mulch has a significant influence on the economic analysis as it increases the total costs.

Half-highbush blueberry plantations are established on mineral soil. To do that, peat must be used as blueberry grows well in acidic soil conditions. Cultivated blueberries are sensitive to over-moisture, but to get a good crop, blueberry must be sufficiently watered (Lareau 1989). In order to prevent the peat from

drying, irrigation systems must be used in blueberry plantations established on mineral soils. In addition to the cost of irrigation systems, the survey showed that half-highbush blueberry plants are 20% more expensive than lowbush blueberry plants. It is possible to cut the cost of plants by growing the plants oneself (Värnik et al. 2000a).

Fertilization costs constitute the greatest part of the maintenance cost. Fertilizer consumption depends on the fertilization need, the fertilizer used and fertilizing equipment. The fertilising costs of strawberries and half-highbush blueberries have been calculated as a mean of the responses obtained in the survey. In the strawberry production, the calculations on fertilizers have been based on fertilizers NPK (6:14:23) and NPK (14:11:25) and the average amount of 190 kg ha⁻¹. As for lowbush blueberry, fertilization costs were calculated on the basis of experimental data from 1999–2006, and only top dressing fertilization was taken into account. As leaf-fertilization and liming did not have a significant effect, they were excluded from the economic analysis.

As a result of the analysis it can be concluded that the cultivation of lowbush blueberries on peat-fields is cheaper, for there is no need for weed control on peat-fields as acidic soil conditions in the bog impede the spread of weeds. Mowing between the roads is an additional cost in both strawberry and half-highbush blueberry plantations.

The problem for the berry cultivators is the cost of labour, as both berries and plants are sensitive to mechanical damage. In Estonia there is no special equipment available for harvesting. Harvesting is therefore done manually, which takes more time and is more - labour-intensive and expensive than mechanical harvesting. Experiments conducted on blueberry cultivation in Canada have shown that mechanical harvesting is 45% cheaper than hand harvesting (Sibley 1994). In 2004 in strawberry plantations in Estonia pickers were paid 0.22–0.26 EUR kg⁻¹, while pickers in Finland received 0.77 EUR kg⁻¹ on average (Koivisto 2005), which is three times more than in Estonia. The survey showed that in 2004 blueberry pickers in Estonia received 0.51 EUR kg⁻¹. A decrease in the labour costs and the longer-term employment of staff on a plantation can be achieved by growing different berry crops. Growing blueberry on 5 ha and strawberry on 3 ha makes it possible to guarantee a small family (2 employees) work amounting to approximately 18000 hours during the six months of the growing and harvesting periods (Värnik et al. 2003). Performing different operations in establishing the plantations and planting in different seasons makes it possible to diversify the type of work and increase

the labour requirements. Harvesting of these crops does not coincide and therefore employment can be extended over a longer period of time. In order to guarantee full employment, the plantation owner should find additional sources of income either from farm tourism, handicraft, processing berries or their marketing.

These results and their influencing factors are applicable in Estonia. For example, analyses conducted in berry cultivation in Germany have shown that the payback period (10–12 years) is very long for blueberry cultivation (Schmidt and Maack 2003). Värnik et al. (2002) however, found that in Estonia, blueberry cultivation payback period is 6–7 years. This shows that economic analysis is influenced by specific economic conditions, the price level of berries, the price of planting material used and the wages of seasonal workers. Finally, we can conclude that the results show that the cultivation of lowbush blueberry on exhausted mineral peat lands is possible and economically profitable.

Acknowledgements

This project was part of the Estonian Canadian project of "Commercialization of Agricultural Production in Estonia", funded partly by the Canadian International Developmental Agency. For use of and help with experimental fields, we thank farmers T. Jaadla, K. Põld and T. Oks. This study was financially supported by the Estonian Science Foundation (Projects 4726, 6046 and 6037) and by Enterprise Estonia.

References

- Abolins, M. and Gurtaja, L. 2006. *Vaccinium* spp. Production Techniques in Latvia. *Acta Horticulturae* 715: 185–190.
- Chemical analysis of soils. 1998. Vorobjova, L.A. (ed.) Textbook, Moscow University Press. p. 272.
- Demircan, V., Ekinci, K., Keener, H. M., Akbolat, D. and Ekinci, C. 2006. Energy and economic analysis of sweet cherry production in Turkey: A case study from Isparta province. *Energy Conversion and Management* 47: 1761–1769.
- Eccher, T., Noé, N. and Bacchetta, M. 2006. The influence of ericoid endomycorrhizae and mineral nutrition on the growth of micropropagated plants of *Vaccinium corymbosum*. *Acta Horticulturae* 715: 411–416.
- Gündogmus, E. 2006. Energy use on organic farming: A comparative analysis on organic versus conventional apricot production on small holdings in Turkey. *Energy Conversion and Management* 47: 3351–3359.
- Heinsalu, H., Niine, H. and Veber, K. 1992. The influence of amelioration on the properties of peat soil. *Estonian soils their reclamation and fertilization*, Transactions of EMTUI, LXX: 32–41.

- Hiirsalmi, H. M.** 1989. Research into *Vaccinium* cultivation in Finland. *Acta Horticulturae* 241: 175–184.
- Ilomets, M.** 2003. On price of extracting peat? *Estonian Nature* 2/3: 20–24. (In Estonian)
- Ilomets, M., Animägi, J. and Kallas, R.** 1995. Estonian peatlands, a brief review of their development, state, conservation, peat resources and management. Ministry of Environment, Tallinn, Estonia p. 1–48.
- Kalt, W., McRae, K. B. and Hamilton, L. C.** 1995. Relationship between surface color and other maturity indices in wild lowbush blueberries. *Canadian Journal of Plant Sciences* 75: 485–490.
- Kloet, V. S. P.** 1988. The Genus *Vaccinium* in North America. Research branch, Agriculture Canada, Ottawa 153 pp.
- Koivisto, A.** 2005. Mansikantuotannon kilpailuetu Suomessa ja Virossa. Helsingin yliopisto. Taloustieteen laitos. Pro Gradu. p. 93. (In Finnish)
- Lareau, M. J.** 1989. Growth and productivity of highbush blueberries as affected by soil amendments, nitrogen fertilisation and irrigation. *Acta Horticulturae* 241: 126–131.
- Methods of soil analysis. 1996. Part 3. Sparks, D.L. (ed.). SSSA Book Series: 5, Madison, Wisconsin, USA, p. 1390.
- Mitchell, D. T. and Read, D. J.** 1981. Utilization of inorganic and organic phosphates by the mycorrhizal endophytes of *V. macrocarpon* and *R. ponticum*. *Transactions of the British Mycological Society* 76: 255–260.
- Moor, U., Karp, K. and Pöldma, P.** 2004. Effect of mulching and fertilization on the quality of strawberries. *Agricultural and Food Science* 13: 256–267.
- Noormets, M., Karp, K. and Paal, T.** 2003. Recultivation of opencast peat pits with *Vaccinium* culture in Estonia. *Ecosystems and Sustainable Development IV*, eds. E. Tiezzi, & C.A., Brebbia, Wessex Institute of Technology, UK and J-L. USO, Universitat Jaume I, Spain, 2, p. 1005–1014.
- Noormets, M., Karp, K., Starast, M. and Paal, T.** 2002. The influence of fertilization on the production of lowbush blueberry (*Vaccinium angustifolium* Ait.) seedlings on opencast peat pits. *Journal of Agricultural Sciences* 5 (8): 293–303.
- Orru, M., and Paal, J.** 2007. Turba kaevandamine: J. Paal (edit.). Jätksoode korrastamise käsiraamat [Mining of peat: J. Paal (edit.). Handbook of restoration of exhausted peat fields] p. 27–33. (In Estonian).
- Paal, T., Starast, M. and Karp, K.** 2004. Influence of different fertilisers and fertilising frequency on the developing of seedlings of *Vaccinium angustifolium*. *Botanica Lithuanica* 10(2): 135–140.
- Paasisalo, S., Kokko, H. and Kärenlampi, S.** 1994. Pensasmustikka marjantuotannossa: kasvatus- ja hoitoohjeita. [High-bush blueberry in berry production: cultivation and protection tips] *Muuruvesi*, 31 ss. (In Finnish)
- Powell, C. L. and Bates, P. M.** 1981. Ericoid mycorrhizas stimulate fruit yield of blueberry. *HortScience* 16 (5): 655–656.
- Procedures for soil analysis. 1995. L.P. van Reeuwijk (ed.) Wageningen: ISRIC, 112 pp.
- Read, D. J. and Stribley, D. P.** 1973. Effect of mycorrhizal infection on nitrogen and phosphorus nutrition of ericaceous plants. *Nature*. London. *New Biologist* 244: 81–82.
- Read, D.J. and Kerley, S.** 1998. The status and function of ericoid mycorrhizal systems. In: A. Varma and B. Hock (eds.). Mycorrhiza: structure, function, molecular biology and biotechnology. Springer-Verlag, Berlin, p. 499–520.
- Sanderson, K. R., Carter, M. R. and Ivany, J. A.** 1996. Effects of gypsum on yield and nutrient status of native lowbush blueberry. *Canadian Journal of Plant Science* 76:361–366.
- Schmidt, E. and Maack, K.** 2003. Berries from Domestic Resources for the Fruit Processing Industry in Germany – Possibilities and Constraints. *Acta Horticulturae* 626: 459–466.
- Sibley, J.** 1994. Lowbush blueberry production and marketing in Nova Scotia a situation report-1994. (<http://nsac.ns.ca/wildblue/facts/pihbc94-08.htm#a8>).
- Smith, S. E. and Read, D. J.** 1997. Mycorrhizal symbioses 2nd ed. Academic Press, London, p. 605.
- Soil Analysis. 1998. Handbook on reference methods. Soil and Plant Analysis Council Inc. CRC Press, p. 247.
- Stackevičienė, E., Butkus, V. and Butkiene, Z.** 1997. Introduction of large cranberries, blueberries and lingonberries and their cultivation basis in Lithuania. *Agricultural Sciences* 2: 58–70.
- Starast, M., Karp, K. and Paal, T.** 2002. The effect of using different mulches and growth substrates on half-highbush blueberry (*Vaccinium corymbosum* x *V. angustifolium*) cultivars ‘Northblue’ and ‘Northcountry’. *Acta Horticulturae* 574: 281–286
- Starast, M., Karp, K., Vool, E., Paal, T. and Albert, T.** 2007. Effect of NPK fertilization and elemental sulphur on growth and yield of lowbush blueberry. *Agricultural and Food Science* 16 (1): 34–45.
- Starast, M., Kõljalg, U., Karp, K., Vool, E., Noormets, M. and Paal, T.** 2006. Mycorrhizal colonization of half-high blueberry cultivars influenced by cultural practises. *Acta Horticulturae* 715: 449–454.
- Stribley, D. P. and Read, D. J.** 1974. The Biology of Mycorrhiza in the Ericaceae. IV. The Effect of Mycorrhizal Infection on Uptake of N15 from Labelled Soil by *Vaccinium macrocarpon* Ait. *New Phytologist*, 73(6): 1149–1155.
- Tamoshaitienė, A., Sheshelgiene, S., Budriuniene, D., Vaichiuniene, J., Lashinskiene, A. and Radushiene, J.** 1997. Ways to increase incomes of farms situated on low fertility land. *Agricultural Sciences* 1: 41–53.
- Värnik, R., Jullinen, V. and Jaadla, T.** 2000a. Investments to mill-peat areas on blueberry cultivation and production. Rural Development Within the Process of Integration into the European Union. International scientific conference reports. Jelgava, p. 382–388.
- Värnik, R., Karp, K. and Jullinen, V.** 2000b. The effect of strawberry variety and the age of plantation on the yield quality and producer price in Estonia. International Multidisciplinary Conference: Integrated View of Fruit & Vegetable Quality, p. 19–30.
- Värnik, R., Lilover, L. and Erman, A.** 2003. The Profitability of Combining Alternative Activities in Small-scale Enterprises (case of berry growing). *Transactions of Estonian Agricultural University* 217: 46–55.
- Värnik, R., Lilover, L., Ohvril, T., Maidre, K. and Erman, A.** 2002. Macroeconomic analysis of blueberry growing in Estonia. Estonian Agricultural University, Faculty of Economics and Social Sciences. Project report of Estonian Agricultural Ministry in cooperation with Nova Scotia College of Agriculture, p. 77.
- Yakovlev, A.** 2000. The impact of fertilizer application methods on the growth and biological productivity of *Vaccinium uliginosum* L. occurring on cutover peatland. In: Problems of rational utilization and reproduction of berry plants in boreal forests on the eve of the XXI century. Proceedings of a international conference, 11–15 September 2000, Gomel-Glubokoye, Belarus, Published by Forest Institute NASB, p. 249–252.

Received 17 November 2008

Accepted 18 June 2010

ВЫРАЩИВАНИЕ ЯГОДНИКОВ НА ПУСТУЮЩИХ ВЫРАБОТАННЫХ ТОРФЯНИКАХ В ЭСТОНИИ: СЕЛЬСКОХОЗЯЙСТВЕННЫЕ И ЭКОНОМИЧЕСКИЕ АСПЕКТЫ

К. Вахейыз, Т. Альберт, М. Ноорметс, К. Карп, Т. Пааль, М. Стараст и Р. Вярник

Резюме

Исследование было проведено для определения возможностей использования выработанных фрезерных торфяников в условиях изменения землепользования. В проведенных экспериментах выявляли пригодность бывшего лесного болота после добычи торфа для выращивания голубики узколистной (*Vaccinium angustifolium*). Культивирование дикорослых ягод на таких площадях является довольно новой ветвью сельскохозяйственной отрасли. Так как данных о питательных потребностях голубики на выработанных торфяниках по-прежнему недостаточно, было проведено пробное изучение удобрения субстрата. В исследовании урожайность использовалась как агротехнический индикатор для оценки эффективности использования торфяных почв. Для оценки рентабельности выращивания голубики, было использовано коэффициент рентабельности. Был проведен сбор данных о расходах на создание, уход и содержание плантаций, а так же на заготовку и сбыт урожая. Целью исследования было определить, является ли выращивание голубики узколистной на открытых торфяных карьерах столь же прибыльным, как культивирование голубики высокорослой (*Vaccinium angustifolium* x *Vaccinium corymbosum*) и клубники (*Fragaria x ananassa*) на минеральных почвах. Кроме того, были рассмотрены возможности улучшения землепользования путем превращения заброшенных торфяников в прибыльные земельные ресурсы. Было установлено, что удобрение голубики узколистной на торфяниках увеличит урожайность от 200 до 535 г на растение. Экономический анализ показал, что рентабельность голубики узколистной на фрезерных торфяниках был 227%, а рентабельность голубики высокорослой и клубники, выращиваемой на минеральной почве, была значительно ниже - 116% и 43% соответственно. Самую высокую прибыль получили от выращивания голубики узколистной на фрезерных торфяниках - 6299 EUR га⁻¹, в то же время от клубники на минеральной почве только 2117 EUR га⁻¹. Прибыль от голубики высокорослой на минеральной почве была 4855 EUR га⁻¹. В итоге можно сделать вывод, что культивирование голубики узколистной позволяет взять в использование исчерпанные фрезерные торфяники, а выращивание голубики узколистной на этих полях является экономически да?е более выгодным, чем выращивание клубники на минеральной почве.

Ключевые слова: *Vaccinium angustifolium*, использование торфяников, выработка торфа, удобрение, урожай, экономический анализ, коэффициент рентабельности