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Success of hardy micro-propagated ornamental shrubs in Northern Finland

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Summary

In vitro propagation was used to study the success of micro-propagated plants in northern areas. Experiments were done on the most valuable origins of the *Viburnum* and *Syringa* genuses, primarily for winter hardiness and growth. Of the species studied, *Viburnum opulus* 'Pohjan Neito' (Tornio), *Syringa* × *josiflexa* 'Veera' and *S.* × *henryi* 'Paulus' were most optimal for ornamental use in northern areas. In vitro propagation is an effective method to produce successful plant material for northern areas.

Introduction

Micro-propagation is commonly used for the propagation of ornamental woody plants, and it has become an important part of the modern plant propagation industry. Micropropagation has the advantage of producing new individuals in manifold numbers compared to traditional cuttings. Trees and shrubs suitable for northern areas can be cultivated on surprisingly uniform media, and their development can be supervised with the same hormones. Micro-propagation has many practical applications, e.g. propagation of disease-free plants, mass propagation of selected genotypes and genetic engineering (HAAPALA et al., 1992; ILAN and KHAYAT, 1997; HAAPALA, 2004).

In order to improve the quality of ornamental plants and to find promising plant material for further use in Northern Finland, plant selection experiments were established at the beginning of 1990's. Micro-propagation methods for over 40 registered plant origins were developed, aiming at mass production of the best, selected, origins (TIGERDSTEDT et al., 1987; HAAPALA et al., 1992; LAINE et al., 1993; TARVAINEN et al., 1993; VÄINÖLÄ et al., 1995).

Species of the *Viburnum* and *Syringa* genuses are widely used as ornamental plants in northern areas. There are not many records of the history of *Viburnum* cultivation in Finland (ALANKO, 1980). According to PARVELA (1930), *Viburnum* species were not used as ornamental plants in northern Finland at least at the beginning of the 20th century, even though nowadays *Viburnum opulus* 'Pohjan Neito', common snowball, is a very popular ornamental shrub in Northern Finland. *Syringa vulgaris* was first introduced to Southern Finland in the mid-1700s, and it began to spread rapidly throughout Finland (SUOMINEN, 1987). *S. vulgaris*, common lilac, and *S. josikaea*, Hungarian lilac, were quite common ornamental plants in private gardens and parks at the end of the19th century already both in Northern Finland and in Finnish Lapland (PARVELA, 1930).

The aim of this study is to i) monitor the success of micro-propagated shrub origins hardy in the north, ii) to assess the field performance of the test shrubs and to iii) recommend the best origins for northern landscaping.

Materials and methods

This study was based on phenological monitoring and observations of several parameters (Tab. 1). Observations were made on eight micro-propagated shrub origins (Tab. 2) at 4 study sites in Northern Finland: **Naruska** (67°09'N, 29°10'E, 213 m a.s.l.) experimental field of the University of Oulu, Agricultural Research Centre of Finland's regional units at **Rovaniemi rural municipality** (66°35'N, 26°01'E, 103 m a.s.l.), **Ruukki** (64°40'N, 25°05'E, 45 m a.s.l.) and **Sotkamo** (64°06'N, 28°20'E, 150 m a.s.l.), corresponding to the Finnish plant hardiness zones V-VII (Fig. 1). Plant material was collected from old parks, gardens, arboretums, nurseries, etc. and propagated for the selection experiments at the Botanical Gardens of the University of Oulu. Shrub cultures were grown on the MS media described by MURASHIGE and SKOOG (1962) or on the Woody Plant Media (VPM) described by LLOYD and MCCOWN (1980) with different mineral and hormone concentrations (HAAPALA et al., 1992).

The plantations at the experimental sites were made in the spring 1992. The study plants were planted in rows, with 1.5 x 2 m between shrubs, and 12 *in vitro* propagated plants per original mother plant were planted at each study site in a random order. A covering sheet was laid on the ground for weed control. The interlinear walkways were sown with grass. The plants were scarcely fertilized (Kemira NPK 10:7:14, 10 g per plant) during the experiment. Dead and broken branches and shoot tips were cut off every spring. Parameters for this study were recorded during 1993 to 1999. The observations were divided into two categories: Phenology and Success (Tab. 1).

Plant material

The *Viburnum* genus includes over 225 species throughout the world, and of these only *V. opulus*, *V. opulus f. roseum* and *V. lantana* are commonly cultivated in Finland (ALANKO, 1980; ESKILSSON, 1994). *Viburnum lantana* L., wayfaring tree, is an easy-to-care shrub that prefers calcareous soils and has decorative dark green leaves. The thick, leathery leaves make this shrub an excellent noise cover plant. The studied origin is an upright shrub 2 m in height with ovate leaves. All flowers in the inflorenscence are fertile, small and white. The red berries turn black when they ripen. Common snowball is a popular and brilliant shrub due its big, white flowers. There are two cultivars, *Viburnum opulus* L. 'Roseum' and 'Pohjan Neito', on sale in Finland, which differ from each other in winter hardiness (JUHANOJA et al., 1998). 'Pohjan Neito' succeeds in Northern Finland. Three origins were studied (Tab. 2). The origins are upright, rounded shrubs 2-3 m in height. Leaves are opposite, with dentate lobes and a broad middle strip. Flowers are in showy ball-shaped clusters, and almost all white flowers are sterile. Origin Tervola has a luxuriant growth habit. Origin Kempele was planted only at the Naruska site.

Genus *Syringa* includes ornamental species and hybrids with beautiful and fragrant, lilac, violet, purple, pink or white flowers. *Syringas* are old and valuable ornamental plants in Finland due their good winter hardiness and abundant flowering. Four cultivars were studied. *S.*

vulgaris L. 'Alba' origin has upright and rather dense shoots that form a shrub 2-5 m in height. Its leaves are dark green and heart-shaped, and the white flowers develop in large terminal clusters. *S. villosa* Vahl 'Hirvas' is an upright shrub of 2-4 m with a regular growth habit. Its flower clusters consist of white flowers. *Syringa* × *josiflexa* Preston ex Pringle *(josikaea* × *reflexa)* 'Veera' is an upright, outward-branching shrub of 2-3 m with a regular growth habit. Its flower clusters are dense and flaccid. Florets are purple to rosy pink and get lighter during flowering. *S.* × *henryi* C.K. Schneider *(S. josikaea* × *S. villosa)* 'Paulus' is a shrub growing 2-3 m high and wide. Its inflorescence is large, abundantly multiple and pink. The shrub has a showy appearance.
The plant material was identified mainly according to HÄMET-AHTI et al. (1992) and RÄTY and ALANKO (2004).

Data analysis

Plant individual specific means for the following phenological parameters measured on a continuous scale were computed: (1) beginning day of leaf burst and (2) ending day of foliation, (3) beginning and (4) ending day of flowering, (5) beginning and (6) ending day of autumn coloration, (7) beginning and (8) ending day of leaf senescence. Of these, the lengths of foliation, flowering and the green (from foliation to autumn coloration) and autumn coloration periods were calculated in days. For the following parameters measured on an ordinal scale, we computed plant-specific medians of the values measured in different years: (1) winter hardiness, (2) ornamental appearance, (3) occurrence of leaf diseases, (4) occurrence of leaf pests, (5) occurrence of shoot diseases, (6) occurrence of shoot pests and (7) occurrence of flowers. For the parameters measured on an ordinal scale, a 5-point scale was used (Tab. 1).

The aim was to find out whether there were differences in the success of the different shrub origins within the *Viburnum* and *Syringa* groups. Hence, we performed statistical analyses separately for each study location (Naruska, Rovaniemi, Ruukki and Sotkamo) and each plant family (*Viburnum* and *Syringa*). The data recorded on a continuous scale were analysed by means of one-way ANOVA with taxa (origin) as the grouping factor. In case the assumptions of ANOVA were not met (homogeneity of variance and normal distribution), and in case the variables were recorded on an ordinal scale, the data were analysed by means of the nonparametric Kruskal-Wallis test.

Climatic conditions at experimental sites

Data on climatic conditions during the experiment were obtained from field research stations and from Finnish Meteorological Institute (Tab. 3). Naruska is the northernmost test site with cold and extremely harsh growing conditions for plants. The effective temperature sum is low, and the soil is nutrient-poor peat land. At Rovaniemi, with its

Tab. 1: Monitoring parameters used in a plant selection experiments along growing season.

Variable	Scale	Scale explanation
A. Phenology		
(April-June)		
Onset of foliation	date	when 10% of budscales are open and buds are green
Full foliation	date	when over 90% of buds are open
(May-July)		
Onset of flowering	date	first 10% of flower buds flushed
End of flowering	date	last 10% of flower buds flushed, 90% of flowers wilted
(August-October)		
Onset of autumn coloration	date	first 10% of leaves autumn coloured
End of autumn coloration	date	last 10% of leaves autumn coloured
Description of autumn coloration	verbal	slow-normal-fast-ugly-moderate-beautiful
Onset of leaf defoliation	date	first 10% of leaves shed
End of defoliation		date last 10% of leaves shed
B. Success		
(April-June)		
Winter hardiness	1-5	1:dead, 2:dead to ground level, 3:dead to snow level, 4:shoot tips dead, 5:tip buds dead or no damage
(July)		
Ornamental appearance	1-5	1:ugly, 2:rather ugly, 3:moderate, 4:rather beautiful, 5:beautiful
Occurrence of leaf diseases	1-5	1:over 90% injury, 2:70% injury, 3: 50% injury, 4:30% injury, 5:no significant injury
Occurrence of leaf pests	1-5	
Occurrence of shoot diseases	1-5	
Occurrence of shoot pests	1-5	
(May-July)		
Occurrence of flowers during full flowering	1-5	1:none, 2:few, single (1-10), 3:moderate (11-30), 4:rather abundant (31-50), 5:abundant (over 50)
(July-August)		
Occurrence of fruit and berries	1-5	1:none, 2:few, single (1-10), 3:moderate (11-30), 4:rather abundant (31-50), 5:abundant (over 50)

mild subarctic climate, growing conditions are harsh, and hares caused wintertime damage to the study plants. The soil is mainly peat. The Ruukki site, located near the Bothnian Bay, has the mildest winters and fertile soil with good structure. In the coastal areas, wintertime weather can be extremely variable, and the snow cover is usually thin.

In the Sotkamo area, the climate conditions are continental with cold winters and warm summers. The snow cover is usually thick. The soil is mineral soil. During the growing season, night frosts may occur at the Naruska and Rovaniemi sites, which are located above the geographical arctic circle (66° N).

Fig. 1: Plant hardiness zones (I a – VIII) in Finland and location of the study sites, Naruska, Rovaniemi, Ruukki and Sotkamo (▲), in Northern Finland. (Plant hardiness zonation source from http://www.mainio.net/article.asp?path=1;1132;1133;5563;38386)

Results

Phenology

Viburnum

At the northernmost site, Naruska, the onset of foliation with *Viburnum opulus* 'Pohjan Neito' origins occurred in June. At the other harsh site, Rovaniemi, the onset of foliation occurred after the end of May. At the more favourable sites further south, Ruukki and Sotkamo, the onset of foliation occurred around mid-May. The difference in the duration (days) of foliation between the origins was significant at Sotkamo ($F_{2,23} = 26.324$***) (1-way ANOVA, F-value with df-value for origins and error) (Fig. 2). Snowballs started flowering at the end of July at Naruska and flowered for over two weeks. At Rovaniemi, flowering started earlier, i.e. at the beginning of July, and the flowering period was short. The onset of flowering at the more southern sites occurred after mid-June. The flowering periods lasted for 10 to 22 days, and the difference in the length of flowering periods was statistically significant (Ruukki; $F_{2,25} = 24.121$***, Sotkamo; $F_{2,33} = 43.947$***) (Fig. 3).

The green periods were shortest, 80 days, at Naruska and 90 to 119 days at the other sites (data not shown). At Rovaniemi ($F_{2,32} = 18.517$***), Ruukki ($F_{2,31} = 14.614$***) and Sotkamo ($F_{2,33} = 81.174$***), *V. lantana* had the longest green period and the snowball origin Tervola the shortest. At the northernmost site, the autumn coloration period began as early as the end of August and defoliation in October. At the other sites, autumn coloration started in September and defoliation at the beginning of October. The difference in the duration of autumn coloration periods was significant at the Rovaniemi ($F_{2,28} = 5.915$ **), Ruukki ($F_{2,31} = 11.886$ ***) and Sotkamo ($F_{2,33} = 48.960$ ***) sites (Fig. 4).

Syringa

Lilacs started foliation at Naruska at the beginning of June (*Syringa vulgaris* 'Alba', no data) and at Rovaniemi at the end of May. At Ruukki and Sotkamo, foliation begun around mid-May. The lengths of the period differed significantly at Rovaniemi ($F_{3,34} = 12.872$ ***) and Sotkamo ($F_{3,34} = 4.342$ **) (Fig. 2). The onset of flowering at Naruska was late: *S.* × *josiflexa* 'Veera' began to flower in August

Tab. 2: Shrubs in plant selection experiments.

Shrub	Registration number	Origin
1. *Viburnum lantana*	87	Tornio (65°50'N, 24°48'E)
2. *Viburnum opulus* 'Pohjan Neito'	91	Tornio (65°50'N, 24°48'E)
3. *Viburnum opulus* 'Pohjan Neito'	89	Kempele (65°20'N, 25°20'E)
4. *Viburnum opulus* 'Pohjan Neito'	293	Tervola (66°05'N, 24°48'E)
5. *Syringa vulgaris* 'Alba'	84	Tornio (65°50'N, 24°48'E)
6. *Syringa villosa* 'Hirvas'	329	Rovaniemi mlk* (66°30'N, 25°50'E)
7. *Syringa* × *josiflexa* 'Veera'	327	Rovaniemi mlk* (66°30'N, 25°50'E)
8. *Syringa* × *henryi* 'Paulus'	297	Rovaniemi (66°30'N, 25°42'E)

*Rovaniemi rural municipality

Tab. 3: Climatic conditions (minimum and maximum values) at the experiment sites from 10 years period (1989-1999).The growing season begins when the daily mean temperature exceeds +5 C° on five days in succession and the ground is at least half snow free. The effective temperature sum is calculated by summing the daily mean temperatures of the days on which the temperature exceeds +5 C° from the beginning of the growing season. (*Climatic data is from the nearest most weather station to Naruska in Salla (66°50'N, 28°40'E, 215 m a.s.l.).)

		Salla*	Rovaniemi	Ruukki	Sotkamo
Beginning of growth period	min	12.5.	2.5.	2.5.	18.4.
(date)	max	5.6.	31.5.	21.5.	11.5.
End of growth period	min	4.9.	7.9.	11.9.	12.9.
(date)	max	29.9.	6.10.	19.10.	19.10.
Duration of growing season	min	95	125	142	137
(days)	max	138	146	164	162
Effective temperature sum	min	651	726	924	900
(C°)	max	891	1007	1146	1219
Annual precipitation	min	427	412	440	472
(mm)	max	789	802	762	605
Snow depth in February	min	45	37	0	15
(cm)	max	93	77	58	56
Temperature	min	-40.6	-42.6	-32.2	-36.6
in February (C°)	max	4.3	3.0	4.1	8.7
Temperature	min	-0.1	3.7	3.4	3
in July (C°)	max	27.5	25.8	26.6	30.7

and *S.* × *henryi* 'Paulus' (*S. villosa* 'Hirvas', no data) in July. At Rovaniemi (*S. vulgaris* 'Alba', no data), the onset of flowering occurred before mid-July. At Ruukki, flowering started in June, except in the case of 'Hirvas', which began flowering in July. At Sotkamo, the flowering period started at the end of June for 'Paulus' and 'Alba', and at the beginning of July for 'Veera' and 'Hirvas', lasting over 12 days ($F_{2, 32} = 56.894$ ***) (Fig. 3).

The green periods were shortest at the harsh Naruska site, around 86 days. *S. vulgaris* 'Alba' showed a long green period of over 123 days, at the other sites. The green periods of the other lilac origins ranged from 105 to 114 days (Rovaniemi; $F_{3, 34} = 27.729$ ***, Ruukki; $F_{3, 37} = 15.442$ ***, Sotkamo; $F_{3, 34} = 13.764$ ***). Autumn coloration at the northernmost site started at the end of August and defoliation around the middle of September. At Rovaniemi, the onset of autumn coloration occurred in September. Defoliation begun at the end of September. At Ruukki, autumn coloration began in September. Defoliation started after mid-September. At Sotkamo, the onset of autumn coloration occurred in September for 'Alba' and 'Hirvas' and at the end of August for the others, and the duration of the periods differed significantly ($F_{3, 44} = 13.789$ ***). Defoliation began at the end of September. (Fig. 4)

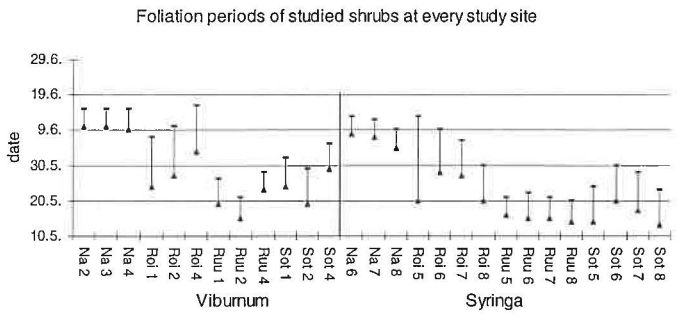

Fig. 2: Foliation periods (beginning and ending date) of the shrubs at every study site. Foliation started when 10% of bud scales were open and buds were green and ended when over 90% of buds had opened. Study sites; Na = Naruska, Roi = Rovaniemi, Ruu = Ruukki and Sot = Sotkamo. Shrubs; 1 = *Viburnum lantana*, 2 = *V. opulus* 'Pohjan Neito' (Tornio), 3 = *V. opulus* 'Pohjan Neito' (Kempele), 4 = *V. opulus* 'Pohjan Neito' (Tervola), 5 = *Syringa vulgaris* 'Alba', 6 = *S. villosa* 'Hirvas', 7 = *S.* × *josiflexa* 'Veera', 8 = *S.* × *henryi* 'Paulus'.

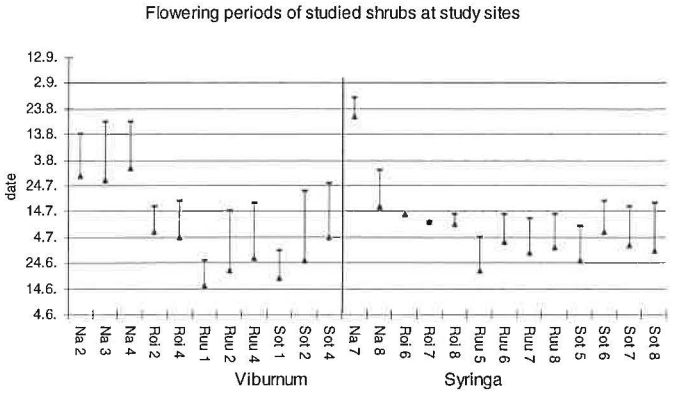

Fig. 3: Flowering periods (beginning and ending date) of the shrubs at every study site. Flowering started when the first 10% of flower buds had flushed and ended when 90% of flowers had wilted. Study sites; Na = Naruska, Roi = Rovaniemi, Ruu = Ruukki and Sot = Sotkamo. Shrubs; 1 = *Viburnum lantana*, 2 = *V. opulus* 'Pohjan Neito' (Tornio), 3 = *V. opulus* 'Pohjan Neito' (Kempele), 4 = *V. opulus* 'Pohjan Neito' (Tervola), 5 = *Syringa vulgaris* 'Alba', 6 = *S. villosa* 'Hirvas', 7 = *S.* × *josiflexa* 'Veera', 8 = *S.* × *henryi* 'Paulus'.

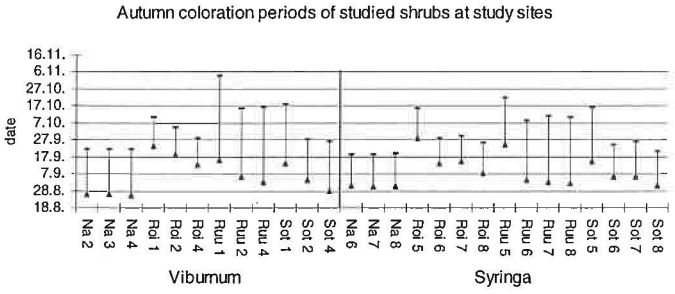

Fig. 4: Autumn coloration periods (beginning and ending date) of the shrubs at every study site. Autumn coloration started when the first 10% of leaves were autumn-coloured and ended when the last 10% of leaves autumn were coloured. Study sites; Na = Naruska, Roi = Rovaniemi, Ruu = Ruukki and Sot = Sotkamo. Shrubs; 1 = *Viburnum lantana*, 2 = *V. opulus* 'Pohjan Neito' (Tornio), 3 = *V. opulus* 'Pohjan Neito' (Kempele), 4 = *V. opulus* 'Pohjan Neito' (Tervola), 5 = *Syringa vulgaris* 'Alba', 6 = *S. villosa* 'Hirvas', 7 = *S.* × *josiflexa* 'Veera', 8 = *S.* × *henryi* 'Paulus'.

Success

Viburnum

At the northernmost site, *Viburnum lantana* suffered serious winter damage, and most of the studied shrubs died during the experiment. The studied snowballs had fairly good winter hardiness, but damaged shoots were observed every spring (Fig. 5 A). At Rovaniemi, *Viburnums* showed moderately good winter hardiness (Fig. 5 B). At Ruukki, *V. lantana* and snowball origin Tornio were hardy against the winter, but origin Tervola suffered small damage at shoot tips. At the snow-rich Sotkamo site, *V. lantana* and snowball origin Tornio had excellent and origin Tervola good winter hardiness. The differences between the origins were statistically significant at the other sites except Rovaniemi (Fig. 5 A, 5 C and 5 D).

All snowball origins were rated as rather beautiful at Naruska. At Rovaniemi, *V. lantana* was evaluated as rather ugly, while snowballs gained moderate values ($X^2 2 = 10.057$**, Kruskall-Wallis X^2 value with df value for origins). All origins were also rated as moderate at Ruukki. *V. lantana* was rated as beautiful and snowballs as rather

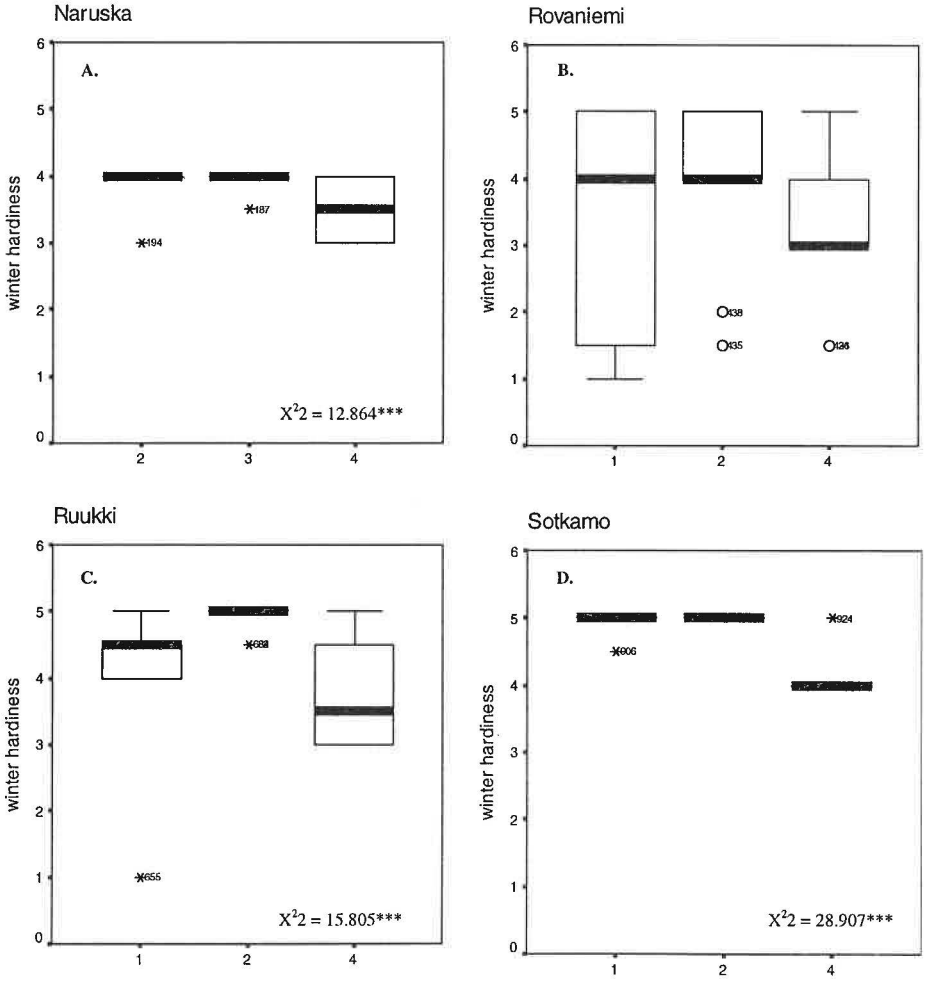

Fig. 5 A-D: Winter hardiness of the studied *Viburnums* at every study site. Shrubs (x-axis); 1 = *Viburnum lantana*, 2 = *V. opulus* 'Pohjan Neito' (Tornio), 3 = *V. opulus* 'Pohjan Neito' (Kempele), 4 = *V. opulus* 'Pohjan Neito' (Tervola). Scale 1-5 (y-axis); 1 = dead, 2 = dead to ground level, 3 = dead to snow level, 4 = shoot tips dead, 5 = tip buds dead or no damage. Median (thick line) and central box that contains 50% of the variation. From the ends of the box, "whiskers" have been drawn that extend 1.5 times the width of the box. Any observation outside these whiskers is considered an outlier. The maximum and minimum values are also indicated. Kruskal-Wallis X^2 values with the df values for the origins tested separately for each study location, *** p = 0.001.

beautiful at Sotkamo ($X^2 2 = 11.165^*$). The studied origins did not suffer from diseases or pests. Only at Rovaniemi did *V. lantana* and snowball origin Tervola experience minor leaf damage due to diseases and pests ($X^2 2 = 6.079^*$).

Flowering was poor at the northernmost sites (Fig. 6 A-B). At Ruukki, the occurrence of flowers was moderate in *V. lantana*, abundant in snowball origin Tornio and scant in origin Tervola. At Sotkamo, the occurrence of flowers was scant in *V. lantana* and moderate in snowballs. The differences were statistically significant at the other sites (Fig. 6 B, 6 C and 6 D) except at Naruska. The occurrence of berries was scant in *V. lantana*.

Syringa

S. vulgaris 'Alba' had poor winter hardiness at the northernmost sites, and the study plants died at Naruska. All the other studied *Syringa* origins had good winter hardiness with only minor winter damage, and the differences between the origins were statistically significant (Fig. 7 A-B). At Ruukki, 'Alba' experienced some shoot tip damage, while the others had excellent winter hardiness, and the difference was significant (Fig. 7 C). No winter damage was recorded at Sotkamo (Fig. 7 D).

The ornamental value of all surviving *Syringas* was rather good at Naruska (Fig. 8 A). At Rovaniemi, 'Alba' was rated as rather ugly, while 'Hirvas' and 'Veera' were considered moderate and 'Paulus' was appreciated as rather beautiful (Fig. 8 B). At Ruukki, 'Alba' was rated as rather ugly, 'Hirvas' and 'Veera' as rather beautiful and 'Paulus' as beautiful (Fig. 8 C). At Sotkamo, 'Alba' and 'Veera' were evaluated as rather beautiful, 'Hirvas' as moderate and 'Paulus' as beautiful (Fig. 8 D). The differences between the origins were significant at every site (Fig. 8 A-D). At Rovaniemi, 'Hirvas' experienced some leaf damage due to diseases, and 'Veera' and 'Paulus' suffered minor leaf damage due to pests and diseases ($X^2 3 = 20.990^{***}$). No damage to shoots was observed. At the other sites, *Syringas* did not suffer any damage due to diseases or pests.

The occurrence of flowers was poor with all studied *Syringas* at the northern sites. At Ruukki, *S. vulgaris* 'Alba' had only a few flowers, while the other studied lilacs flowered quite abundantly. At Sotkamo, 'Alba' and 'Hirvas' flowered poorly, 'Paulus' had few flowers, and

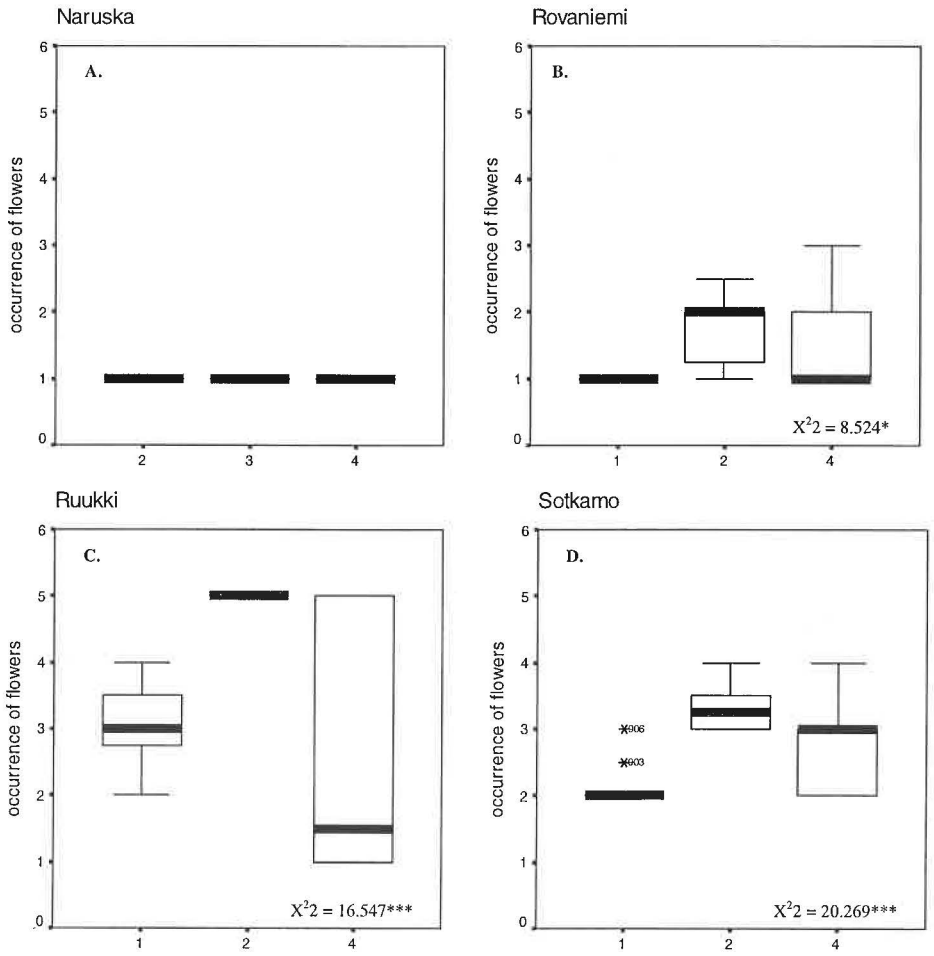

Fig 6. A-D: Occurrence of flowers in the studied *Viburnums* at every study site. Shrubs (x-axis);1 = *Viburnum lantana*, 2 = *V. opulus* 'Pohjan Neito' (Tornio), 3 = *V. opulus* 'Pohjan Neito' (Kempele), 4 = *V. opulus* 'Pohjan Neito' (Tervola). Scale 1-5 (y-axis); 1 = none, 2 = few, single, 3 = moderate, 4 = rather abundant, 5 = abundant. Median (thick line) and central box that contains 50% of the variation. From the ends of the box, "whiskers" have been drawn that extend 1.5 times the width of the box. Any observation outside these whiskers is considered an outlier. The maximum and minimum values are also indicated. Kruskal-Wallis X^2 values with the df values for the origins tested separately for each study location, *** p = 0.001.

'Veera' a moderate amount of flowers. The difference between origins was significant at every study site ($p<0.001$***).

Description of autumn coloration

At the eastern study sites, Naruska and Sotkamo, *Viburnums* were rated as beautiful and at Ruukki as moderate with their multiple autumn colours. At Naruska, *Syringas* gained moderate values. At Ruukki, the origins were rated as ugly or moderate due to their brownish-yellow autumn coloration. At Sotkamo, white-flowered *Syringas* were rated as ugly and the others as moderate. (Rovaniemi, no results)

Discussion

Most woody ornamental plants are propagated vegetatively through cuttings. However, some woody ornamental species and cultivars are difficult to propagate by cuttings. Rooting success may be low, or many rooted cuttings die during the first winter. For example, cutting success is poor with *Syringa vulgaris* and *S. josikaea* and moderate with *Syringa* × *henryi* (PIERIK et al., 1988; TEGEL, 2000). *In vitro* cultures of *Syringa* allow certain genotypes to be efficiently propagated, and this method can be a powerful tool for mass propagation of the desired species and cultivars with some elaboration of propagation protocols (REFOUFELET et al., 1998). *In vitro* propagation methods can be improved by manipulating propagation conditions (CAMERON et al., 2001). Apparently, all the lilac species can be propagated *in vitro* (FIALA, 2002). *Viburnum lantana* and *V. opulus* 'Pohjan Neito' are usually propagated in Finnish nurseries through cuttings. *In vitro* propagation was here successfully used for the studied plant origins. A major benefit of *in vitro* propagation is that it rapidly produces a large amount of new plant material. When adult plant material is taken into propagation, the juvenile phase of growth is sometimes bypassed and the *in vitro* propagated plants flower earlier compared to plants propagated with traditional methods. In some cases, *in vitro* culturing of woody plants may also cause rejuvenation and delay flowering (GEORGE, 1996; JESCH and PLIETZSCH, 2000). In this study, all the studied micro-propagated origins performed naturally under field conditions. Plants in the juvenile

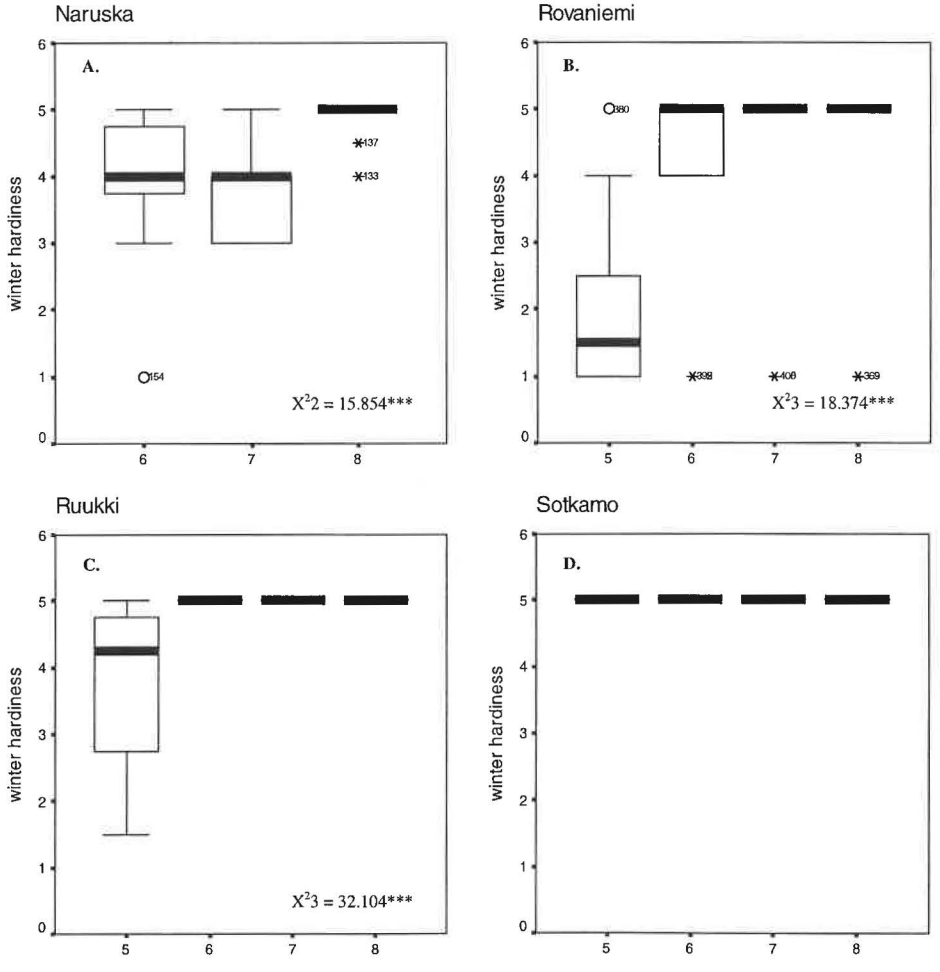

Fig 7. A-D: Winter hardiness of the studied *Syringas* at every study site. Shrubs (x-axis); 5 = *Syringa vulgaris* 'Alba', 6 = *S. villosa* 'Hirvas', 7 = *S.* × *josiflexa* 'Veera' and 8 = *S.* × *henryi* 'Paulus'. Scale 1-5 (y-axis); 1 = dead, 2 = dead to ground level, 3 = dead to snow level, 4 = shoot tips dead, 5 = tip buds dead or no damage. Median (thick line) and central box that contains 50% of the variation. From the ends of the box, "whiskers" have been drawn that extend 1.5 times the width of the box. Any observation outside these whiskers is considered an outlier. The maximum and minimum values are also indicated. Kruskal-Wallis X^2 values with the df values for the origins tested separately for each study location, *** p = 0.001.

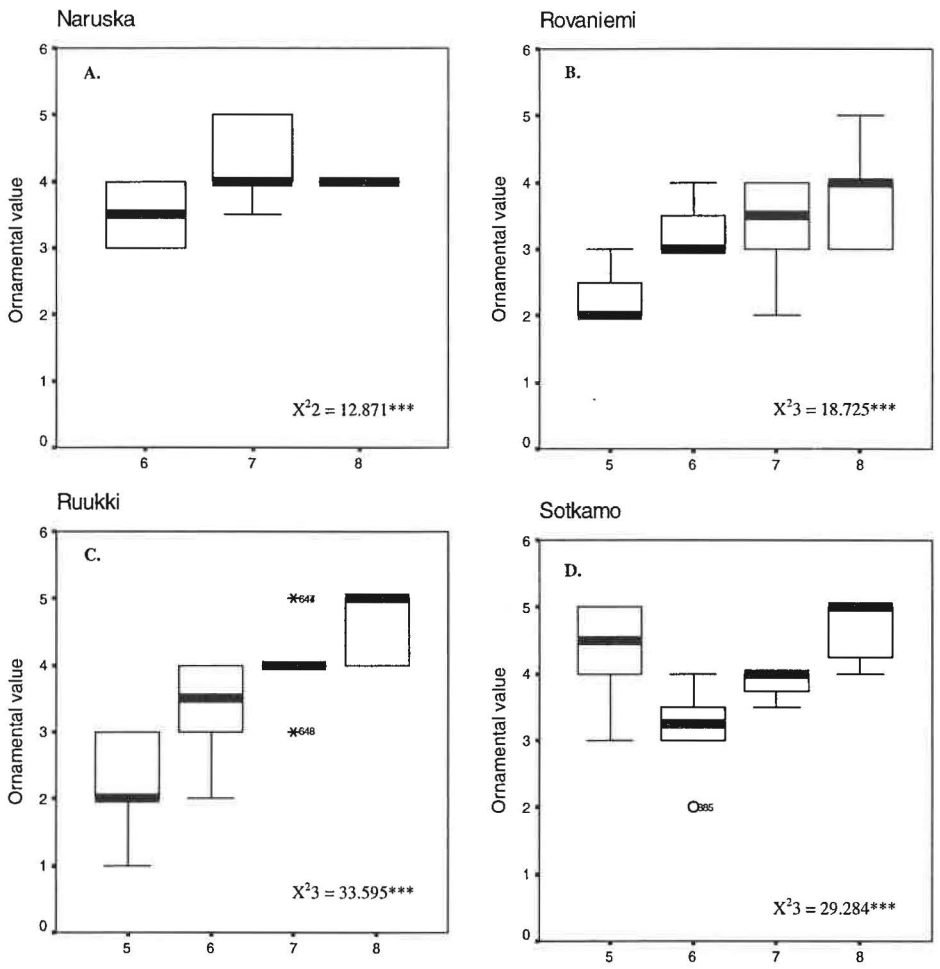

Fig 8. A-D: Ornamental values of the studied *Syringas* at every study site. Shrubs (x-axis); 5 = *Syringa vulgaris* 'Alba', 6 = *S. villosa* 'Hirvas', 7 = *S.* × *josiflexa* 'Veera' and 8 = *S.* × *henryi* 'Paulus'. Scale 1-5 (y-axis); 1 = ugly, 2 = rather ugly, 3 = moderate, 4 = rather beautiful, 5 = beautiful. Median (thick line) and central box that contains 50% of the variation. From the ends of the box, "whiskers" have been drawn that extend 1.5 times the width of the box. Any observation outside these whiskers is considered an outlier. The maximum and minimum values are also indicated. Kruskal-Wallis X^2 values with the df values for the origins tested separately for each study location, *** p = 0.001.

phase of growth are generally easier to propagate by both cutting and micro-propagating than woody plants that have reached the adult phase (PREECE and READ, 2001). Micro-propagation is the only method to keep the characteristics of poorly propagating or sterile individuals and species, and it can be used to enhance the traditional propagation methods.

In order to succeed, cultivated plants must be able to adapt to the prevailing growing conditions, e.g. the light and temperature of their habitat. Winter hardiness is one of the most important characteristics and a precondition for good success of ornamental plants (e.g. BRANDER, 1982; BRANDER, 1989; CARLSSON, 1993; RICHER-LECLERC et al., 1994). Cultivars with poor winter hardiness have poor flowering capacity and low ornamental value as, for example, did the *Viburnum* origins at the northernmost study sites at Naruska and Rovaniemi. The occurrence of flowers and the length of the flowering period are commonly appreciated in plant evaluation and have been important factors in other plant selection studies (WEBSTER, 1988; BRANDER, 1989). Most of the shrubs studied here were able to acclimate well to the study site habitats, excluding the northernmost site in the case of some origins, e.g. *V. lantana* and *S. vulgaris* 'Alba'. When plants from southern origins are grown at northern sites, they seldom develop dormancy early enough in the autumn and also break dormancy too early in the spring and therefore suffer serious winter damage. In this study, all the origins except snowball origin Kempele were clearly northern. Snowball origin Tervola was in leaf for only 80 days at the Ruukki and Sotkamo sites, even though the growing season at these sites is considerably longer than in the mother plant's original growth habitat at Tervola, which is located near Rovaniemi (Tab. 2). The duration of the green period at the study sites and the onset of foliation and defoliation in the studied shrubs were consistent with the long-term averages of the beginning and end of the growing season recorded at the study sites. Long-term studies with a minimum duration 5 years are needed to obtain reliable average data of the phenological parameters in a certain area (BEAUBIEN et al., 2003). In the future, higher temperatures are expected to lengthen the growing period by making bud break earlier in the spring and bloom earlier in the summer in the colder regions (BEAUBIEN et al., 2003; POP et al., 2000). Whether or not commercial shrubs will benefit from the change in the timing of bud break is uncertain. Gardening type experiments could be used to study the role of genotype in relation to temperature and phenological events (BEAUBIEN et al., 2003).

Viburnums are versatile ornamental shrubs and good noise cover plants, and they usually have beautiful berries and autumn coloration (FLINT, 1989; ESKILSSON, 1994; ECK, 1997), which was also noticed

in this study. The genus includes numerous beautiful species and cultivars that are, unfortunately, not hardy enough to flourish in the northern parts of Finland (ALANKO, 1980). *V. lantana* is considered an easy-to-care calciphilic with ornamental dark green leaves. The shrubs succeeded best at the slightly maritime Ruukki test site, with more nutrient-rich soil and milder winters compared to the other study areas. Their flowering was poor, but the plant can be used at favourable sites due to its long-lasting green leaves and handsome growth habit. *V. lantana* has been reported to have ornamental value due to its colourful berries (FLINT, 1989), but the occurrence of berries was poor in the present study. *V. lantana* grows naturally in relatively mild climates and moderately shaded habitats (KOLLMAN and GRUBB, 2002), and it could hence have potential at the boundaries of inhabited areas and areas in a natural state. The *Viburnum* genus is best known for its showy white flower clusters in the snowball bush (ESKILSON, 1994). To achieve rich flowering, *V. opulus* 'Pohjan Neito' needs a nutrient-rich, sunny habitat. Origin Tornio had best winter hardiness, and it is preferred to Tervola. Origin Tervola succeeded quite well in JUHANOJA et al.'s (2001) study. In Lapland, in a cold climate and in poor soils, *Viburnums* do not have good potential due to the annual winter damage they tend to incur. Environmental stresses (e.g. little light) may significantly reduce flowering and fruiting on *Viburnums* (FLINT, 1989). All the studied cultivars were healthy, and the genus *Viburnum* is considered to have few disease and pest problems (FLINT, 1989). Furthermore, *V. lantana* is protected from rabbits and other herbivores by defensive secondary compounds, e.g. oxalates and glycosides (GRUBB et al., 1999; KOLLMAN and GRUBB, 2002). Snowball cultivars are considered to be susceptible to floral herbivores (FLINT, 1989; ESKILSSON, 1994; JUHANOJA, 1998), but the cultivars grown here seemed to be resistant against floral herbivory. The showy flowers of the snowball bush also have value as cutting plants used in indoor decorations (ESKILSSON, 1994).

In cold northern areas, lilacs are among the showiest flowering shrubs (FIALA, 2002). White-flowered *Syringa vulgaris* cultivars are considered weaker compared to the purple and lilac forms, and this was also observed in this study. *S. vulgaris* 'Alba' had poorest winter hardiness and poor flowering. *S. villosa* 'Hirvas' was the other white-flowered lilac studied, with good winter hardiness, but poor flowering capacity. 'Hirvas' is known to flower abundantly at older age. Both of the studied white-coloured lilacs were slightly pink at the beginning of flowering. The lilac flower colour varies under different soil and weather conditions and depending on the stage of inflorescence (FIALA, 2002). Overall, white-flowered cultivars cannot be recommended due to their poor flowering. The lilacs 'Veera' and 'Paulus' can be recommended for ornamental use in Northern Finland. 'Veera' has the best flowering capacity and 'Paulus' the best winter hardiness. The 'Veera' cultivar from Rovaniemi rural municipality was also tested in another selection study, and it proved to be a valuable cultivar (JUHANOJA et al., 2001). The poor flowering of the *Syringa* origins limits their ornamental value in Lapland, even though they have good winter hardiness. *Syringas* are best when grown in areas with cold winters, which helps to set the buds for bloom, but not in arctic conditions (FIALA, 2002). Some lilac species grown in Finland hybridize easily with each other (JUHANOJA et al., 2001), sometimes resulting in beautiful hybrids, such as the *Syringa* × *josiflexa* 'Veera' studied here. Identification of these forms is sometimes difficult, because identification is mainly based on leaf shape and floral characteristics, which are variable in the field. New DNA techniques can also be used to identify the specific parentage of lilac hybrids (KI-JOONG and JANSEN, 1998).

Conclusions

Micropropagation is an effective method to produce ornamental woody plant material. The success of *in vitro* propagated shrub material was good under the harsh growing conditions of the present study sites in Northern Finland. The present results show that the monitoring parameters used can give reliable information, which, in turn, can be used to select plant material for areas with harsh climate. The following plants are recommend for northern landscaping: *Viburnum opulus* 'Pohjan Neito' origin from *Tornio, Syringa* × *josiflexa* 'Veera' and *S.* × *henryi* 'Paulus'. Other study plants can also be used, especially at more favourable sites, whereas *S. vulgaris* 'Alba' and *V. lantana* are likely not to have any potential for ornamental use in northern areas. Microclimatic factors and soil properties have a major impact on how ornamental plants thrive at their growth habitats, and by manipulating these factors, we can also cultivate some sensitive cultivars in northern areas.

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