THE SELECTS OF BEARBERRY (*ARCTOSTAPHYLOS UVA-URSI* (L.) SPRENG.) FROM NATURAL POPULATIONS IN POLAND

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ABSTRACT

Five plants of bearberry selected from natural stands in Poland and one from a Botanical Garden were propagated by cuttings. The clonal plants were first kept under observation for two years planted on different substrates in containers and were afterwards field cultivated for three subsequent years. The existence of a significant differentiation within these *Arctostaphylos uva-ursi* clones was proved. Two selects of good ornamental features as well as with high concentration of medicinal substance – arbutin were chosen. Plants started fruiting in the fourth year of growth and the area covered by a single plant exceeded 2 m² after five years of cultivation.

KEY WORDS: arbutin, *Arctostaphylos uva-ursi*, vegetative propagation, selection

INTRODUCTION

Bearberry is a small evergreen shrub which belongs to the family of Ericaceae. It is found on the northern hemisphere, growing in North America, Europe and in the northern part of Asia. It is the only species of the numerous genus *Arctostaphylos* (50-70 species) distributed so widely. The southern border of its compact appearance crosses the territory of Poland (Gawłowska 1964).

Bearberry grows in dry, sparse pine forests, on sandy soils and dunes, in sunny or semi-shaded places. It is a melliferous and medicinal plant (Farmakopea Polska IV 1970), which is a significant raw material for medicines used in the treatment of urinary tract diseases (Dombrowicz et al. 1991). In Poland, in wild state, bearberry has been partially protected by law since 1957. However, it is seldom cultivated, and when it is, it grows mainly in collections (Czekalski 1991). Bearberry may be used for fastening sand-dunes and as protection against erosion in an open landscape. It may also be used as an ornamental ground-covering plant with red fruits, planted in rock gardens or for enhancing heather plants compositions (Rey 1978, 1980, 1982).

There are a number of cultivars around the world, in Poland known mainly from literature, such as "Massachusetts", "Point Reyes", "Native", "Alaska" "Oregon Hybrid" (Linderman, Call 1977) mentioned in American or Canadian ("Vancouver Jade") papers (Macdonald 1986). In Europe the work on cultivation method of bearberry as an ornamental plant was carried out in Switzerland. In the catalogue of the well known Hachmann's plant nursery (Germany) there are three cultivars offered ("Massachusetts", "Vancouver Jade", "Snowcap" – single examples of the last two were introduced to Po-

land (Woźniak 1993)). On territories of the Czech and Slovak Republics bearberry is cultivated for pharmaceutical purposes (Leifertowa et al. 1971, 1987, Musil et al. 1988) and a domestic cultivar "Arbuta" was registered there in 1981 (Leifertova et al. 1985, Jahodar et al. 1986, Musil et al. 1988).

A small and still decreasing number of wild bearberry stands can also be found in Poland. The best method of protecting wild populations is the propagation and cultivation of plants. Before more bearberries die out in our country, the species and its variability in its natural sites should be investigated and its usefulness assessed.

MATERIAL AND METHODS

In the spring of 1987 observations of several natural stands of bearberry in Piła, Bydgoszcz and Toruń provinces were carried out. Five healthy and strongly growing plants from the territory of Tuchola Forests were selected. They were propagated in the spring of the same year by stem cuttings. In this way at least 60 clonal plants of each select were obtained. The clonal plants were observed in 1988 and 1989 while growing in containers (2 dm³ pots), and during three subsequent years in conditions of field cultivation. Four different substrates were used in containers (slightly loamy forest sand taken from *Calluna vulgaris* heather stand, peat, peat mixed with sand from the bottom of the Warta river in a 2:1 proportion, peat mixed with pine bark in a 2:1 proportion). All the substrates were fertilized in the same manner (Malinowska 1991, 1993). The results of chemical analysis of the applied substrates are collected in Table 1.

The five selects (denoted hereafter with SI to SV) which had been chosen from natural stands were compared with

Table 1. The chemical analysis of substrates before planting the plants.

Substrate	pH H ₂ O	pH KCl	Salt content	N NO ₃	P PO ₄	K	Ca	Mg
			[g dm ⁻³]					
slightly loamy sand	4.7	4.51	1.95	120	12	220	300	15
peat *	4.7	4.73	3.42	260	120	240	800	45
peat with sand	4.7	4.50	2.34	100	52	320	1240	75
peat with pine bark *	4.7	4.30	1.30	140	72	320	580	50

* – pH of peat and peat mixed with pine bark substrates were modified to the 4.7 level with CaCO₃ added in the amount estimated on the basis of neutralization curve.

bearberry cultivated in the Botanical Garden in Wrocław (hereinafter referred to as W), which had been propagated in the same way.

The plants were observed in respect to their health, flower bud formation and fruiting. At the end of their growth in the autumn of every year length and width of a mat formed by every plant as well as the diameter of the main stem directly over the substrate surface were measured. In the first and second year of the container cultivation the total length of all shoots was measured, too. The mass of dry leaves was also determined (on the basis of three randomly chosen plants of each select growing in every substrate).

In 1989 measurements of leaf dimensions of the particular selects were taken (also on the basis of three randomly chosen plants). The length and width of the leaf blade, the length/width ratio and the length of petiole were compared. The third and fourth leaves of the first growth in the second year of cultivation, considered to constitute a fairly representative sample, were picked from 5 randomly chosen shoots of one plant, and gave a total of 30 leaves of each select growing in the given conditions.

The chemical analysis of arbutin content in the leaves (the main medicinal substance) was performed using the method described in Farmakopea Polska IV (1970). Next, the productivity of arbutin from a single plant of a particular select was calculated, expressed as mean mass of arbutin (in grams) obtained from all leaves of a single plant.

The results of measurements were subject to variance analysis for two-factor experiments and subsequently to Duncan's test.

RESULTS

Plants of all selects were growing strongly. This can be seen from the sums of the shoot length (Fig. 1) and from the size of mats formed by single plants (Table 2), achieved after two years of cultivation in containers.

It was found that selects from natural stands (denoted in Figures as SI-SV) were lower and had a greater total length of shoots than bearberry from the Botanical Garden in Wrocław (W). A significantly stronger growth of shoots was observed on peat containing substrates compared to the slightly loamy sand. The total shoot length of the most strongly growing selects exceeded 8 m. The selects differed in the number

Fig. 1. The sum of shoot length of single plants after two years of cultivation.

of shoots and their length and also in the diameter of the main stems measured directly over the substrate surface.

It was noticed that selects planted in peat had definitely the greatest number of shoots (Table 3) and the thickest main stems compared to other media (Table 4). All selects originating from the Tuchola Forests had greater number of shoots than the clonal plants from the Botanical Garden in Wrocław, but diameters of their main stems were significantly smaller.

Significant differences in the shape of the leaf blade, the mean mass of a single leaf and the mass of dry leaves in various selects were noticed. The leaf blades of the plants originating from the Botanical Garden were highly significantly larger compared to selects from natural stands – their length and width as well as petiole length were greater (Fig. 2). It was found (with a high statistical significance) that peat stimulates the increase of the length of the leaf blade compared with peatless media.

Although the clonal plants of the select from Wrocław had bigger leaf blades, the mass of dry leaves picked from a single plant was after the first year of cultivation only significantly greater than that of selects from Tuchola Forests. In the second year of cultivation the intensity of the shoot growth of bearberry from natural populations was so much greater, that the dry mass of leaves obtained from the selects SI and SII exceeded the mass obtained from the plants of select W from the Botanical Garden.

Table 2. The growth of bearberry *Arctostaphylos uva-ursi* (L.) Spreng. after two years of cultivation on the substrate composed of peat mixed with river sand in proportion 2:1.

Dimension	Growth [cm]						
	Selects						
	Wrocław Botanical Garden	Selects from stands in Tuchola Forests					
		SI	SII	SIII	SIV	SV	mean
height	11.8	7.1	8.4	10.2	7.5	8.9	8.4
length	45.4	43.3	47.3	42.8	60.7	58.6	50.5
width	34.7	35.8	32.4	24	48.3	47.9	37.7

Table 3. Mean number of shoots on *Arctostaphylos uva-ursi* (L.) Spreng. selects after two years of growth in containers on different substrates. Mean values marked with the same characters are not statistically different at the level of significance $\alpha = 0.05$.

Substrate	Number of shoots						
	Selects						
	Wrocław Botanical Garden	Selects from stands in Tuchola Forests					
		SI	SII	SIII	SIV	SV	mean
slightly loamy sand	50	72	85	82	103	100	88.4 a
peat	90	181	146	129	150	164	154.0 b
peat with sand	70	141	138	98	111	119	121.4 ab
peat with pine bark	76	157	171	94	97	121	128.0 ab
mean	71.5 a	137.75 b	128.25 b	100.75 ab	115.25 ab	126.00 b	

Fig. 2. The length (a) and the width (b) of leaf blades of the bearberry selects after two years of cultivation in containers in different substrates. The leaf blade length is highly significantly ($\alpha = 0.01$) greater when the plants grew on peat compared to other substrates.

Table 4. The diameter of the main stem of *Arctostaphylos uva-ursi* (L.) Spreng. selects as measured directly above the substrate surface after two years of growth in containers on different substrates. Mean values marked with the same characters are not statistically different at the level of significance $\alpha = 0.05$.

Substrate	Diameter of the main stem [mm]						
	Selects						
	Wrocław Botanical Garden	Selects from stands in Tuchola Forests					mean
		SI	SII	SIII	SIV	SV	
slightly loamy sand	7.5	5.8	6.4	5.7	5.2	5.0	5.6 a
peat	8.9	6.9	7.3	6.3	5.3	5.9	6.3 a
peat with sand	7.4	6.3	6.6	4.9	6.0	5.4	5.8 a
peat with pine bark	8.0	6.7	6.8	5.8	5.9	5.3	6.1 a
mean	8.0 c	6.4 b	6.8 b	5.7 a	5.6 a	5.4 a	

The leaf blade length/width ratio is the most significant feature of bearberry while considering it as raw material for drugs (Fig. 3). The selects SI and SII, characterized by the smallest length/width ratio significantly distinguished themselves in the productivity of arbutin from a single plant (Fig. 4). The productivity was influenced by the mass of dry leaves from a single plant (Fig. 5) as well as by the arbutin content (Fig. 6). Chemical analyses proved significant differences of arbutin content among leaves of the studied clones.

The observed clonal plants of all selects of *Arctostaphylos uva-ursi* growing in four substrates formed flower buds, although not on all plants. The average number of buds per plant fluctuated in the first year from 1 to 1.7 and in the second year from 1 to 3.9. The greatest number of such plants belonged to the SIV select (approx. 50% in the two years), and the smallest number to the SI select (4,6% in the first and

12,4% in the second year). Only some buds turned into flowers, and during the experiment with container cultivation no fruiting was observed. The select from the Botanical Garden in Wrocław did not form any flowering buds in the first year, however in the second year buds were found on every plant growing in peat, peat mixed with bark or slightly loamy forest sand, but only on 1/3 of the plants growing in peat mixed with river sand. Plants of that select planted in peat had the greatest number of shoots with flower buds as terminals (average 11.2), those planted on slightly loamy forest sand had the smallest number (2.4).

Despite increased pH of substrate in the year 1992 (6.63 to 6.92) the chosen selects which were field cultivated preserved their features. The biggest plant of the SI select created a mat 167 cm long and 166 cm wide and the main stem diameter measured at the substrate surface attained 1.9 cm. Other

Fig. 3. The leaf blade length to width ratio of the bearberry selects after two years of growth in containers in different substrates.

Fig. 4. The productivity of arbutin from leaves of single plants of the selects under examination after two years of growth.

Fig. 5. The weight of dry leaves picked from single plant of the selects under examination after two years of growth.

plants of that select were smaller, but the diameters of their main stems at the surface of substrate exceeded 2 cm. The plants of the SII select also grew strongly. The biggest one made in the fifth year of cultivation a mat 167 cm long and 128 cm wide. The diameter of the main stem at the surface of substrate was 2.15 cm. The plants started fruiting in the fourth year of cultivation. They had from some to more than ten fruits – maximum at SI – 28. The plants of SII select fruited less – 2 to 8 fruits per plant.

The six plants of the clone of *Arctostaphylos* from the Botanical Garden in Wrocław created smaller mats. The biggest one was 120 cm long and 100 cm wide. In 1991 a single red fruit was observed on the biggest plant only, in 1992 on the same plant there were 3 fruits. Only half of the plants formed flower buds.

DISCUSSION AND CONCLUSIONS

The comparisons of the five selects of bearberry originating from the territory of the Tuchola Forests proved clearly the existence of differences within the species *Arctostaphylos uva-ursi* with regard to leaf blade shape, intensity of growth and also the content of a medicinal substance – arbutin. The observations and measurements allowed us to identify two selects – SI and SII as especially useful for either planting as ornamental ground covering plants or for pharmacy. Those plants grew strongly and tightly covered the ground surface.

(The selects SIV and SV created bigger mats, but did not cover the surface as tightly as SI and SII.)

The level of arbutin content in the leaves of young plants of those selects in the years 1988 and 1989 fluctuated between 10.2% to 14.6% depending on their growth conditions. It should be noticed that the leaves were picked late in the autumn (15 Nov. 1988 and 27 Nov. 1989) following the instruction of Farmakopea Polska IV (1970). Analyses of arbutin content were performed three month after harvesting. Gawłowska (1965) has found that the arbutin content decreases in the period between October and late autumn, when it reaches the highest level. So, it may be expected that the percentage of arbutin in the leaves of chosen selects could be even higher. For comparison, the leaves of the first cultivar registered in Czechoslovakia in 1981 – *Arbuta* – selected especially for the pharmaceutical industry, contained 11 to 14% of arbutin (Musil et al. 1988).

According to Farmakopea Polska IV (1970) the leaves of bearberry can be used as a raw material for pharmacy as long as they contain at least 6% of arbutin. According to ČSL norm *Folium uvae-ursi* should contain minimum 7% of arbutin.

Polish selects after two years of cultivation in containers (in peat, peat mixed with sand and peat mixed with bark) produced between 30 to 40 g of dry leaves from a single plant.

The select of bearberry from the Botanical Garden in Wrocław which was compared to the plants from wild stands dif-

Fig. 6. The content of arbutin in the leaves of the selects under examination after the first (a) and the second (b) year of growth.

fered significantly in leaf size, diameter and length of shoots and arbutin content. It had bigger and prettier leaves with a characteristic glitter. That select is of higher value for ornamental purposes, but can also be treated as an arbutin providing plant. In our experiments the level of arbutin in the leaves of that select fluctuated from 8.5 to 12.4%.

Bearberry from sandy soils grow and develop well on raised peat and on substrates with a peat admixture. However, some modifications of leaves due to the cultivation on peat were noticed. Attention was paid to the increase of leaf blades and petiole length.

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SELEKTY MĄCZNICY LEKARSKIEJ (*ARCTOSTAPHYLOS UVA-URSI* (L.) SPRENG.) ZE STANOWISK NATURALNYCH W POLSCE

STRESZCZENIE

Mącznica lekarska jest zawsze zieloną krzewinką należącą do rodziny *Ericaceae*. Może być traktowana jako kobiercowa roślina ozdobna o czerwonych owocach. Dostarcza również w wielu krajach surowca farmakopoealnego, którego nie daje się łatwo zastąpić. W Polsce w stanie naturalnym jest rośliną zagrożoną i objętą częściową ochroną. Wiosną 1987 roku przeprowadzono obserwacje szeregu stanowisk naturalnego występowania mącznicy lekarskiej w województwach pilskim, bydgoskim i toruńskim. Wyselekcjonowano 5 zdrowych i silnie rosnących roślin z obszaru Borów Tucholskich. Rozmnożono je wegetatywnie przez sadzonki pędowe, uzyskując co najmniej po 60 roślin klonalnych z każdego selektu. Rozmnożono również okaz pochodzący z Ogrodu Botanicznego we Wrocławiu. Klony obserwowano w latach 1988 i 1989 w warunkach uprawy pojemnikowej, a przez następne trzy lata w warunkach uprawy zagonowej. Z przeprowadzonych porównań wybranych selektów wynika wyraźnie, że występuje zróżnicowanie w obrębie gatunku *Arctostaphylos uva-ursi*. Rośliny różnią się kształtem blaszek liściowych, się wzrostu, a także zawartością substancji leczniczej – arbutyny. Najcenniejszymi spośród badanych okazały się dwa selekty – SI i SII. Rosły one silnie, charakteryzowały się dużą liczbą pędów, które dobrze pokrywały powierzchnię. Największa roślina po pięciu latach uprawy utworzyła płat o powierzchni przekraczającej 2 m². Średnice głównych pędów mierzone bezpośrednio przy powierzchni podłoża wynosiły około 2 cm. Liście tych selektów miały także wysoką zawartość arbutyny. Rośliny rozpoczęły owocowanie w czwartym roku uprawy. Miały od kilku do kilkunastu owoców – SI maksymalnie 28 na jednej roślinie. Rośliny selektu SII owocowały mniej obficie – 2 do 8 owoców.

SŁOWA KLUCZOWE: arbutyna, *Arctostaphylos uva-ursi*, rozmnażanie wegetatywne, selekcja.