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The effect of mulching and pruning on the vegetative growth and yield of the half-high blueberry

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Abstract. The aim of this research was to determine the influence of different mulches (peat, sawdust, plastic) and different pruning methods (moderate, severe) on the growth and yield of the half–high blueberry (*Vaccinium corymbosum* x *Vaccinium angustifolium)* ´Northblue´. The effect of a mixture of soil and peat was studied in the case of peat alone and peat and plastic mulches. The experiment was established in 1996 in South Estonia and in 2002 blueberry bushes were pruned. The results of the study showed that mulching significantly influenced nutrient content and pH. Depending on the mulch, the soil pH ranged from 4.5 to 6.1 – there was more acid soil in the peat treatment. The use of mulches had some influence on productivity of pruned half-high blueberry plants. When peat was applied a canopy of pruned plants recovered very well after one year. Within three years the plants had the same yield as un-pruned variants but four years after pruning the yield was highest in the variants where peat was applied. Plastic mulch is not suitable for blueberries: it decreases the yield and four years after pruning the normal plant growth in our study had not recovered. Severe pruning is more suitable for half-high blueberry fruiting plants in northern climate conditions.

Key words: *Vaccinium corymbosum* x *Vaccinium angustifolium,* pH, yield, berry weight, moderate pruning, severe pruning, peat, black plastic, sawdust, nutrient

INTRODUCTION

The half-high blueberry (*Vaccinium corymbosum* x *Vaccinium angustifolium*) cultivars are rather winter hardy and are able to grow in northern regions, where highbush blueberry (*Vaccinium corymbosum*) cultivation is not possible (Luby et al., 1989). From earlier trials in Estonia it has been found that the half-high blueberry ´Northblue´ and ´Northcountry´ tolerate Estonian climate conditions well (Starast et al., 2002). At the same time it was observed that in the mature stage the intensity of vegetative growth decreased. In North America lowbush blueberry (*Vaccinium angustifolium*) plants are severely pruned each year after harvest in order to facilitate mechanical harvest, to improve the quality of berries and to decrease the requirement of chemical control when there plant diseases are present (Hancock & Draper, 1989). In order to stabilize the yield moderate pruning should be used in highbush blueberry plantations (Jansen, 1997). The productivity of five-year old branches decreased considerably, thereby it is recommended to prune out all the branches thicker than 4 cm. Siefker & Hancock (1987) have found that 40% of the largest branches and only 20% of the medium-size branches should be removed without reducing yields substantially. However, the experimental trials made in Poland prove that heavy pruning is advisable, resulting in regular high and quality yields (Smolarz & Chlebowska, 2002). One year after severe pruning blueberries do not yield at all, but the bushes bear a substantial crop in the following summer and will give full production in the third year (Howell et al., 1975).

Mulching has a beneficial effect in blueberry cultivation. The use of mulches enables suppression of weed growth, conservation of moisture by reducing evaporation, increased infiltration of water and soil temperature and decreased soil-temperature fluctuations, enhancement of the mineral nutrient availability and preservation or improvement of the soil structure (Libik & Wojtaszek, 1973). Mulching results in a uniform root distribution from the plant crown outward, with most roots in the upper 15 cm soil (Spiers, 1986). Mycorrhizal colonization increases in half-high blueberry roots when mulches are used (Starast et al., 2006). Mulches also maintain a more constant media pH, and in some cases contribute to acidification of the soil (Karp et al., 2006; Korcak, 1988).

The present research shows that the use of mulches and the influence of pruning on blueberry plants are often studied separately. Little attention has been paid to the mutual influence of the pruning method and the choice of mulch in an older plantation. In northern countries winter hardiness of young blueberry plants is problematic. Plants produce numerous shoots but they do not finish growing according to the predicted schedule (Starast et al., 2002). They are herbaceous, not ligneous, and the first frosts damage the shoots. Severe pruning enhances the development of new shoots; the same problem can appear in an older plantation as well. Therefore we can suggest that the mulches that increase plant growth can concurrently decrease winter hardiness of the blueberry after pruning. On the other hand, mulches can promote root development of older bushes and influence the accumulation of metabolic nutrients and cold hardiness. Accordingly, older plants may give different results compared with those of young ones. ’Northblue´ is the hybrid of lowbush and highbush blueberry. On this basis a hypothesis is raised: a) severe pruning is suitable for the ´Northblue´, and, b) the productivity of pruned plants depends on the choice of mulch. The aim of this research was to determine the influence of different mulches and different pruning methods on the growth and yield of the half-high blueberry ´Northblue´.

MATERIALS AND METHODS

Experimental sites and treatments

The experiment was carried out in Tartu County (South Estonia) (58° 15’ N, 26° 43’ E). By WRB classification (2006) the soil in the experimental area was Enti-Umbric Albeluvisol, and the texture was sandy loam. The plantation was established in 1996 with one-year-old *in vitro* propagated plants of half-high blueberry ´Northblue´. The gap between the plants was 0.7 m and the space between rows was 1.5 m. The experimental design was a randomized complete block in 3 replications with 15 plants per plot. Five different kinds of treatments were employed (on figures and tables they will be indicated with abbreviations): 1) peat mulch (PM); 2) sawdust mulch (SM); 3) plastic mulch (0.04 cm thick black polyethylene) (PlM); 4) mineral soil mixture with peat and peat mulch (PM + P); 5) mineral soil mixture with peat and plastic mulch (PlM + P). In treatments 4 and 5, each plant received 10 l peat in the growing substrate before planting. Plastic mulch was put in place before planting. Organic mulch treatments were applied at a 70-cm-wide band on the plant row immediately after planting in June, 1996. The ground was covered with a 5-cm layer of peat or sawdust mulch. Two years later, a 2–3 cm layer of organic mulch (peat, sawdust) was added to the ground in spring.

In the seventh cultivation year (2002) the plants were pruned once at the beginning of May before the bud break. Three pruning variants were used in all mulching variants: control – no pruning (NP); moderate pruning – removing old dark–brown branches (30–40% of the canopy) (MP); severe pruning – all bush branches were cut at 5 cm above the ground (SP).

Weather conditions

After pruning (2002) the weather conditions were very good for plant growth: the summer was warm and precipitation was sufficient (Table 1). The climate was unfavourable in 2004. May was rainy, cool and night frost occurred. In the spring of 2005 the air temperature was on the average level, but it rained twice as much as usual. July, August and September were warmer than average. July was drier and August more rainy.

Table 1. Air temperature and precipitation in 2002–2005 in the experimental area 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)						
2002	20.1	15.4	80.7	111.7	126.7	58.1	78.5
2003	36.6	105	58.8	87.8	109.4	17.8	39
2004	6	37.8	184	76.2	104.8	86.2	35.4
2005	21.8	114	54.2	21.8	92.4	59.4	38
1966–1998	35	55	66	72	79	66	56
	Average air temperature (°C)						
2002	12.2	19.8	16.5	25.4	25.5	14.9	4
2003	3.3	11.6	13.1	19.6	15.1	11.4	3.8
2004	5.7	10.3	13.4	16.6	16.9	11.8	5.7
2005	5	10.9	14.5	19.5	16.6	12.7	6.7
1966–1998	4.3	11.6	15.1	16.7	15.6	10.4	5.5

Measurements and analyses

Soil analyses were taken in the autumn of 2002 and 2004. Samples for analyzing were taken close to the plants from the soil layer reaching 20 cm. Soil pH_{KCl} was determined with the use of Evikon pH Meter E 6115. Soil samples for analyses of macro element content were taken in 2002 and 2004. The content of P- (ammonium lactate extractable), K- (ammonium lactate extractable), Ca- and Mg- (1 M ammonium acetate extract, pH 7.0) were estimated in the Laboratory of Plant Biochemistry of the Estonian University of Life Sciences (Official Methods of Analysis, 1990).

For the estimation of dry weight of blueberry roots, the soil samples were taken in the autumn of 2002 under the canopy of a blueberry plant with cylinder volume 90.4 cm^3. Roots were separated from the sample and dried in the thermostat at the temperature of 105ºC until constant weight was achieved. In 2004 the soil penetration resistance was measured with a cone penetrometer (cone angle 30°, stick diameter 12 mm) in every 0.20 m layer down to 0.6 m (1 MPa = 10 kg cm^{-2}).

In autumn 2002, 2003 and 2004, the height and width of the blueberry plants were measured and the number of shoots (longer than 15 cm) per plant were counted. In 2005 there was no difference in the growth of the plants; the data for that year will not be presented.

The half-high blueberry berries ripen gradually, so the yield was picked four times in August in every experimental year (2003–05). The total yield per plant was calculated by summarizing yields of different harvesting days. The average berry weight was achieved by weighing 10 randomly chosen berries from each bush.

Statistical analysis

The study results were analyzed by ANOVA table. The differences between variants were determined by the least significant difference (LSD) test and differences at $P \leq 0.05$ were considered statistically significant. Different letters in figures and tables indicate significant differences.

RESULTS AND DISCUSSION

Mulching significantly influenced the soil nutrient content in a seven-year old (2002) plantation (Table 2). The content of magnesium was higher in SM and PM + P treatments. Phosphor content was higher in SM variants and potassium in PlM variants. Calcium content was the lowest when plastic mulch was used. Depending on mulches the soil pH ranged from 4.5 to 6.1. In both experimental years the soil became more acidic with the use of PM and PM+P treatments.

Mulching also influenced soil penetration (Fig. 1). PM + P and PlM + P treatments had mellower soil in the upper layer (0…20 cm; PlM + P treatments had mellower soil in deeper layers.

Most roots were in the depth up to 5 cm. The mass and depth of roots depend significantly on mulch (Fig. 2). The plants grown in PlM-P treatment had the biggest root system.

Table 2. In 2002 and 2004 P, K, Ca and Mg content in the soil (averages for 0–20 cm soil depth) and soil pH as influenced by mulch treatments.

Year	Treatment	pH_{KCl}	mg kg^{-1}			
			P	K	Ca	Mg
2002	PM	5.9b	129ab	54c	1338a	116ab
	SM	6.1a	166a	80b	1447a	132a
	PlM	5.9b	132ab	121a	1121ab	79c
	PM+P	5.9b	133ab	67cb	1347a	140a
	PlM+P	5.9b	102b	115ab	1221a	97bc
2004	PM	4.5e	115b	45c	907b	90bc
	SM	6.0ab	119b	60bc	1083ab	100bc
	PlM	5.2d	119b	91b	980ab	93bc
	PM+P	5.0cd	144ab	61bc	1082ab	98bc
	PlM+P	5.3c	129ab	101ab	1094ab	106b
	LSD $_{0.05}$	*0.2*	*46*	*30*	*306*	*25*

PM – peat mulch; SM – sawdust mulch; PlM – plastic mulch; PM + P – ground mixture with peat and peat mulch; PlM + P – ground mixture with peat and plastic mulch.
*Means followed by different letters within the same column are significantly different by LSD at $P \leq 0.05$

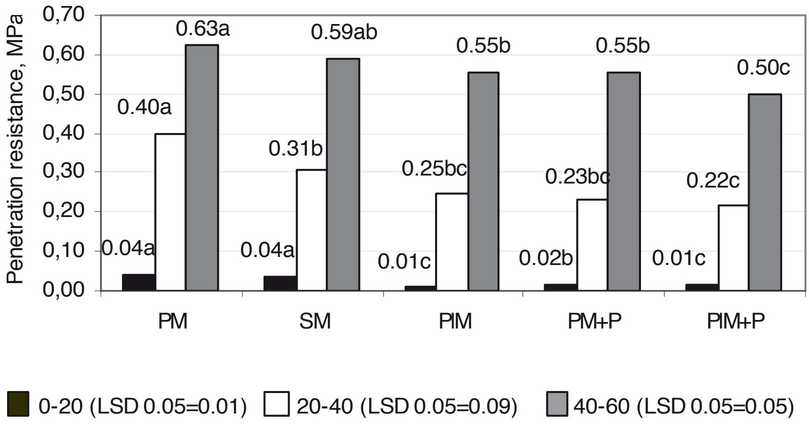

Figure 1. Effect of mulch materials on soil penetration resistance (1 MPa = 10 kg cm^{-2}) in 2001.
PM – peat mulch; SM – sawdust mulch; PlM – plastic mulch; PM + P – ground mixture with peat and peat mulch; PlM + P – ground mixture with peat and plastic mulch.
*Means followed by different letters with the same colour are significantly different by LSD at $P \leq 0.05$

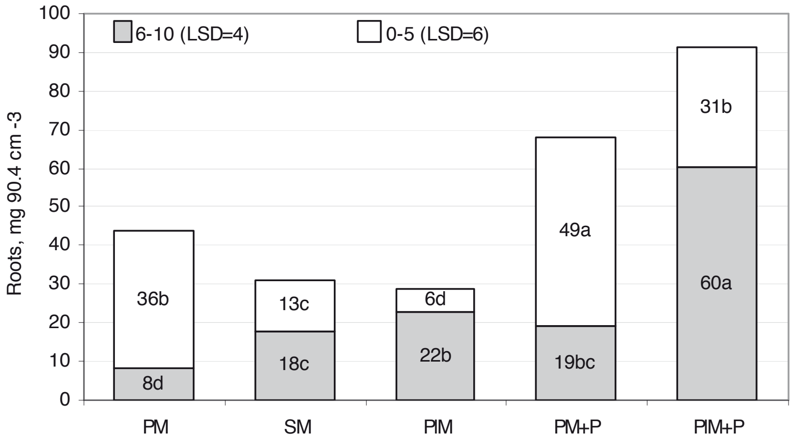

Figure 2. Effect of mulch materials on dry weight of roots (mg 90.4 cm $^{-3}$) in 2001.
PM – peat mulch; SM – sawdust mulch; PlM – plastic mulch; PM + P – ground mixture with peat and peat mulch; PlM + P – ground mixture with peat and plastic mulch.
*Means followed by different letters with the same colour are significantly different by LSD at $P \leq 0.05$.

In all experimental years pruned plants had a bigger canopy in PM, PM + P treatments (Table 3). Sawdust mulch increased plant growth in 2004. Three years after pruning (2005) the blueberry plants had similar canopy size in all pruning variants (data not shown). Depending on mulch application plants had 1–5 new shoots if plants were not pruned. Pruning increased the development of shoots. Severely pruned blueberry plants had a significantly higher number of one-year-old shoots in PM and PM + P treatments.

The yield of trial plants was extremely variable – 4 to 1341 g per bush, which was caused both by mulching and pruning (Table 4). In 2003 unpruned plants had still higher productivity. In addition to that, PM and PM + P treatments increased the yield much more. However there were heavier berries in the variant in which moderate pruning with PM treatment and severe pruning with PlM + P treatment were used. In 2004 and 2005 the moderate pruned plants cultivated with PM+P treatment had a higher yield. Heavier berries were produced in the variant using severe pruning with SM treatment (2004) and PM + P (2005) treatments.

Severely pruned plants had full production three years after pruning and the blueberry plants with peat (mulch or mulch and soil mixture with peat) treatment had higher yield. Similar results were detected in a highbush blueberry plantation where the yield recurred three years after rejuvenation (Howell et al., 1975). The experiment showed that the plant growth and yield after pruning depends significantly on the growth medium. The contents of soil nutrients were at a good level; only potassium content was low. However, potassium content was the highest with the use of plastic mulch.

3. Effects of mulch materials and pruning treatments on plant height, width (cm) and number of long shoots in 2002, 2003 and 2004.

Treatment	Plant height (cm)			Plant width (cm)			Number of shoots		
	2002	2003	2004	2002	2003	2004	2002	2003	2004
PM, NP	48A	62A	72A	53A	76A	85A	2EF	3B	2BC
PM, MP	51A	55AB	68A	50A	71AB	85A	6CD	4AB	3B
PM, SP	41AB	53AB	72A	44AB	59AB	75AB	14A	5A	6A
SM, NP	46A	59A	62A	47A	68B	80A	5D	3B	3B
SM, MP	47A	52AB	63A	51A	59AB	77AB	7C	3B	4B
SM, SP	39B	51B	70A	43AB	58C	82A	10B	4AB	4B
PlM, NP	29CD	39D	42B	33C	44D	58B	2EF	1C	2BC
PlM, MP	31C	38D	46AB	41AB	45CD	57B	3E	1C	1C
PlM, SP	23D	40CD	52AB	31C	43D	58B	8C	2BC	4B
PM+P, NP	52A	63A	70A	51A	70AB	90A	3E	3B	3B
PM+P, MP	47A	59A	68A	53A	71AB	92A	7C	3B	2BC
PM+P, SP	47A	55AB	75A	51A	66B	88A	14A	4AB	7A
PLM+P, NP	35BC	48BC	80A	50A	59BC	80A	1F	1C	2BC
PlM+P, MP	31C	45C	58AB	46AB	52C	58B	3E	1C	3B
PlM+P, SP	27CD	45C	57AB	40B	46CD	57B	15A	1C	3B
LSD 0.05	*7*	*6*	20	*7*	*8*	*22*	*2*	*2*	*2*

*Means followed by different letters within the same column are significantly different by LSD at $P \leq 0.05$

PM – peat mulch; SM – sawdust mulch; PlM – plastic mulch; PM+P – ground mixture with peat and peat mulch; PlM + P – ground mixture with peat and plastic mulch. NP – no pruning; MP – moderate pruning; SP – severe pruning.

Table 4. Effects of mulch materials and pruning treatments on plant yield (g plant $^{-1}$) and berry weight (g) in 2003, 2004 and 2005.

	Yield per plant (g)			Berry weight (g)		
Treatment	2003	2004	2005	2003	2004	2005
PM, NP	1124A	50CD	778B	1.8AB	2.4A	1.7C
PM, MP	807B	87CB	921AB	1.9A	2.2C	1.8B
PM, SP	210D	27CD	893AB	1.8AB	2.2C	1.7C
SM, NP	489C	26CD	260D	1.8AB	2.2C	1.7C
SM, MP	138D	44CD	352CD	1.7B	2.2C	1.7C
SM, SP	124D	60C	451C	1.8AB	2.4A	1.7C
PlM, NP	211D	4D	39E	1.4CD	1.4F	1.5E
PlM, MP	173D	5D	111DE	1.3D	1.5E	1.3F
PlM, SP	60D	21CD	224D	1.5C	1.8D	1.5E
PM+P, NP	1341A	132B	858AB	1.8AB	2.2C	1.8B
PM+P, MP	895B	192A	1012A	1.8AB	2.3B	1.8B
PM+P, SP	143D	162AB	920AB	1.7B	2.3B	2.0A
PlM+P, NP	484C	77C	192ED	1.6BC	2.2C	1.5E
PlM+P, MP	518C	47CD	429C	1.5C	2.3B	1.5E
PlM+P, SP	38D	92BC	496DC	1.9A	2.2C	1.6D
$LSD_{0.05}$	*254*	*50*	*172*	*0.2*	*0.1*	*0.1*

*Means followed by different letters within the same column are significantly different by LSD at $P \leq 0.05$.

PM – peat mulch; SM – sawdust mulch; PlM – plastic mulch; PM + P – ground mixture with peat and peat mulch; PlM + P – ground mixture with peat and plastic mulch.

NP – no pruning; MP – moderate pruning; SP – severe pruning

An explanation could be that potassium leaches easily from soil, but with the use of plastic mulch, potassium leaching stops. Despite that, plants with plastic mulch had poor productivity, perhaps because fewer plant roots developed. A vigorous and large root system is a base for good plant productivity. Normal plant canopy recovered very quickly if peat was applied. We can suppose that the peat influences soil pH, increasing acidity of soils, which is the preferred growth medium of blueberry plants. In the trial the application of peat increased soil acidity and plant growth and yield increased significantly. Holmes (1960) has found that the optimum pH for the growth of a highbush blueberry is in the range of 4-5. The lowbush blueberry growth was optimal in the soil with pH 4.2 if no mulch was used and when sawdust was incorporated into soil, the soil pH was 4.9 (Hall et al., 1963). Mulches also maintain a more constant media pH, and in some cases contribute to acidification of the soil (Korcak, 1988). With high soil pH, blueberry plants do not grow well, mainly because of poor root growth. Under such conditions minor soil elements available for root development and uptake are not sufficient (Spiers, 1984). The experiment with rabbit-eye blueberries showed that mulching resulted in a uniform root distribution from the plant canopy outward, with most roots in the upper 15 cm soil. Incorporated peat tended to concentrate the root system near the crown area – mostly at the 30–45 cm depth (Spiers, 1986). Also, in our experiment, the root growth was very good with the application of peat, however, the blueberry roots remained only in the surface layer of soil. The experiments carried out with highbush blueberries on mineral soil demonstrated that while adding peat and crushed pine bark to growth substrate, the physical conditions of the soil would be improved (Smolarz, 1985; Haynes & Swift, 1986). In our experiment we mixed peat into soil with incorporated peat mulch. That enabled a uniform root distribution from the plant canopy outward and also improved the physical conditions of the soil. The previously mentioned treatment can be one reason for good vegetative plant growth and high yield productivity after pruning.

In 2004 there were some night frosts in the blooming season (May) causing a very low yield in all treatment variants. However, pruned blueberry plants in peat treatments had the best yield that year. Starast et al. (2002) also indicated that peat mulch and peat soil amendments increased vegetative growth in a young half-high blueberry plantation. The blueberries growing in peat incorporated soil were also productive in Canada (Dale et al., 1989). The results of the current trial have demonstrated that the mentioned treatment favoured the vegetative growth of mature plants and the yield after pruning was good. The research of the root system has shown the influence of different mulches on the development of roots, and that plants with a good root system will recover more quickly after pruning.

CONCLUSIONS

The use of mulches has influence on the productivity of pruned half-high blueberry plants. When peat is applied the canopy of pruned plants recovers very well within one year. After three years the pruned plants have the same yield as unpruned variants, but four years after pruning the plant yield is the highest. Plastic mulch is not suitable for blueberries, because it decreases the yield, and four years after pruning the normal plant growth does not recover. Consequently, the hypothesis is confirmed: severe pruning is suitable for half-high blueberry fruiting plants in northern climate conditions. Furthermore, the severe pruning method can be regarded as cheaper than thinning, over the course of years. The experiment is being continued. We would like to specify how many years severe pruning is needed to retain high and stable productivity for blueberries with different mulch application.

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