PROTECTION OF GENETIC RESOURCES OF POMOLOGICAL PLANTS AND SELECTION OF GENITORS WITH TRAITS VALUABLE FOR SUSTAINABLE FRUIT PRODUCTION

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SOME EXPERIMENTS ON THE ECOLOGICAL CULTIVATION OF THE LINGONBERRY (V*accinium vitis-idaea* L.) IN A MOUNTAINOUS REGION OF SLOVAKIA

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A B S T R A C T

From 1995 to 2003, two varieties of lingonberry (*Vaccinium vitis-idaea* L.) were evaluated in terms of their potential for ecological cultivation at the Research Station of the Grassland and Mountain Agriculture Research Institute in Krivá na Orave, which is located in a mountainous region of northern Slovakia at an altitude of 700 meters above sea level. The varieties evaluated were a native wild variety and 'Koralle', a cultivated variety.

The native wild variety had poor yields and poor fruit quality, and cannot be recommended for commercial cultivation. 'Koralle' had high yields and high fruit quality, and can be recommended for commercial culture. In addition, 'Koralle' bears two crops a year, although the second crop may not always ripen at high altitudes.

Key words: *Vaccinium vitis-idaea* L., ecological cultivation, mountainous region

INTRODUCTION

In Slovakia, lingonberries are harvested only from patches which grow naturally in the mountains. Not enough lingonberries can be harvested to satisfy domestic demand because the native wild varieties have low yields and because of the frequent destruction of lingonberry patches stands in national parks and nature reserves.

Lingonberries are also harvested from naturally occurring patches in Scandinavia, the Baltic countries and Russia. Lingonberries are cultivated on plantations in Germany, Sweden and Chile.

The lingonberry requires a sunny site with moist, well aerated, humus-rich soil with a optimal pH from 3.5 to 4.5 (Dierking and Dierking, 1993; Dierking and Krüger, 1984). Ecological lingonberry production is a promising way to profitably exploit the poor, acid soils typical of the mountainous areas of northern Slovakia in an environmentally friendly way.

The aim of this study was to evaluate a native wild variety and the cultivated variety 'Koralle' in terms of their potential for ecological cultivation in mountainous areas of northern Slovakia.

MATERIAL AND METHODS

From 1995 to 2003, two varieties of lingonberry (*Vaccinium vitis-idaea* L.) were evaluated in terms of their potential for ecological cultivation.

The experiment was carried out at the Research Station of the Grassland and Mountain Agriculture Research Institute in Krivá na Orave, which is located in a mountainous region of northern Slovakia at an altitude of 700 meters above sea level. The experimental site was situated on a slope with a pitch of 10% and a northern exposure. Mean annual temperature is 6°C. Total annual rainfall ranges from 800 to 900 mm, with maximum monthly rainfall in June and July (Tab. 1). The soil is a sandy-loamy illimeric brown soil with a pH of 3.7 to 3.8, a humus content of 21 mg/kg, a phosphorus content of 7 mg/kg, and a potassium content of 48 mg/kg.

The varieties evaluated were a native wild variety and 'Koralle', a cultivated variety.

'Koralle' is the oldest and most widely grown lingonberry cultivar. It is an upright plant with moderate vigor and a moderate spreading tendency. 'Koralle' is highly productive and bears medium-sized, brilliant red berries which can be harvested with hand rakes or by machine.

Plants of both varieties were vegetatively propagated in one liter of pure peat per plant. In 1994, the one-year-old plants were planted 0.4 x 0.4 meters apart in a randomized block design with four replicates of ten plants each. The plot area was 1.6 m^2 (2.0 x 0.8 m). No fertilizers or herbicides were applied. The bushes were not irrigated. The plots were weeded by hand.

Soil analyses were performed in 1995, 1998 and 2001.

Every year from 1995 to 2003, the plant height, the flowering time, the harvest time, the yield per plant, and the weight of 100 berries were recorded for each variety.

Observations on winter hardiness and on diseases and pests were also recorded.

T a b l e 1. Climatic conditions over the growing season (Krivá na Orave site)

Parameter		50 year average*	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Mean air temperature [°C]	April	6.0	5.4	4.7	4.9	2.1	7.4	7.8	7.0	4.9	5.4	4.5
	May	11.4	11.1	8.7	12.0	11.6	10.4	10.0	11.7	11.9	13.1	13.0
	June	16.3	13.8	14.1	14.6	13.6	15.8	15.1	14.4	12.4	19.2	16.1
	July	16.3	16.6	16.8	13.2	14.8	15.6	17.8	14.5	16.2	17.8	16.7
	August	15.8	16.0	14.3	14.5	14.8	15.0	13.8	15.9	15.9	16.0	15.4
	September	12.0	11.0	10.4	8.7	10.5	10.8	13.2	9.1	9.9	9.4	10.6
Total rainfal [mm]	April	58	82	55	65	53	79	77	62	58	18	50
	May	86	76	58	128	72	47	43	76	38	92	146
	June	108	84	158	84	71	114	112	67	127	83	55
	July	123	81	143	99	250	89	96	142	276	127	118
	August	96	66	141	97	76	32	67	28	41	74	3
	September	80	93	46	176	41	140	36	49	120	81	60

*Data recorded at the Research Station in Krivá na Orave

RESULTS

Soil analyses

During the course of the trial, soil acidity remained optimal for lingonberry cultivation, humus content and phosphorus content decreased, and potassium content and magnesium content increased (Tab. 2).

Table 2. Results of soil analyses in 1995, 1998 and 2001

Parameter	Native wild variety			'Koralle'		
Year	1995	1998	2001	1995	1998	2001
pH	3.7	3.8	3.7	3.7	3.8	3.7
Humus [%]	32.2	26.1	25.8	32.2	26.1	28.5
Available P [$mg.kg^{-1}$]	7.4	6.7	3.1	7.4	5.5	4.0
Available K [$mg.kg^{-1}$]	23.0	26.6	29.6	23.0	24.9	29.6
Available Mg [$mg.kg^{-1}$]	25.3	25.8	44.9	25.3	23.2	33.5

Plant height

The native wild variety grew slowly and reached a maximum height of about 110 mm in the third year after planting.

'Koralle' grew faster and reached a maximum height of about 220 mm in the sixth year after planting.

Plants of 'Koralle' were larger, more compact, and more upright than plants of the native wild variety.

Flowering time

With the wild variety, the spring flowering period started between May 20 and May 30. With 'Koralle', the spring flowering period started between May 18 and May 30.

'Koralle' also had a more intense summer flowering period which began between July 24 and August 8. Flowering often lasted into late autumn, which reduced the intensity of spring flowering the following year.

Harvesting time

With the native wild variety, the harvest period started between August 6 and September 3. With 'Koralle', the summer harvest period started between August 2 and August 24, and the autumn harvest period started between September 30 and October 16.

With 'Koralle', the second flush of flowers is already developing when the first crop of berries is ready to be harvested. The flowers can be damaged if harvested with hand rakes. The mild frosts that occur during the autumn harvest period did not affect the yield or quality of the autumn crop.

T a b l e 3 . Selected parameters of lingonberry (*Vaccinium vitis-idaea* L.)

Parameter			1995	1996	1997	1998	1999	2000	2001	2002	2003	Total 1995-2003	Average 1995-2003
Native wild variety	plant height [mm]		85	85	107	112	108	104	112	111	112		
	flowering time		May 28	May 20	May 30	May 25	May 24.	May 22	May 24	May 20	May 22		
	harvest time		Aug. 22	Aug. 6	Aug. 13	Aug. 19	Aug. 11	Aug. 24	Sept. 3	Aug. 16	Aug 30		
	yield per plant [g]		3.7	20.0	17.4	2.7	8.3	8.5	11.5	10.3	8.2	90.6	10.0
	weight of 100 berries [g]		22.5	22.2	23.0	22.2	26.0	27.1	24.1	33.2	23.7		24.3
'Koralle'	plant height [mm]		155	164	167	177	185	214	217	219	217		
	flowering time	first	May 28	May 20	May 30		May 24	May 22	May 22	May 18			
		second	July 24	Aug. 2	Aug. 4	July 31	Aug. 3	Aug. 8	July 31	Aug. 1	Aug. 2		
	harvest time	first	Aug. 22	Aug. 2	Aug. 13		Aug. 11	Aug 24	Aug. 23	Aug 8			
		second	Oct. 7	Oct. 3	Oct. 16	Oct. 9	Oct. 13	Oct. 16	Oct. 16	Sept. 30	Oct. 7		
	yield per plant [g]	first	11.3	37.1	23.6		19.1	0.7	10.3	42.3		144.4	16.0
		second	61.7	73.7	113.3	43.2	118.7	75.9	131.4	123.5	71.0	812.4	90.3
		total	73.0	110.8	136.9	43.2	137.8	76.6	141.7	165.8	71.0	956.8	106.3
	weight of 100 berries [g]	first	32.0	35.0	32.5		25.0	25.6	31.3	34.8			30.9
		second	25.6	19.7	19.4	22.5	25.5	20.7	27.5	28.9	20.9		23.4
		mean	28.8	27.4	26.0	22.5	25.2	23.2	29.4	31.8	21.0		

Yield per plant

With the native wild variety, the yearly yield ranged was low and averaged only 10 grams per plant. Berry size and color were not uniform, and many berries were damaged by rotting.

With 'Koralle', the summer yield was also low and averaged only 16 grams per plant. However, the autumn yield was much higher, and ranged from 43 to 131 grams per plant, with an average of 90 grams per plant. Berry quality was considerably higher than with the native wild variety. The autumn crop was not significantly damaged by rotting.

Berry weight

With the native wild variety, the average weight per 100 berries was 24.3 grams.

With 'Koralle', the average weight per 100 berries was 30.9 grams for the summer harvest, and 23.4 grams for the autumn harvest.

Berry weight tended to decrease as yield increased (Tab. 3).

Winter hardiness

After the snow cover melted in 1995 and 1996, the soil repeatedly froze and thawed. This dislodged many of the plants and damaged their roots. Some plants were dislodged to the point that they had to be replanted. 'Koralle' suffered more damage than the native wild variety. Nevertheless, both the wild native variety and 'Koralle' proved to be relatively winter hardy at the experimental location, where winter temperatures can get quite low. For example, the temperature fell to -29°C in 1996 and to -24°C in 1999 (Tab. 4).

Table 4. Minimum winter air temperatures from 1994 to 2003 [^{o}C]

Years	November	December	January	February	March
1994-1995	-9	-12	-25	-11	-10
1995-1996	-18	-22	-22	-21	-11
1996-1997	-6	-29	-21	-21	-11
1997-1998	-10	-20	-19	-26	-16
1998-1999	-13	-23	-11	-15	-9
1999-2000	-9	-24	-19	-16	-11
2000-2001	-2	-14	-19	-20	-9
2001-2002	-9	-22	-28	-11	-6
2002-2003	-9	-24	-26	-25	-12

Data recorded at the Research Station in Krivá na Orave

The regular and reliable snow cover also reduced the number of plants killed by severe cold spells. In the spring of 2003, the snow cover had already melted when a period of severe cold weather with freezing rain occurred. The delicate young stem tips, leaves and flower buds were partially damaged and

had to be cut off. This accounts for the slight decrease in plant height and the lack of a spring flowering period reported for 2003. There was also no spring flowering period in 1998 for similar reasons (Tab. 3).

Diseases and pests

In the autumn of 1996, there were sporadic outbreaks of a fungal disease caused by *Allantophomopsis cytisporea*, which causes the leaves to turn black and fall off. The proportion of leaf area damaged by the fungus was 40% with the native wild variety, and 65% with 'Koralle'. A more severe outbreak occurred during the winter of 1999-2000, when the proportion of leaf area damaged was 72% with the native wild variety, and 85% with 'Koralle'. This accounts for the exceptionally low yields with 'Koralle' in 2000 (Tab. 3).

No other significant pests or diseases were observed.

DISCUSSION

In this trial, the wild variety reached a maximum size of about 110 mm, and 'Koralle' reached a maximum size of about 220 mm. This agrees well with previous reports that plant size in the elderberry ranges from 100 to 300 mm (Dierking and Kruger, 1984; Šimala, 2001, 2003).

In this trial, yearly yield with 'Koralle' ranged from 43 to 166 grams per plant. In a previous experiment in which 'Koralle' was grown using different fertilizers and pine bark mulch, yields ranged from 88 to 99 grams per plant (Ścibisz and Pliszka, 1985).

'Koralle' has been reported to be capable of producing 1 kg of berries per square meter (Dierking and Dierking, 1993). In this trial, the yield per square meter was this high only in 2002, when 'Koralle' produced 1.0 kg per square meter. In all other cases, the yield per square meter was lower.

In a previous trial of new cultivars, the average yearly yield per plant was reported to be 140 grams per plant for 'Ida', and 150 grams per plant for 'Linnea' (Gustavsson and Trajkowski, 1999). In this trial, the yearly yield for 'Koralle' ranged from 43 to 166 grams per plant, with an average of 106 grams per plant.

CONCLUSIONS

The native wild variety had poor yields and poor fruit quality, and cannot be recommended for commercial cultivation.

The cultivated variety 'Koralle' is much more productive and bears larger fruits than the native wild type. 'Koralle' produced two crops a year, in summer and in autumn. The autumn crop was much larger than the summer crop.

Based on this and previous studies, we recommend that, when 'Koralle' is grown commercially at higher altitudes, the summer crop not be picked to avoid damaging the developing second flush of flowers. This will increase the size of the autumn crop, which is of higher quality.

An altitude of 700 m can be considered the upper limit at which 'Koralle' can be profitably cultivated in the mountainous areas of northern Slovakia.

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WYBRANE BADANIA Z EKOLOGICZNĄ UPRAWĄ BORÓWKI BRUSZNICY (*Vaccinium vitis-idaea* L.) W GÓRZYSTYM REGIONIE SŁOWACJI

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STRESZCZENIE

W latach 1995-2003 badano możliwości ekologicznej uprawy dwóch form borówki brusznicy (*Vaccinium vitis-idaea* L.) w górskim regionie północnej części Słowacji (Kriv á na Orave, 700 m n.p.m.).

Wyniki prac doświadczalnych potwierdziły brak przydatności roślin borówki brusznicy do intensywnej uprawy z powodu jej słabego plonowania i niskiej jakości owoców. Jedynie odmiana 'Koralle' została oceniona jako odpowiednia ze względu na wysokie plonowanie i dobrej jakości owoce uzyskiwane podczas drugiego (jesiennego) zbioru, co z praktycznego punktu widzenia jest cechą pożądaną. Czynnikiem ograniczającym uprawę odmiany 'Koralle' jest konieczność zlokalizowania plantacji na odpowiedniej wysokości n.p.m. (< 700 m), ponieważ w przeciwnym razie owoce z drugiego (zasadniczego) zbioru mogą nie zdążyć dojrzeć.

Słowa kluczowe: borówka brusznica, ekologiczna uprawa, odmiany, plonowanie