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Growth Habit of Arctic Bramble (*Rubus arcticus*) within Kaansoo Conservation Area in Estonia

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Abstract

Arctic bramble (*Rubus arcticus* L. ssp. *arcticus*) is a relic of sub-arctic climatic conditions in Estonia. It has been a protected species since 1958 but there has been a steady reduction in its natural area of distribution, which is possibly due to habitat degradation and conversion to agricultural land. Therefore, the influence of habitat conditions in arctic bramble vegetative growth parameters needed clarification. The focus of this research is on five types of arctic bramble natural habitat and one plantation, in which plants originated from one of the natural habitats. The analysis of the results showed that the plants did not reproduce in nature and that there were considerable differences in the plants' petiole length, shoot length, and node number per shoot compared to those growing in the plantation. Light unweighted forest trees canopy openness and habitat light levels had a significant impact on arctic bramble vegetative growth parameters in Kaansoo natural habitats. Light canopy openness and diffuse solar radiation encouraged shoot elongation and plant vegetative growth. Bryophyte and dicotyledonous companion plants influenced arctic bramble growth; an increase in the number of companion plants increased the node number and leaf number per shoot. Soil pH was negatively correlated with leaf size and dry weight and between soil moisture and petiole length. Soil moisture was positively correlated with node number per shoot, leaf number per shoot and N-Tester values (which measure light transmittance).

Key words: shoot length and number, node number, leaf parameters, plant dry weight, soil moisture and pH, companion plants, illumination.

Introduction

Arctic bramble (*Rubus arcticus* L. ssp. *arcticus*) grows naturally in cold temperate zone areas of the northern hemisphere – in Finland, Norway, Sweden, Russia, and rarely, Estonia (Eichwald 1958, Ryynänen 1973, Hultén and Fries 1986). The species needs a cool summer and a long day for good growth. Two subspecies, *Rubus arcticus* ssp. *stellatus* [(Sm.) B. Boivin] and *R. arcticus* ssp. *acaulis* (Michx. Focke) grow in North America and possibly Siberia. Subspecies *arcticus* is a valuable berry culture due to its rich content of chemical compounds, which gives it a peculiar flavour and aroma. The flavour content of other subspecies is significantly lower; therefore they are less valued as a berry culture (Ryynänen 1972). In plantation conditions, the major problem of ssp. *arcticus*, as compared to ssp. *stellatus* is disease (Tammisola 1988). The spread of downy mildew (*Peronospora sparsa* Berk.) has become a major problem for arctic bramble cultivation (Prokkola et al. 2001, Vool et al. 2009).

Estonia is situated on the southern boundary of the arctic bramble's area of distribution, and natural growth areas are restricted to isolated moderately sized sites (Eichwald 1965). The only permanent natural habitat as a relic of sub-arctic climatic conditions of arctic bramble in Estonia is in Kaansoo. Other arctic bramble habitats in Estonia are either short-term, related to seed dissemination by birds, or have been degraded due to human activities. Arctic bramble has been a protected species in Estonia since 1958 and belongs to category II of protected species (Eesti punane raamat 1998). According to the Estonian Red List of Threatened Species arctic bramble has been critically endangered (threat category 4) since 2008.

Arctic bramble mainly grows in bogs, wet meadows, ditches and open spruce-hardwood forests (Ryynänen 1973). Features of arctic bramble habitats include little or no shade and a moist substrate with a high organic content. It also rapidly spreads in burned or cleared areas (Ryynänen 1973). In Finland, where arctic bramble is more widely spread, the main reason for the decline in its natural habitat is considered to be a decrease in the numbers of forest fires. Forest fires have a positive effect on arctic bramble growth due to forest ashes having a high nutrient content and increasing the competitive advantage of arctic bramble over companion plants (Tammisola 1988). In Estonia as well in Scandinavia, its area of distribution has been steadily shrinking due to the modernizations of agriculture and forest. Arctic bramble is able to compete with other species in excessively moist condition. However when areas are drained, arctic bramble is outcompeted by species that grow better in the drier conditions. Soil condition change promotes woody plants vigorous growth, this leads to overshadowing arctic bramble and supplanting it (Reier 2002a). Therefore, there is a reason to believe that in too crowded or too shaded plant communities, arctic bramble is a weak competitor and will easily be replaced by other species.

Unfavourable environmental conditions cause plant plasticity and, decrease in flowering and yield (Reier 2002b). Spring night frosts damage the blossoms. In plantations, arctic bramble starts blooming during the first half of May, while in nature it does not happen until the end of May due to semi-shadowed habitat (Starast 1998, Karp 2001, Vool et al. 2003). In the shade of the wood, the bramble suffers less from the frosts (Ryynänen 1973). However, too warm growth conditions cause rapid growth of young shoots in early spring and these can be damaged by late spring night frost (Tammisola 1988, Karp et al. 2000b). In semi-shade snow melts slowly, which inhibits rapid spring growth and, thus, lessens damage induced by night frost (Ryynänen 1973). The habitat light condition also affects bramble flowering. A too shaded habitat decreases or a stop generative shoots growth as well flowering (Reier 2002b).

According to the atlas of Estonian flora, arctic bramble has been found in 10 out of 17 habitats during the last century, whereas, in Latvia and Lithuania the species is extinct (Ingelög et al. 1993, Kukk and Kull 2005). In Estonia, arctic bramble is on the edge of extinction. By examining arctic bramble's natural habitats it is possible to help the species preservation and spreading. The aim of the present research is to explore the impact of habitat conditions; soil parameters, companion plants, and illumination on arctic bramble vegetative growth within Kaansoo in Estonia.

Materials and methods

Arctic bramble sampling in natural habitats

The investigation was carried out in arctic bramble (*R. arcticus* ssp. *arcticus*) conservation natural area in Pärnumaa Kaansoo (58°34'N-25°11'E) and a plantation in Tartu county (58°15'N26°38'E). Arctic bramble habitat and growth data were collected in July 2003 and 2006 from 5 different Kaansoo arctic bramble isolated patches, which were located approximately 2 km from each other. Additionally, arctic bramble companion plants and soil conditions were recorded. The Kaansoo isolated patches are the following:

(I) Isolated patches in the Seasaare habitat were located in a drained peatland birch (*Betula* sp.) and spruce (*Picea* sp.) forest. Approximately 5% of the arctic bramble population was with generative shoots.

(II) Isolated patches in the Vormissaare habitat were situated in the minerotrophic swamp birch forest (meadowsweet birch forest), surrounded predominantly by birches. Meadowsweet [*Filipendula ulmaria* (L.) Maxim.] was a dominant plant, competing with arctic bramble for sufficient daylight. Approximately 5% of the arctic bramble population was with generative shoots, mainly in the northern part of the population where illumination conditions were better.

(III) Isolated patches in the Rähnissaare habitat were located in a brushy area on the edge of minerotrophic swamp birch forest, where mainly willows (*Salix* sp.) grow. Arctic bramble plants grew in shade created by tall graminoids (*Calamagrostis canescens, Deschampsia caespitosa, Carex disticha* etc.) (Table 1).

(IV) Isolated patches in the Pardissaare habitat were situated in a sparse drained peatland birch forest, where birches, aspens (*Populus* sp.) and rowans (*Sorbus aucuparia* L.) grow. These areas were similar to wooded meadows in a mesic forest prior to drainage. This is the place where the first Estonian arctic bramble cultivated strain (E1) was found. Stone brambles (*Rubus saxatilis* L.) and *Calamagrostis* sp. were the main companion plants for the arctic bramble in these areas. Approximately 20% of the arctic bramble population was with generative shoots.

(V) Isolated patches in the Tammsaare habitat were in a minerotrophic swamp birch forest (with carr patches), with scarcely populated by graminoids. Approximately 20% of the arctic bramble population was with generative shoots. In 2003, various companion plants, mainly from *Dicotyledoneae* classes, but also including *Bryophyta* species were found in this habitat (Table 1).

The first Estonian cultivar of arctic bramble E1 originated from the Pardissaare habitat Kaansoo (Figure 1). In 1995, after receiving the permission from the Estonian Environment Ministry, the cultivar was re-

Table 1. Arctic bramble companion plants from classes *Dicotyledoneae*, *Monocotyledoneae* and division *Bryophyta* in Kaansoo habitats (I – Seasaare, II – Vormissaare, III – Rähnissaare, IV – Pardissaare, V – Tammsaare) in 2003

Species	Habitats					Species	Habitats				
	I	II	III	IV	V		I	II	III	IV	V
Dicotyledoneae						***Monocotyledoneae***					
Angelica sylvestris		+		+		*Agrostis canina*	+	+			
Caltha palustris			+			*A. cappillaris*	+				+
Cardamine amara			+			*Calamagrostis canescens*			+	+	
Dryopteris carthusiana					+	*Carex disticha*			+		
Equisetum palustre		+			+	*C. elongata*	+				
Filipendula ulmaria			+			*C. flava*			+		
Fragaria vesca	+			+		*C. vaginata*		+			
Galium palustre		+	+	+	+	*Deschampsia caespitosa*	+				
Geum rivale		+				*Festuca rubra*	+	+			+
Lysimachia vulgaris	+				+	*Luzula pilosa*					+
Lythrum salicaria			+			*Poa angustifolia*	+		+	+	
Maianthemum bifolium					+	*P. palustris*				+	
Melampyrum pratense			+			*Agrostis canina*	+	+			
Potentilla erecta	+					***Bryophyta***					
P. palustris			+			*Brachytecium sp.*		+		+	+
Ranunculus acer	+					*Calliergonella cuspidata*		+	+		
R. auricomus	+					*Climacium dendroides*		+	+		+
R. cassubicus				+		*Dicranium scoparium*					+
Rubus saxatilis				+		*Eurynchium sp.*	+	+		+	+
Stellaria graminea			+			*Hylocomium splendens*	+				
S. media		+		+		*Plagiomnium affine*					+
Trientalis europaea	+			+	+	*P. cuspidatum*	+			+	
Viola canina	+					*P. ellipticum*		+	+		+
V. epipsila	+	+			+	*P. undulatum*		+			
V. palustris			+			*Pleurozium schreberi*	+				

moved from its habitat in Kaansoo for the research purposes. Arctic bramble plants were propagated in vitro. In the plantation, the rows of arctic bramble were planted alternately with raspberry (*R. idaeus* L.) canes. Raspberries were planted in 1999 and arctic bramble plants in May 2000. The experimental plants were planted on a bed with plastic mulch (black polyethylene with thickness of 0.06 mm), 60 cm in width. A drip-irrigation system was placed under the mulch. The distance between plants in a row was 33 cm. The area

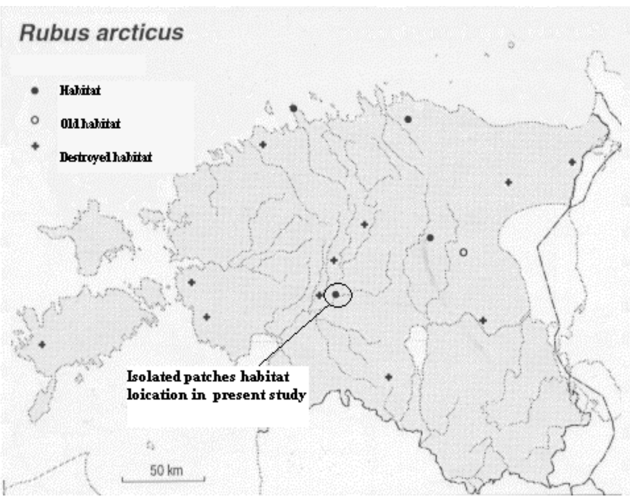

Figure 1. Arctic bramble distribution and present study isolated patches habitat location in Estonia (Kukk 1999)

between the plastic mulch rows of arctic bramble and raspberry plants was covered with sawdust mulch. The research was only conducted in the plantation in 2003 because in 2005, the plants had become infected with downy mildew disease and, therefore, the plantation was eliminated.

In Kaansoo, the soil types of the experimental area were *Stagni-Mollic Gleysol* (I, II and V habitats) and *Dystri-Histric Gleysol* (II and IV habitats) (Word Reference Base for Soil Resources, 2006). The first type of the soil is characterised by a particular uppermost litter horizon of 2 to 4 cm in thickness, the second – peat horizon, which thickness may reach 30 cm. In the plantation, the soil type was *Luvisol* (Word Reference Base for Soil Resources 2006). Soil pH was determined using an Eviko pH meter. The content of phosphorus (P: ammonium lactate extractable), potassium (K; ammonium lactate extractable), calcium (Ca) and magnesium (Mg; 1 M ammonium acetate extract, pH 7.0) were estimated in the Laboratory of Plant Biochemistry of Estonian University of Life Sciences.

Table 2. Soil analysis results in Kaansoo habitats (I – Seasaare, II – Vormissaare, III – Rähnissaare, IV – Pardissaare, V – Tammsaare) and in the plantation in 2003

Habitats	pH_{KCl}	Dry matter %	P mg kg^{-1}	K mg kg^{-1}	Ca mg kg^{-1}	Mg mg kg^{-1}	Organic matter %
I	3.23	96	26.1*	185**	1599**	171****	11.3****
II	3.89	77	62.8**	300***	5878****	706****	63.5****
III	4.30	88	43.9**	373***	3851***	796****	34.1****
IV	3.49	91	48.6**	328***	2651***	305****	26.9****
V	4.15	75	90.7***	163**	4725****	695****	51.2****
Plantation	5.29	99	111.5***	277***	1590**	135***	3.6*

The astericks (*) indicate soil content levels of P, K, Ca, Mg and organic matter: *Low, **Average, ***High, ****Very high

Measurements

The number of arctic bramble shoots and shoot growth parameters were counted using a randomized complete block 1-m^2 (in 3 replications) design. The shoot length (cm) was measured from the ground to the shoot tip. Similarly, the node number of the shoot was counted. The leaf number was counted per shoot and the second or the third petiole length (cm) on the shoot was measured. The same second or third leaf area (mm^2) per shoot was measured with AM100 (ADC BioScientific Ltd.) area meter. Chlorophyll content of the plants was measured using the portable Hydro N-Tester (SPAD-500, chlorophyll meter, Minolta Camera Co. Ltd.). It permits a rapid and non-destructive determination of leaf chlorophyll content by measuring leaf transmittance: 1 or 2 leaves in the middle of the shoot were selected for measurement. Three samples comprised 30 leaf (a total of 90 per habitat) measurements on average. Tree height was measured with Suunto clinometer PM-5/1520.

To determine the dry weight of the above ground shoots per 1 m^2 of arctic bramble and its companion plants, the shoots were dried in the oven (Memmert, model 400) for 24 hours at a temperature of 40 °C and for 2 days at the temperature of 70 °C until a constant weight was achieved. Companion plants were divided into three groups: bryophytes, graminoids and other plants.

Illumination conditions of the studied species were estimated by hemispherical photography using a COOLPIX 950 digital camera equipped with FC-E8 'fish-eye' lens (Nikon) on 24 July 2003. The illumination availability was characterized by unweighted canopy openness (open, the percentage of clear sky compared with the total hemisphere), direct site factor (DSF, the proportion of direct solar radiation reaching a given location under canopy), and indirect site factor (ISF, the proportion of diffuse solar radiation reaching a given location). The three characteristics were calculated from hemispherical photographs using WinSCANOPY software (Regent Instruments Inc.) according to the standard overcast sky model (Anderson 1966).

Statistical analysis

A one-way analysis of variance was used for vegetative growth parameters. To evaluate significances of differences among habitats, the least significant difference ($LSD_{0.05}$) was calculated. Different letters in the figures marked significant differences. The natural arctic bramble habitats results of 2003 were used to study the correlation between plants growth and habitat parameters. Linear correlation coefficients between variables were calculated; the significance of coefficients being *$P \le 0.05$, **$P \le 0.01$.

Results

The plant vegetative growth

The shoots number of arctic bramble plants growing in natural habits ranged from 149 to 421 m^{-2} (Figure 2, A). Habitat had a significant influence on shoot number in both years; shoots were most numerous in habitats IV and V. In 2006, the number of shoots remained largest in habitats IV and V but they were also significantly more in habitat I. Arctic bramble plants' dry weight among habitats ranged from 9 to 52 g m^{-2} (Figure 2, B). The dry weights were also heaviest in habitats IV and V. In 2003 the dry weight in habitat V was significantly higher than habitat IV but the data were similar between the two habitats in 2006. Habitat V was the only one where a difference between years was observed.

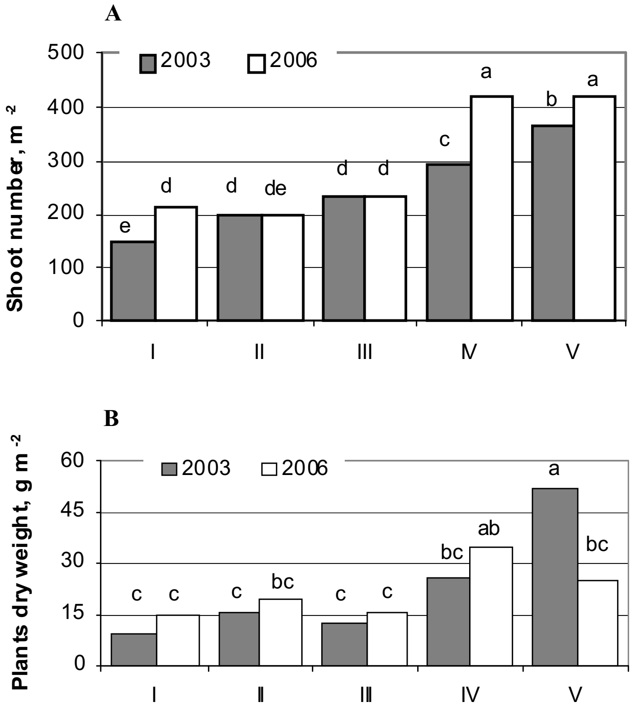

Figure 2. Influence of habitat and year on arctic bramble vegetative characters: A – shoot number m^{-2} and B – plant dry weight g m^{-2}. Habitats: I – Seasaare, II – Vormissaare, III – Rähnissaare, IV – Pardissaare, V – Tammsaare. Means followed by different letters within the same character format are significantly different by $LSD_{0.05}$

Arctic bramble shoot leaf number in natural habits and the plantation ranged from 2.8 to 4.4 (Figure 3, A). The leaf number differed significantly amongst the different habitats and increased between 2003 and 2006 in three of them (II, III, IV). The leaf number of plants in the plantation was not statistically significantly different from that of plants in habitats II and V in 2003. The year and the habitat influence on the leaf size were significant. Larger leaves were observed in habitat I in 2006 and in habitat IV in 2003 (Figure 3, B). There were also indications that leaves grew larger in the plantation than in the natural habits. Shoot petiole length ranged from 2.2 to 3.9 cm (Figure 3, C). In 2003 plants growing in the plantation had significantly shorter petioles than in any of the natural habits. A significant difference in petiole length between years was only observed in habitat V.

Leaf N-Tester value, which indirectly measures chlorophyll content, ranged from 212 to 381 (Figure 3, D). In both years, an influence of habitat was detected. Values did not differ significantly between years in any habitat type except for those in habitat V; N-Tester value was smaller in 2006. Leaf N-Tester value in the plantation was not significantly different to the plants growing in the natural habits.

Arctic bramble node number per shoot ranged from 3.3 to 6.5 and was larger in plants from plantation (Figure 3, E). Habitat V was the only one where shoot node number was the same in 2003 and 2006. Arctic bramble shoot length ranged from 8.9 to 17.2 cm (Figure 3, F). The longest shoots were measured in the plantation and the shortest, in habitat V in 2006. Shoot lengths of plants were similar between years except in habitat V where the shoots were longer in 2003 than in 2006.

Habitat conditions impact

Correlation analysis has indicated that habitat conditions have an impact on arctic bramble vegetative growth parameters (Table 3). Positive correlation was discovered between habitat openness and ISF values, and between shoot height (P≤0.01) and number (open P≤0.05, ISF P≤0.05). Furthermore, illumination parameters and arctic bramble dry weight content correlated positively (open P≤0.05, DSF P≤0.01, ISF P≤0.01). Graminoids did not affect arctic bramble growth, however, there was a positive correlation between bryophytes and other (non-graminoid) companion plants and arctic bramble node number (P≤0.05) and leaf number per shoot (P≤0.05). Positive correlation was also found between bryophytes and other companion plants on arctic bramble petiole length (P≤0.05). Negative correlation was between soil pH with leaf size (P≤0.05) and dry weight (P≤0.05) and between

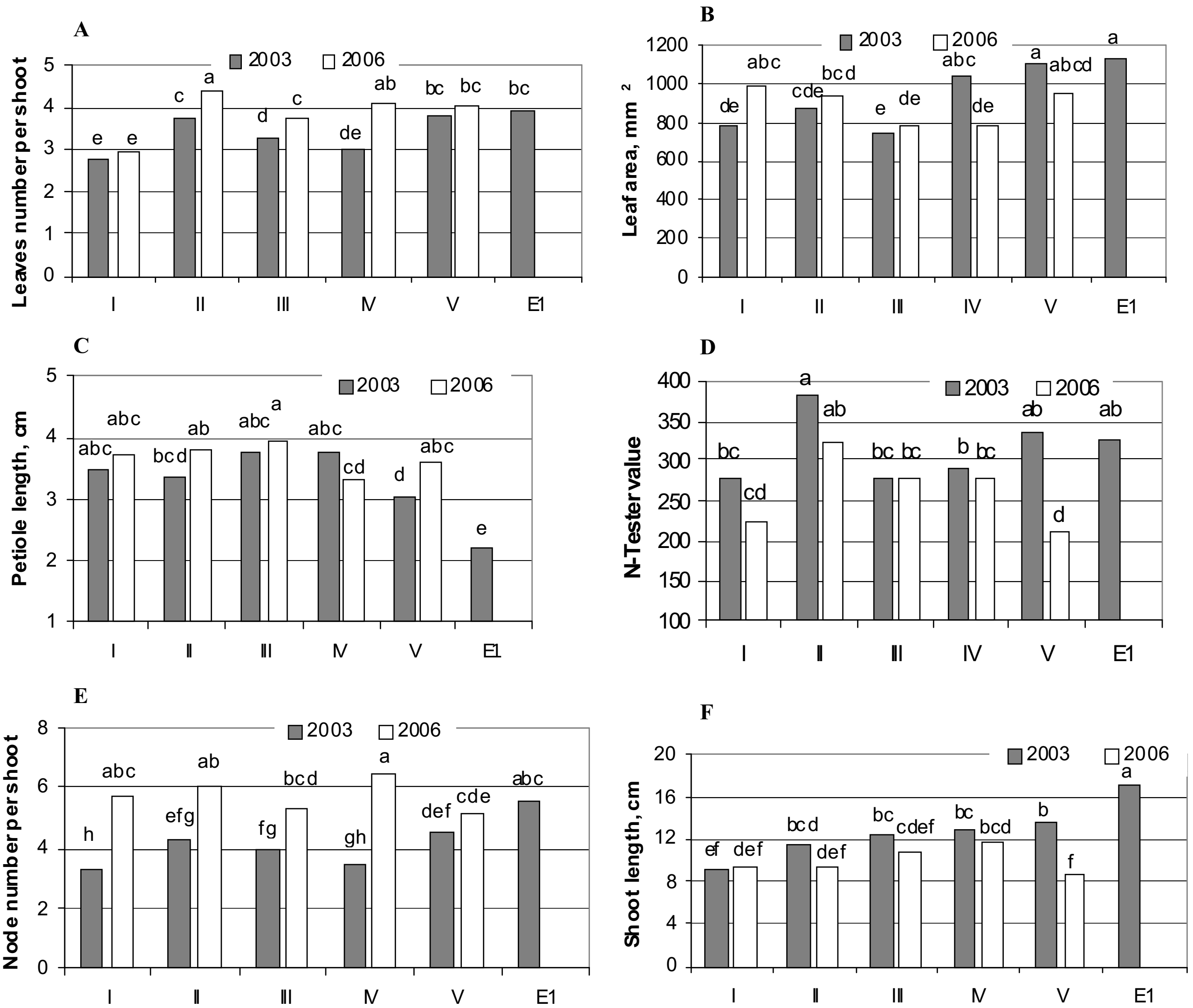

Figure 3. Influence of habitat and year on arctic bramble vegetative parameters: A – leaves number per shoot, B – leaf area (mm^2), C – petiole length (cm), D – N-Tester value, E – node number per shoot and F – shoot length (cm). Habitats: I – Seasaare, II – Vormissaare, III – Rähnissaare, IV – Pardissaare, V – Tammsaare and E1. Means followed by different letters within the same character format are significantly different by $LSD_{0.05}$

soil moisture and petiole length ($P \le 0.05$). Soil moisture was positively correlated with node number per shoot ($P \le 0.05$), leaf number per shoot ($P \le 0.01$) and N-Tester values ($P \le 0.01$).

7.4 in both natural habitats and in plantations (Jaaniste 1991, Karp 2001, Vool et al. 2009). When comparing mineral soil nutrients content level in the plantation and natural areas, we discovered that phosphorus (P), potassium (K), magnesium (Mg) content was high and calcium (Ca) content – average in plantation (Table 2). In isolated patches in habitat I soil values of P, Ca, Mg and organic matter were low. In habitat II, Ca and organic matter content values were high; in habitat III, K and Mg content were elevated; and in habitat V where plants had the lowest dry weight and K content was also lowest. From the above stated we may conclude that soil nutrient composition had no impact on the research results. Nutrient availability depends on soil moisture (Bengtson et al. 2005), which tends to be more sporadic in natural habits than in the plantation, where moisture is provided by an irrigation system.

Table 3. Correlation coefficients between arctic bramble growth parameters and habitat characteristics in Kaansoo in 2003 (n=14). The asterisks (*) indicate significance levels: *$P \le 0.05$, **$P \le 0.01$, ns=not significant. DSF – illumination direct site factor, ISF – indirect illumination site; DW – dry weight

Investigated values	*Shoots length*	*Shoot number*	*Node number per shoot*	*Leaves number per shoot*	*Petiole length*	*Leaf area*	*N-Tester value*	*Arctic bramble DW*
Open	**0.731****	**0.654****	0.327 ns	0.332 ns	-0.329 ns	0.252 ns	0.097 ns	**0.670****
DSF	0.343 ns	0.378 ns	0.151 ns	0.160 ns	-0.486 ns	0.187 ns	0.134 ns	**0.538***
ISF	**0.702****	**0.576***	0.312 ns	0.328 ns	-0.263 ns	0.166 ns	0.087 ns	**0.538***
Graminoides DW	0.166 ns	0.170 ns	-0.032 ns	-0.152 ns	0.330 ns	-0.193 ns	-0.479 ns	-0.041 ns
Bryophytes DW	0.051 ns	-0.157 ns	**0.600***	**0..564***	0.150 ns	-0.254 ns	0.299 ns	-0.218 ns
Other companion DW	0.457 ns	0.184 ns	**0.540***	**0.592***	-0.369 ns	**0.504***	0.369 ns	0.468 ns
Trees height	-0.128 ns	0.069 ns	-0.329 ns	-0.288 ns	-0.074 ns	0.474 ns	-0.044 ns	0.214 ns
Soil pH_{KCl}	-0.026 ns	-0.224 ns	-0.057 ns	-0.012 ns	0.467 ns	**-0.497***	-0.018 ns	**-0.572***
Soil moisture	0.397 ns	-0.115 ns	**0.518***	**0.642****	**-0.598***	0.242 ns	**0.644****	0.434 ns

Discussion

The research showed that, arctic bramble growth parameters in natural habits and in the plantation varied significantly: in the plantation, petiole length was shorter but shoots were longer, with a greater node number per shoot. The plants in the plantation grew considerably higher than in natural habits, with a larger node number that rules out the possibility of plant elongation. The plants' growth in the plantation may have benefited from plastic mulch and, thus, excluding the necessity to compete with other plants for soil nutrients and moisture. In natural conditions, arctic bramble has to compete for nutrients with other companion plants. Moreover, illumination conditions are low, which leads to shoot elongation and, also may hinder fruit bud formation. In nature, the plants failed to reproduce; however, in the plantation, the yield of berries in 2003 (the second crop year) was 473 g 10 m^{-1} (Vool et al. 2009).

In study, soil pH varied from 3.7 to 5.5 (soil was more acidic in habitat I) and affected vegetative growth, but did not affect the leaf chlorophyll content. Ryynänen (1973) pointed out that although arctic bramble is not constrained by soil pH, his experiments showed that arctic bramble yield decreased with higher soil pH. In the present research, soil pH was higher in the plantation but the plants reproduced, in nature pH was lower but the plants did not produce fruit. Kokko et al. (1993) and Larsson (1969) have found that the most suitable pH range for arctic bramble is from 4 to 5.5. In Estonia, soil pH ranged from 5.4 to

The correlation analysis indicated that plant growth in natural habitats was primarily influenced by the habitat illumination conditions. Arctic bramble plants shoot number, length and weight depend on illumination, the percentage of clear sky compared with the total hemisphere and the proportion of diffuse solar radiation. The direct solar radiation did not have any effect on arctic bramble growth because trees created shade in most growth areas. The connection between all illumination measurement values and arctic bramble dry weight was related to a larger shoot length and number per each area unit. Kavaliauskas (2002) discovered that *R. plicatus* plants' height is also significantly influenced by illumination conditions and plants grew higher in habitat types that are similar to the edge of a drainage ditch. The present research revealed that the shoot length and node number per shoot in the plantation were to a certain extent larger compared to nature. Previous supports the theory that illumination promotes arctic bramble growth. In nature, arctic bramble growth is positively affected by diffuse solar radiation and they grow higher. However, it does not influence node number and we may conclude that such habitat conditions encourage plant plasticity. Reier (2002b) mentions that arctic bramble blooming ceases in shady habitats but the plants may remain vegetative for a lengthy period of time. Kavaliauskas (2002) concludes that, in habitats with higher illumination, plants have more flowers and fruiting shoots per plant. In the present research, arctic bramble plants neither flowered nor produced fruit in natural habits, so the illumination contributes to greater vegetative growth. It has been reported that growth also depends on the density of woody plants growing in the area, which is related to their shading the shorter statured arctic bramble plants (Weiner 1985). The present research did not reveal woody plant height impact over most arctic bramble vegetative growth parameters, except leaf surface area, which increased with woody plants' height.

Bryophyte and dicotyledonous plants were the companion plants that mainly influenced arctic bramble node number and leaf number per shoot. The present research indicated no significant relationship between companion plants and shoot length. If habitat conditions are favourable for companion plants, arctic bramble is a weak competitor and will easily be replaced by other plants (Tammisola 1988). Companion plants influence on arctic bramble may be related to habitat conditions. For example, in moist areas arctic bramble starts growing fast in spring, earlier than companion plants which may reach their maximum height only by midsummer (e.g. meadowsweet *Filpendula*). Similarly, in growth areas rich in solar radiation competitive herbaceous plants grow better and supplant arctic bramble (Reier 1982). Bryophyte and arctic bramble competition is not intense; the former, appears to assist in creating suitable growth conditions for arctic bramble in excessively moist habitats. Graminoid species and grass species, which form thick clumps (e.g. *Deschampsia caespitosa, Calamagrostis canescens*), compete with arctic bramble both above and under the ground. Spruce casts the most shade among the trees within arctic bramble habitat and was particularly well-represented in Kaansoo habitat I, where arctic bramble shoot and leaf numbers were fewer.

Research also indicated that higher moisture causes an increase in node and leaf number per shoot and N-Tester value and a decrease in petiole length. Ryynänen (1973) and Pirinen et al. (1998) described how favourable environmental conditions influence arctic bramble growth parameters and leaf size. Lohi (1974) discovered that the leaves of cloudberry (*R. chamaemorus* L.), an arctic bramble related species, grow larger in shadowed areas and are smaller in open sunny areas. Although, the present research did not provide any confirmation of any relation between soil moisture and leaf size, we may conclude that a shadowed growth area is more protected against water evaporation and, thus, more favourable for arctic bramble vegetative growth. The research revealed that a shorter petiole length was related to increased moisture. In Kaansoo, petiole length decreased together with soil moisture increase. Ricard and Messier (1996) also discovered that forest trees canopy influenced petiole length in raspberry (*Rubus idaeus* L.). This type of impact is excluded. In the present research petioles were always measured from the middle of the shoot and can not be directly compared to these results. The results from the present study are based on the data of only two years and further research on the influence of soil moisture on arctic bramble growth parameters is needed.

In research area soil moisture also influenced positively leaf chlorophyll content. Previous experiments have indicated correlation between chlorophyll meter reading and N content of plant leaves (Porro et al. 2001, Gianquinto et al. 2009). Vestberg (1992) found that arctic bramble nitrogen nutrition does not depend on soil N content because the roots are in a symbiosis with vesicular-arbuscular mycorrhiza. Mycorrhizal fungi capture nutrients such as nitrogen and micronutrients from the soil. Moisture affects mycorrhiza spread and we can speculate that the higher the soil moisture is, the better the fungi can capture nitrogen, subsequently increasing leaf N content. Throughout our research, it was observed that the leaf chlorophyll content was consistently higher in habitat II. This provides evidence for our conclusion regarding moisture and N-content correlation, as habitat II had *Dystri-Histric Gleysol*, which is characterised by continuous excessive moisture and higher organic matter content (Table 1). Previous experiments conducted in Estonia showed that the leaf chlorophyll content might depend on the plant growth stage; thereby the lower value is during the period of massive blooming in May and higher during the yield ripening period in July (Karp et al. 2000a, Reier 2002b). Thus, plant nutrient supply decreases significantly in case of fast growth and during blooming, when the demand for nutrients is extraordinarily high.

Conclusion

Arctic bramble growth varies in the different isolated patches of native habitat in Kaansoo. No negative changes in plant status (plant density, vegetative growth parameters and chlorophyll content) were detected during the period of this study (2003 to 2006). However, the plants did not reproduce in natural habits and differed significantly from those growing in the plantation. In natural habitats and the plantation, petiole length, shoot length, and node number per shoot were significantly different. In Kaansoo, arctic bramble vegetative growth parameters were mainly influenced by illumination (canopy openness and diffuse solar radiation), companion plants and soil moisture. Plant distribution dynamics in natural habitats and in a controlled plantation environment may be issues of further research. These parameters are important to consider when determining optimal cultivation. Also these studies may provide forest trees managers with information on how to manipulate forest canopies to encourage arctic bramble growth and development in Estonia.

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СОСТОЯНИЕ ПОЛИНИКИ (*RUBUS ARCTICUS*) В ЭСТОНИИ В ЗАКАЗНИКЕ КААНСОО

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Резюме

На протяжении последнего века поленика (*Rubus arcticus* L. ssp. *arcticus*), реликтовое растение, произрастающее с тех времен, когда климат Эстонии был предполярным, является охраняемым видом из-за постоянного сокращения его среды обитания. Вышеизложенное указывает на необходимость исследования влияния условий среды обитания на вегетативные параметры роста арктической малины в различных местах Каансоо. В центре внимания данного исследования – пять видов естественной среды обитания и одна плантация, растения которой были взяты из одного из указанных выше, естественных мест обитания. В результате проведенного исследования мы выяснили, что, растения не плодоносили в естественных условиях. Более того, были отмечены существенные различия в длине черешков, стеблей и количестве узлов на каждом стебле у растений, произрастающих в природных условиях и в плантации. В районе Каансоо особое влияние на вегетативные параметры роста арктической малины оказывали, прежде всего, нормальная разреженность полога и уровень освещенности – его повышение, в последствие, приводило к увеличению количества и длины стеблей растений. Лёгкая разреженность полога и рассеянный солнечный свет способствовали растяжению растений. Среди сопутствующих растений, моховидные (*bryophyta*) и другие (двудольные) растения класса *dicotyledonous* оказывали наибольшее влияние на вегетативные параметры роста арктической малины; более того, увеличение числа сопутствующих растений прямопропорционально повышало количество узлов и листьев на каждом стебле. В ходе исследования, получила подтверждение гипотеза относительно сильной корреляции уровня pH в почве и ее влажности, с одной стороны; и показателя N-тестера (показатель содержания азота), длины черешков, количества узлов и листьев, с другой.

Ключевые слова: поленика (*Rubus arcticus* L. ssp. *arcticus*), условия среды обитания, вегетативные параметры роста, виды сопутствующих растений.