Persistence of Progenies of Wild Cherry (*Prunus avium* L.) at Northern Limit of Natural Distribution Range in Transfer to Lithuania

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Abstract

The aim of this study was to analyse the possibility of enriching the local population of wild cherry (*Prunus avium* L.) with introduced material capable to withstand rigorous environmental conditions. Progenies of wild cherry from nine European countries were tested in northern marginal site of species' distribution range. Persistence of progeny in relation to transfer to new environment refers here to the height loss due to frost damage and to the certain variability among morphological traits. The progenies were evaluated at two and three years of age in the provenance nursery trial in central Lithuania. *F*-ratios and significance of provenance and block fixed effects, Pearson and Spearman correlation coefficients, Tukey comparison lines for *LS*-means of provenances were estimated for set of traits: tree height at the end of the vegetation period and in the next spring, tree diameter, tree height to diameter ratio, the diameter of strongest branch or side stem, branch diameter to tree stem diameter ratio, and autumn over-coloration of shoot tips, leaf gland length in relation to petiole width, leaf gland colour.

The analysis of variance of most traits revealed that the effects of provenance, block, and provenance by block interaction were statistically significant and indicates a presence of genetic differences in populations' general performance and in ecological reaction norms. Very weak correlation between tree height and tree branchiness ratio gives an indication of breeding possibility of fast growing trees while retaining relatively slim branches.

Independent samples *t*-test and Levene's test for equality of variances approved the relationship between tree morphology parameters and leaf gland characters of survived saplings. Determination of changes in morphology of wild cherry survivors showed that induction of gland pigments is not subjected to stress.

The autumn over-coloration of cherry shoot tips was considered as stress indicator in this study. The more damaged tree tips were in autumn, the less tree height was next spring.

It was found strong and significant correlation between gland number and hardiness zone index at populations' origin locations (r = 0.60, P = 0.03). Positive correlations between the maximum number of glands and hardiness zone index, tree height in spring of 2011 and longitude were moderate but not sufficiently significant.

In general, wild cherry reproductive material from Poland and Austria may be candidates for further testing for the potential introduction of the most fitted populations to Lithuania.

Key words: *Prunus avium*, wild cherry, introduction, persistence, growth, morphology.

Introduction

Prunus avium (L.) includes sweet cherries, cultivated for human consumption, and wild cherry trees, also called mazzards, grown for their wood (Webster 1996, Ganopoulos et al. 2011). The origin of sweet cherry is believed to be in the region close to the Caspian and Black Seas and this species is indigenous to countries to the south of the Caucasus Mountains (Webster 1996). The initial spread of the wild cherry was caused by bird migrations and the distribution was depending on the movement distances of bird populations (Webster 1996). The secondary spreading of the wild cherry was mostly human-caused for use in horticulture and the natural range of wild sweet cherry expanded from place of origin northwards to the southern Sweden, eastwards to the northern India and southwards to isolated islands of Portugal. The Baltic Sea region is the northern limit of range of distribution of *P. avium*. In Lithuania *P. avium* is scattered throughout temperate broadleaf forest (Gudžinskas 2000), with prevalence in the western part of the country (Petrokas 2011; Figure 1). This abundance is possible due to it grows best in beech or beech-hornbeam forests (Chukhina 2008) and the northern boundary of the European hornbeam (*Carpi-*

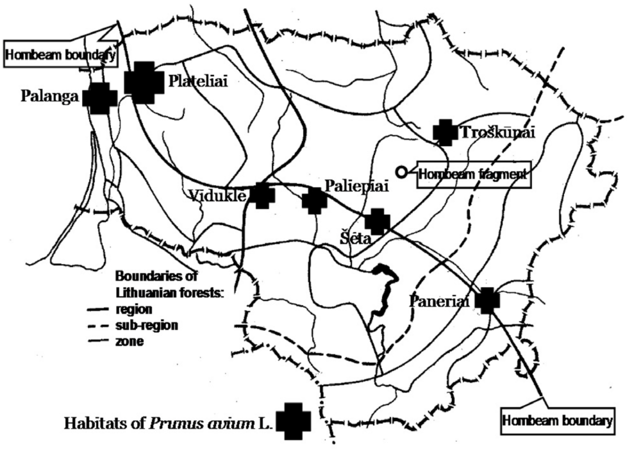

Figure 1. Occurrence/habitats of *Prunus avium* L. in Lithuania

nus betulus L.) natural distribution range lies across Lithuania (Karazija 1988).

We chose to focus our efforts on the wild cherry as it is native forest tree species, which can grow on a wide variety of soil types. It has the advantage of fast growing, producing a high quality hardwood timber in about 70 years which is in demand for furniture making and able to substitute for wood of tropical hardwoods. Wild cherry is the most important European timber species in the family Rosaceae (Russell 2003). In Lithuania wild cherry is spreading to forest stands naturally from domesticated sources or from already escaped semi-wild trees. There are no mature stands of *P. avium* in Lithuania although groups or individual trees grow as admixture in some stands of other tree species while young trees are abundant in understory of many stands. Our aim is to develop vigorous, locally well adapted trees with good stem form suitable for wider use in forestry and farm woodland plantings. At the time, wild cherry do not have a very good forestry reputation, as many trees were of unknown origin or quality; many were probably of sweet cherry type.

Based on the assumption that natural selection has optimised populations to their local environment, European guidelines for the sustainable management of forests in Europe (MCPFE 1993, Anon. 1999) advocate and encourage the use in forestry high quality local seed sources that are genetically and phenotypically adapted to the site. However, in many cases an environmentally induced variation appears to be non-adaptive (e.g. de Jong 2005, van Kleunen and Fisher 2005). It is argued that stressful environments that are outside the natural range can break down genetic buffering mechanisms, and increase the variance associated with different traits (e.g. Rutherford 2000, 2003). Carroll et al. (1997) emphasizes the importance of measuring fitness related traits, and paying attention to the subset of individuals that persist and flourish in the new environments. Ghalambor et al. (2007) summarises that ‘if an identifiable subset of individuals that possess a particularly favourable combination of plastic traits is found to be the successful colonizers of new environments, such evidence could show an important role of plasticity in facilitating adaptation’. Analysis of provenance transfer tests shows remarkable width of adaptability and persistence and, in consequence, the extended width of ‘local’ adaptation even under dramatic changes in thermal conditions and, to a lesser extent, in moisture supplies (Mátyás 2007). This phenomenon indicates the substantial conservatism in the climatic adaptation of numerous tested tree species, which has an inherent genetic basis and may have been enhanced by evolution (Mátyás and Nagy 2005). Therefore, we expect that some provenances or individuals of wild cherry could be able to succeed even outside their current natural range and thus would show viability in a study like this. In general, it was concluded that research of the wild cherry and similar species which are bird-dispersed (ornithochory) are very complex and have to be based on individual tree level research (Ballian et al. 2012, Petrokas 2010).

The aim of this study was to analyse the possibility of enriching the local population of *P. avium* trees better designed to withstand rigorous environmental conditions. The first goal was to analyse survival, growth, and morphology of the wild cherry at northern marginal site of species’ distribution in transfer to Lithuania from West and Central European countries. The second goal was to provide some methodical guidance to facilitate the establishment and analysis of future clonal tests.

Materials and Methods

Test material

Progeny of wild cherry from nine European countries was tested in the Dubrava nursery trial in Central Lithuania. Information on geographical origin and type of basic material of Austrian (AtK, AtT), Belgian (BeM), British (GbH), Danish (DkF, DkNZ, DkS), German (De127, De129, De131), Italian (ItBF, ItL, ItMB), Lithuanian (LtT), Polish (PlK, PlZ), and Spanish (EsCL) test material is presented in Table 1. Hardiness zones of wild cherry provenances studied (Table 1) are indicated based on the map by Heinze and Schreiber (1984). This map divides Lithuania into the two zones based on average lowest winter temperatures (Figure 2).

The provenance trial was established in 2010 by the Institute of Forestry, Lithuanian Research Centre

Table 1. Origin, type and amounts of progeny of wild cherry in Dubrava nursery trial. ID – provenance identification code (the first and the second letters indicate country code), HZ – hardiness zone, N_{2010} and N_{2011} – number of survived and measured individuals in 2010 and 2011

Provenance ID	Provenance	Type of basic material	Latitude	Longitude	HZ	N_{2010}	N_{2011}
EsCL	O Courel Lugo	Seed source	43.01	?7.56	9	53	20
ItBF	Bosco Fontana	Selected stand	45.12	10.44	8	171	70
ItMB	Monte Baldo	Seed source	45.46	10.51	8	164	41
ItL	Lusiana	Seed source	45.47	11.34	8	64	18
AtK	Koenigshof	Seed orchard	48.01	16.74	7	225	91
AtT	Tulln	Seed orchard	48.33	16.08	7	147	54
De131	Zweibrücker Hügeland	Selected stand	49.22	7.32	7	199	89
PlZ	Zwierzyniec Adamow	Stand	50.58	23.12	6	154	122
BeM	Mommedeel	Seed orchard	50.82	4.74	8	106	5
PlK	Krasnystaw Borek	Stand	51.00	22.95	6	199	142
De127	Hildesheimer Wald	Selected stand	52.12	9.88	7	187	42
GbH	Hardwick	Seed orchard	52.47	?2.43	8	99	47
De129	Chorin	Selected stand	52.89	13.90	7	42	21
DkF	Buskegärd	Selected stand	55.15	15.05	8	119	56
DkS	Soroe	Seed source	55.42	11.58	8	71	22
DkNZ	North Zealand	Seed source	55.83	12.24	8	139	39
LtT	Plateliai	Seed source	56.03	21.82	6	1187	485
51ThTr BZ001	Dubrava nursery trial		54.85	24.05	5	3326	1364

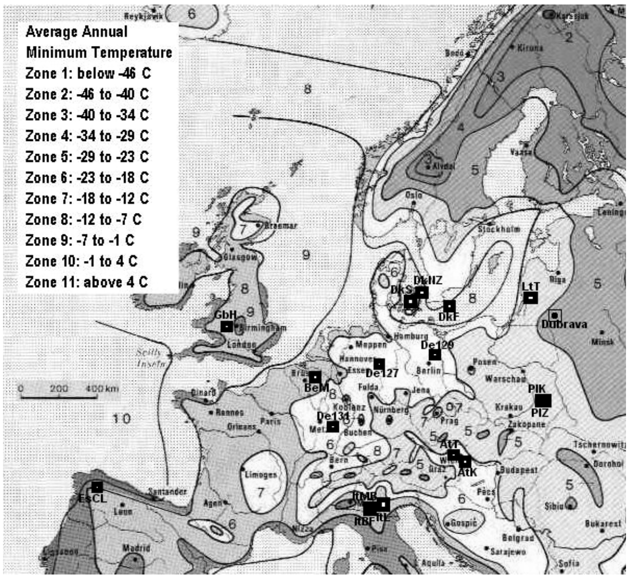

Figure 2. Hardiness zones of plants in Europe (Heinze and Schreiber 1984) and location of wild cherry provenances studied. Provenances indicated with squares and codes: Austrian (AtK, AtT), Belgian (BeM), British (GbH), Danish (DkF, DkNZ, DkS), German (De127, De129, De131), Italian (ItBF, ItL, ItMB), Lithuanian (LtT), Polish (PlK, PlZ), and Spanish (EsCL)

for Agriculture and Forestry, and Dubrava Experimental and Training Forest Enterprise transplanting 1-year greenhouse raised seedlings of open pollinated progenies to nursery in linear row plots, replicated in two blocks. Spacing between rows was 0.45 m; distance between trees was 0.20 m. About 3,300 trees have been planted in 2010.

Trait estimation

Wild cherry traits were estimated at age two and three. In total, the number of measured trees (valid cases, N) was 2,251 in the year 2010 and 1,117 in the year 2011.

The height (in cm) of tree stem to upper alive bud (H_{2010}) and the diameter (in mm) of stem over bark at root collar (D_{2010}) were measured with crosswise calliper after the end of the vegetation period at the nursery trial in 2010. The ratio of tree height to diameter (H/D) was obtained to characterise tree slenderness. In spring of 2011, the height to upper green (alive) bud was measured (H_{2011}, in cm) to characterise the extent of spring frost damage on each survivor. Frost damage during winter and spring 2010/2011 was estimated as the height loss ($HL_{2011} = H_{2010} - H_{2011}$). Tree survival rate of each population was estimated as the percentage of the remaining trees at the end of the vegetation season of the year 2011 from the initial number of trees in the year 2010.

Stem branchiness and forking at age two was evaluated as the ratio of the diameter (in mm) of strongest branch or secondary stem to the diameter (in mm) of stem (D_{br}/D).

The autumn over-coloration of cherry shoot tips was considered as stress indicator. Autumn over-coloration of green tree (shoot) tips was defined at age two as follows: 1 – yellowish – the tip is healthy, 2 – reddish – the tip is slightly damaged, 3 – brown – the tip is moderately damaged but still alive, 4 – blackish – the tip is dry.

In this study distinctive characters refer to the leaf gland traits of wild cherry scored at age three at mid-July 2011. Observations were made on the fifth leaf from the top of summer shoot and on all the successive leaves of that shoot of survivors. We have done the following evaluations of leaf glands and transformations of scores:

1) the pigmentation or ground coloration: 0^{th} – white or petiole colour, 1^{st} – orange or yellowish, 2^{nd} – red or reddish, 3^{rd} – purple or dark reddish; gland colour: 0 – not red ($0^{th} + 1^{st}$), 1 – red ($2^{nd} + 3^{rd}$);

2) the maximum length of glands when viewed from above: 1^{st} – up to half the width of a petiole, 2^{nd} – over half the width of a petiole, 3^{rd} – petiole width and more; gland length: 0 – 1^{st}, 1 – $2^{nd} + 3^{rd}$;

3) the maximum number of glands (1, 2, 3, 4, 5 or 6); gland number: 0 – 1-2, 1 – 3-6.

Data analyses

Analyses initially included all trees. Peculiarities of growth variation were determined at the species and provenance levels. The variance analysis was done with the MIXED procedure in SAS Software (SAS Institute, Inc., SAS/STAT Software, Release 9.3, 2012) which uses mixed model equations (MME) and the restricted maximum likelihood (REML) method. *F* tests were carried out to determine when the fixed effects (population and blocks) were significantly different from zero. The following linear model was used for data analysis:

$$y_{jmn} = \mu + b_j + p_m + pb_{mj} + \varepsilon_{jlmn},$$

where y_{jmn} is an observation on the n^{th} tree from the m^{th} provenance, μ is the field trial mean, b_j is the fixed effect of the jth block, p_m is the fixed effect of the mth provenance, pb_{mj} is the fixed effect of interaction between the mth provenance and the jth block, and e_{jmn} is the random residual.

The normality of residuals' distribution and homogeneity of variances were tested with SAS GLM and UNIVARIATE procedures (SAS Institute, Inc., SAS/STAT Software Release 9.3, 2012).

Pearson and Spearman correlation coefficients between traits and correlation coefficients between provenance trait means and geographical data were calculated using SAS CORR procedure. *LS*-means and Tukey comparison lines for *LS*-means of provenances were estimated using SAS GLM procedure (SAS Institute, Inc., SAS/STAT Software Release 9.3, 2012)

Independent samples *t*-test of SPSS (Statistical Package for the Social Sciences) 16.0 for Windows® was used to compare two classes of a growth parameter that were not related. The results for *t*-test indicated where the means for the two independent classes were significantly different at the 5%-probability level. Prior to conducting statistical analyses, each variable was tested for deviations from the normal distribution and for homoscedasticity using Levene's test for equality of variances.

To calculate subgroup means and related univariate statistics for the dependent variables of tree height, height loss, H/D ratio, and branchiness ratio D_{br}/D within categories of gland maximum length the Means procedure of SPSS 16.0 for Windows® was used. Using this procedure, we had layered position within the level of gland maximum length and observed how average height loss differs by gland coloration.

Results

The analysis of variance revealed that the effects of Provenance, Block, and Provenance × Block interaction were statistically significant for most of traits (Table 2) except the Block effect for D_{br} /D_{2010} ratio and tree height in spring of 2011. Phenotypic correlations between traits of wild cherry progeny in Dubrava nursery trial are presented in Table 3. There was statistically significant negative relationship between tree height in spring of 2011 and tree tip autumn over-coloration in 2010. It means the more damaged tree tips were in autumn, the smaller tree height was next spring. It must be noted statistically significant negative relationship between tree tip autumn over-coloration in 2010 and leaf gland length in 2011 as well as statistically significant positive relationships between the leaf gland length and the rest of the traits. Hypothetically, it means the greater length of the glands the better.

The two classes of gland colour had about the same amounts of variability between the scores of morphology parameters at the 5%-probability level, as

Table 2. Results of ANOVA of wild cherry progeny traits in Dubrava nursery trial: *F*-ratio and level of significance of provenance, block and provenance by block interaction effects. H_{2010} and H_{2011} – tree height at the end of 2010 and in spring of 2011, D_{2010} – tree diameter in 2010, H/D – tree ratio of H_{2010} to D_{2010}, D_{br} – the diameter of strongest branch or side stem, D_{br}/D – tree branchiness ratio of D_{br} to D_{2010}, TiOc – autumn over-coloration of shoot tips in 2010, and GlPi – gland pigmentation, GlLe – gland length in relation to petiole width, GlCo – gland colour in 2011

Trait	*F*-ratio and level of significance					
	Provenance effect		Block effect		Provenance × Block interaction	
D_{2010}	55.296	***	162.849	***	11.868	***
D_{br}/D	14.110	***	2.538	.	6.771	***
D_{br}	26.641	***	22.243	***	11.615	***
GlLe	4.888	***	11.720	***	2.600	***
GlPi	7.033	***	43.479	***	4.724	***
GlCo	7.069	***	45.787	***	3.831	***
H_{2010}	46.973	***	331.155	***	12.006	***
H/D	44.234	***	175.036	***	9.142	***
H_{2011}	38.225	***	0.143	.	6.129	***
TiOc	7.146	***	13.899	***	2.768	***

Level of significance: * – 0.05 > *P* > 0.01, ** – 0.001 > *P* < 0.01, ***– *P* < 0.001

Table 3. Phenotypic correlations and their level of significance for the traits of wild cherry. For traits abbreviations description see Table 2

Trait	H_{2010}	D_{2010}	H/D	D_{br}	D_{br}/D	TiOc	H_{2011}	GlCo
D_{2010}	0.796 [1] ***							
H/D	0.601 [1] ***	0.033 [1]						
D_{br}	0.325 [1] ***	0.593 [1] ***	-0.207 [1] ***					
D_{br}/D	-0.062 [1] ***	0.123 [1] ***	-0.270 [1] ***	0.824 [1] ***				
TiOc	-0.216 [2] ***	-0.246 [2] ***	-0.016 [2]	-0.076 [2] ***	0.047 [2] **			
H_{2011}	0.276 [1] ***	0.400 [1] ***	-0.048 [1] *	0.200 [1] ***	0.008 [1]	-0.330 [2] ***		
GlCo	0.210 [2] ***	0.108 [2] ***	0.154 [2] ***	0.009 [2]	-0.042 [2]	0.003 [2]	-0.015 [2]	
GlLe	0.324 [2] ***	0.329 [2] ***	0.122 [2] ***	0.195 [2] ***	0.064 [2] **	-0.063 [2] *	0.131 [2] ***	0.184 [2] ***

Level of significance: * – 0.05 > P > 0.01, ** – 0.001 > P < 0.01, ***– P < 0.001
[1] Pearson correlation coefficient and its P-value
[2] Spearman correlation coefficient and its P-value

the resulting significance values of Levene's test were greater than 0.05 (Table 4). However, only univariate mean values of tree H/D ratio were significantly different within both classes of gland colour at the highest probability level (see the significance values of the *t*-test from the top row in Table 4): red gland colour was characteristic of the survivors having greater class mean of tree H/D ratio, i.e. red gland colour was characteristic of slimmer trees (Table 5). Tree branchiness ratio D_{br}/D, autumn tip over-coloration, or spring height were not related with gland colour in such a way as described above.

The univariate mean values of tree H/D ratio or D_{br}/D ratio (Table 6) were significantly different within both classes of gland length at the 0.1%-probability or the 0.9%-probability level, respectively (see the significance values of the *t*-test from the top row). Over half the width of a petiole gland length was characteristic of the survived saplings having greater class mean of tree H/D ratio or D_{br}/D ratio (Table 7). The estimation of statistical relationships between gland length and autumn tip over-coloration or spring height was not possible as the classes of gland length had different amounts of variability between the scores (Table 6, Levene's test).

Height loss due to the frost damage did not vary simply as a function of gland maximum length (Table 8); therefore it must take into account both gland length and gland colour. *Mean ± SE* column shows how average height loss differs by gland pigmentation or ground coloration of skin within level of gland maximum length. Although greater height loss was

Table 4. The univariate tests of morphology parameters of wild cherry survivors used to compare two independent classes of their leaf gland colour at age three in 2011. *M ± SE* = mean ± standard error, Sig. = significance, CI = confidence interval

Parameters	Equal variances	Levene's test		*t*-test				95% CI of the Difference	
		F	Sig.	*t*	*df*	Sig. (2-tailed)	*M ± SE* Difference	Lower	Upper
Tree H/D ratio in 2010	assumed	0.128	0.721	-5.532	1114	0	-7.62 ± 1.38	-10.33	-4.92
	not assumed			-5.405	708.334	0	-7.62 ± 1.41	-10.39	-4.85
Tree branchiness ratio D_{br}/D in 2010	assumed	2.845	0.092	1.474	1114	0.141	0.02 ± 0.01	-0.01	0.04
	not assumed			1.434	700.146	0.152	0.02 ± 0.01	-0.01	0.04
Tip over-coloration in 2010	assumed	0.071	0.789	-0.143	1114	0.886	-0.01 ± 0.05	-0.10	0.09
	not assumed			-0.143	746.854	0.886	-0.01 ± 0.05	-0.10	0.09
Spring height in 2011	assumed	0.224	0.636	0.096	1361	0.924	0.16 ± 1.63	-3.05	3.36
	not assumed			0.096	883.504	0.924	0.16 ± 1.64	-3.06	3.37

Table 5. Group statistics of gland colour for the tree H/D ratio of wild cherry at age three in 2011. *N* = the number of valid cases, *M ± SE* = mean ± standard error, *SD* = standard deviation

Growth parameter	Gland colour	*N*	*M ± SE*	*SD*
Tree H/D ratio in 2010	Not red	740	85.64 ± 0.78	21.21
	Red	376	93.27 ± 1.17	22.79

characteristic of survivors having red gland colour across all the levels of gland maximum length, the gap widens over the increase in gland length. The extent of frost damage of survived saplings having glands of petiole width and larger can be characterised by average height loss of 77.51 ± 2.60 cm while that of the sapling having glands over half the width of a

Table 6. The univariate tests of morphology parameters of wild cherry survivors used to compare two independent classes of their leaf gland length at age three in 2011. *M* ± *SE* = mean ± standard error, Sig. = significance, CI = confidence interval

Parameters	Equal variances	Levene's test F	Levene's test Sig.	*t*-test t	*df*	Sig. (2-tailed)	*M* ± *SE* Difference	95% CI of the Difference Lower	95% CI of the Difference Upper
Tree H/D ratio in 2010	assumed	1.666	0.197	-4.160	1114	0	-5.71 ± 1.37	-8.41	-3.02
	not assumed			-4.134	784.630	0	-5.71 ± 1.38	-8.43	-3.00
Tree branchiness ratio D_{br}/D in 2010	assumed	0.962	0.327	-2.623	1114	0.009	-0.03 ± 0.01	-0.06	-0.01
	not assumed			-2.593	773.211	0.010	-0.03 ± 0.01	-0.06	-0.01
Tip over-coloration in 2010	assumed	10.516	0.001	2.120	1114	0.034	0.10 ± 0.05	0.01	0.19
	not assumed			2.043	717.899	0.041	0.10 ± 0.05	0.00	0.20
Spring height in 2011	assumed	40.349	0	-4.983	1361	0	-8.08 ± 1.62	-11.26	-4.90
	not assumed			-5.385	1076.440	0	-8.08 ± 1.50	-11.03	-5.14

Table 7. Group statistics for gland length of wild cherry's growth parameters at age three in 2011. *N* = the number of valid cases, *M* ± *SE* = mean ± standard error, *SD* = standard deviation

Growth parameters	Gland length	*N*	*M* ± *SE*	*SD*
Tree H/D ratio in 2010	Up to half the width of a petiole	391	84.50 ± 1.12	22.19
	Over half the width of a petiole	725	90.21 ± 0.81	21.72
Tree branchiness ratio D_{br}/D in 2010	Up to half the width of a petiole	391	0.35 ± 0.01	0.20
	Over half the width of a petiole	725	0.38 ± 0.01	0.20

saplings having glands of petiole width and larger can be characterised by average height loss of 92% of initial tree height while that of the sapling having glands over half the width of a petiole was 74%, and that of the sapling having glands up to half the width of a petiole was 65%. One individual from Poland (PlK7) had no leaf glands at all however it lost 76 cm of height (78 cm) due to the frost damage of yr. 2010/2011. Frost damage of survived sapling having red

Table 8. Growth parameters by gland traits statistics for wild cherry survivors at age three in 2011. *N* = the number of valid cases, H_{2010} ± *SE* = mean ± standard error of tree height (cm) in 2010 yr., HL_{2011} ± *SE* = mean ± standard error of tree height loss (cm) due to frost damage in 2010/2011

Gland maximum length	Gland coloration		*N*	H_{2010} ± *SE*	HL_{2011} ± *SE*	Tree H/D ratio	Tree branchiness ratio D_{br}/D
Up to ½ the width of a petiole	White or petiole colour	Not red	132	71.33 ± 2.17	49.73 ± 2.28	78.95 ± 1.83	0.37 ± 0.02
	Orange or yellowish		177	76.75 ± 2.10	55.38 ± 2.43	86.33 ± 1.66	0.37 ± 0.01
	Red or reddish	Red	69	81.12 ± 3.82	61.61 ± 4.91	89.64 ± 2.86	0.27 ± 0.03
	Purple or dark reddish		13	88.00 ± 7.63	52.77 ± 8.81	88.61 ± 5.00	0.35 ± 0.06
	Total		391	76.06 ± 1.41	54.49 ± 1.63	84.50 ± 1.12	0.35 ± 0.01
Over ½ the width of a petiole	White or petiole colour	Not red	82	82.73 ± 3.01	54.04 ± 3.42	83.90 ± 2.48	0.36 ± 0.02
	Orange or yellowish		262	92.33 ± 1.71	60.59 ± 2.11	88.64 ± 1.22	0.39 ± 0.01
	Red or reddish	Red	141	96.10 ± 2.80	69.28 ± 3.64	92.01 ± 1.86	0.36 ± 0.02
	Purple or dark reddish		31	101.64 ± 5.88	72.32 ± 7.00	97.23 ± 4.08	0.42 ± 0.04
	Total		516	92.39 ± 1.31	62.63 ± 1.63	89.32 ± 0.93	0.38 ± 0.01
Petiole width and more	White or petiole colour	Not red	14	105.57 ± 10.76	59.36 ± 9.19	80.50 ± 7.42	0.41 ± 0.05
	Orange or yellowish		73	104.64 ± 3.18	66.31 ± 3.68	88.26 ± 2.28	0.40 ± 0.02
	Red or reddish	Red	99	109.64 ± 2.84	87.00 ± 3.92	94.98 ± 2.52	0.41 ± 0.02
	Purple or dark reddish		23	126.91 ± 4.58	83.22 ± 8.40	101.74 ± 2.52	0.33 ± 0.04
	Total		209	109.52 ± 1.99	77.51 ± 2.60	92.41 ± 1.58	0.39 ± 0.01
Total	White or petiole colour	Not red	228	77.53 ± 1.87	51.87 ± 1.89	80.83 ± 1.46	0.37 ± 0.01
	Orange or yellowish		512	88.70 ± 1.29	59.61 ± 1.47	87.78 ± 0.91	0.38 ± 0.01
	Red or reddish	Red	309	97.09 ± 1.87	73.24 ± 2.41	92.43 ± 1.33	0.36 ± 0.01
	Purple or dark reddish		67	107.67 ± 3.88	72.27 ± 4.78	97.10 ± 2.33	0.38 ± 0.03
	Total		1116	89.88 ± 0.94	62.56 ± 1.09	88.21 ± 0.66	0.37 ± 0.01

petiole was 62.63 ± 1.63 cm, and that of the sapling having glands up to half the width of a petiole was 54.49 ± 1.63 cm. The average height loss of the saplings of red gland colour was 72.75 ± 3.59 cm while that of the saplings of not red gland colour was 55.74 ± 1.68 cm. The largest gland maximum length was characteristic of the slimmest saplings (88.21 ± 0.66 is the mean of tree H/D ratio) of purple (dark reddish) gland coloration, the smallest gland maximum length was characteristic of the thickest saplings of white (petiole colour) gland coloration. Frost damage of survived gland colour was characterised by average height loss of 86% of overall mean of tree height while this of the sapling having not red gland colour was 66%.

European populations' progenies of wild cherry substantially differed in mortality and growth losses due to frost damages (Table 9). The highest survivability was observed in the Polish populations (survival rate was 75.3%), the worst – in the Belgian (4.7%). While the smallest height loss (H_{2010} – H_{2011}) and the smallest initial height (H_{2010}) was observed for Austrian AtT population (38.56 ± 2.10 and 50.10 ± 1.66, cor-

Table 9. Statistics for wild cherry's provenances at Dubrava nursery trial. S – survival (in %), ID – national identification number, H_{2010} and H_{2011} – tree height (cm) at the end of 2010 and in spring of 2011, D_{2010} – tree diameter (mm) in 2010, H/D – the ratio of H_{2010} to D_{2010}, D_{br} – the diameter (mm) of strongest branch or side stem, D_{br}/D – the ratio of D_{br} to D_{2010}, *M* ± *SE* – mean ± standard error, *CV* – coefficient of variation in %

Provenance ID	S	H_{2010}		H_{2011}		D_{2010}		H/D		D_{br}		D_{br}/D	
		M ± *SE*	*CV*	*M* ± *SE*	*CV*	*M* ± *SE*	*CV*	*M* ± *SE*	*CV*	*M* ± *SE*	*CV*	*M* ± *SE*	*CV*
AtK	40	100.74± 1.86 cd*	28	18.70± 1.81 b	145	10.33 ± 0.19 cb	27	98.30 ± 1.22 de	19	3.48 ± 0.17 d	75	0.33 ± 0.02 de	70
AtT	37	50.10± 1.66 j	40	11.54± 1.18 ced	123	5.80 ± 0.11 h	23	84.58 ± 1.67 gh	24	1.97 ± 0.10 h	60	0.33 ± 0.02 fde	61
BeM	5	70.83 ± 2.91 h	42	2.22± 1.18 f	548	6.50 ± 0.23 h	37	106.31± 1.96 a	19	1.40 ± 0.14 i	106	0.19± 0.02 h	100
De127	22	72.77 ± 2.06 hg	39	3.97 ± 0.69 f	239	8.04 ± 0.17 f	28	88.97 ± 1.63 fg	25	3.02 ± 0.13 edf	57	0.37 ± 0.02 dec	57
De129	50	97.17 ± 5.69 bcd	38	6.02± 2.12 fe	228	11.33 ± 0.51 a	29	84.29 ± 3.01 igh	23	4.76 ± 0.37 a	50	0.41 ± 0.03 bac	41
De131	45	79.78 ± 2.12 ed	38	8.37 ± 1.23 fe	207	8.48 ± 0.18 e	30	92.68 ± 1.33 c	20	3.45 ± 0.14 d	56	0.41 ± 0.02 bac	51
DkF	47	99.28 ± 3.79 bc	42	16.03± 2.88 cb	196	9.76 ± 0.32 cbd	35	99.33 ± 1.93 bc	21	3.24 ± 0.24 ed	81	0.31± 0.02 fe	68
DkNZ	28	105.52± 2.67 a	28	36.94 ± 2.56 a	82	11.73 ± 0.27 a	26	89.67 ± 1.42 fe	18	4.27 ± 0.28 ba	74	0.34 ± 0.02 fde	65
DkS	31	78.36 ± 4.21 fe	45	18.62± 3.51 b	159	9.10 ± 0.29 ed	27	82.76 ± 2.62 gh	26	4.20 ± 0.26 bac	51	0.46 ± 0.02 a	43
EsCL	38	88.81 ± 3.77 bcd	32	15.74± 3.13 cbd	145	10.76 ± 0.40 a	28	82.57 ± 2.32 fgh	21	4.38 ± 0.32 ba	55	0.40± 0.02 bdac	45
GbH	47	96.27 ± 2.62 bc	27	6.66 ± 1.63 fe	243	9.40 ± 0.22 ced	24	103.24± 2.27 ba	22	4.19 ± 0.24 bac	57	0.44 ± 0.02 ba	50
ItBF	41	103.86± 2.31 ba	29	8.80± 1.21 ed	179	9.91 ± 0.19 cbd	24	105.54± 2.04 a	25	3.24 ± 0.18 d	73	0.33 ± 0.02 fde	70
ItL	28	73.77 ± 3.87 fg	42	2.20± 0.50 f	181	8.63 ± 0.35 e	33	84.16 ± 2.20 fg	21	3.50 ± 0.30 dc	69	0.38 ± 0.03 bdec	63
ItMB	25	60.84 ± 2.24 i	47	2.81± 0.46 f	212	7.29 ± 0.16 g	28	81.17± 1.82 ih	29	2.54 ± 0.14 g	69	0.35 ± 0.02 dec	66
LtT	41	80.42± 0.97 f	36	14.56± 0.68 cbd	138	9.92 ± 0.10 cbd	29	80.50± 0.66 i	25	3.99 ± 0.08 bc	61	0.40± 0.01 bac	55
PlK	71	94.39 ± 2.09 cd	31	33.72± 2.65 a	111	9.03 ± 0.18 e	28	104.73± 1.37 ba	18	2.75 ± 0.13 egf	66	0.29± 0.01 fg	62
PlZ	79	96.47 ± 2.08 bc	27	33.12± 2.72 a	102	10.10 ± 0.19 b	23	95.95 ± 1.52 dc	20	2.59 ± 0.14 gf	67	0.25± 0.01 g	68
Mean		**84.13 ± 0.59**		**15.03 ± 0.44**		**9.27 ± 0.05**		**90.16 ± 0.41**		**3.40 ± 0.04**		**0.36 ± 0.00**	
Min		7		0		2		18		0		0	
Max		211		170		21		257		13		1.33	

* *LS*-means with the same letter are not significantly different (Tukey HSD test, P <0.05)

respondingly), the largest height loss and the largest initial height was observed for Italian ItBF population (95.07 ± 2.52 and 103.86, correspondingly). According to the coefficients of within-population variation of spring height (H_{2011}) wild cherry survivors lined up as follows (starting with the progeny showing best uniformity of the data): DkNZ, PlZ and PlK (similar progenies), AtT, LtT, AtK, EsCL, DkS, ItBF, ItL, DkF, De131, ItMB, De129, De127, GbH, and BeM.

In total, survivors were thicker and had less thick branches or side stems than the saplings had initially (mean of tree H/D ratio in 2010 was 88.21 ± 0.66 vs 90.16 ± 0.41 and mean of tree branchiness ratio D_{br}/D in 2010 was 0.37 ± 0.01 vs 0.36 ± 0.00). The best initial tree branchiness ratios D_{br}/D (or slimmest branches) were observed for significantly different Belgian and Polish progenies, the worst – for the Danish DkS and British GbH (see Tukey comparison lines for *LS*-means for D_{br}/D in Table 9). *LS*-means of the Lithuanian LtT for D_{br}/D were not significantly different from the German De129 and De131. Thickest stems (i.e. initial tree H/D ratios ranging from 100) were observed for similar BeM and ItBF, PlK and GbH populations' progenies. Healthiest tree tips were observed for the Danish DkNZ population; however its survival rate was low in comparison to the Polish rivals (Table 10). The greatest mean of gland length along with its lowest *CV* was observed for the British GbH population. According to the *CV*s of gland length in relation to petiole width Wild cherry populations of survivors lined up as follows (starting with the progeny showing best uniformity of the data): GbH, DkNZ, ItBF, De129, DkF, EsCL, AtK, LtT, ItL, PlK, DkS, De127, De131, BeM, PlZ, AtT, and ItMB. According to the *CV*s of gland colour the populations' progenies lined up as follows (starting with the progeny showing best uniformity of the data): BeM, ItBF, GbH, DkF, EsCL, PlZ, ItL, De129, PlK, DkNZ, AtK, AtT, ItMB, LtT, De131, DkS, and De127. In conclusion, the ItBF, GbH, DkF, EsCL populations' survivors were most uniform

Table 10. Statistics for wild cherry's progenies at Dubrava nursery trial. S – survival (in %), ID – national identification code of provenance, *M* ± *SE* – mean ± standard error, *CV* – coefficient of variation, in %

Provenance ID	S	Tip autumn overcoloration[a] in 2010		Gland length[b] in 2011		Gland colour[c] in 2011	
		M ± *SE*	*CV*	*M* ± *SE*	*CV*	*M* ± *SE*	*CV*
AtK	40	2.04 ± 0.07	53	0.77 ± 0.04	55	0.35 ± 0.05	137
AtT	37	1.51 ± 0.08	63	0.46 ± 0.07	109	0.35 ± 0.07	137
BeM	5	1.78 ± 0.11	65	0.60 ± 0.25	92	0.80 ± 0.20	56
De127	22	1.80 ± 0.07	55	0.60 ± 0.08	85	0.02 ± 0.02	750
De129	50	1.60 ± 0.15	62	0.81 ± 0.09	49	0.43 ± 0.11	119
De131	45	1.84 ± 0.07	54	0.56 ± 0.05	89	0.22 ± 0.04	191
DkF	47	2.09 ± 0.11	57	0.80 ± 0.05	50	0.50 ± 0.07	100
DkNZ	28	1.34 ± 0.07	55	0.82 ± 0.06	48	0.36 ± 0.08	136
DkS	31	1.76 ± 0.13	59	0.64 ± 0.11	77	0.18 ± 0.08	217
EsCL	38	1.50 ± 0.10	52	0.80 ± 0.09	51	0.50 ± 0.12	102
GbH	47	1.60 ± 0.09	54	0.89 ± 0.05	35	0.51 ± 0.07	98
ItBF	41	1.84 ± 0.08	60	0.81 ± 0.05	48	0.64 ± 0.06	75
ItL	28	1.86 ± 0.13	56	0.72 ± 0.11	64	0.44 ± 0.12	116
ItMB	25	2.09 ± 0.09	54	0.27 ± 0.07	167	0.29 ± 0.07	159
LtT	41	1.73 ± 0.03	60	0.72 ± 0.02	64	0.23 ± 0.02	187
PlK	71	1.37 ± 0.05	55	0.67 ± 0.04	70	0.37 ± 0.04	130
PlZ	79	1.52 ± 0.07	61	0.46 ± 0.05	109	0.44 ± 0.05	114
Mean		**1.74 ± 0.02**		**0.67 ± 0.01**		**0.33 ± 0.01**	
Min		1		0		0	
Max		4		1		1	

[a] Ranges from 1 (yellowish, i.e. tree tip is healthy) to 4 (blackish, i.e. the tip is dry)
[b] Ranges from 0 (up to half the width of a petiole) to 1 (over half the width of a petiole)
[c] Ranges from 0 (not red) to 1 (red)

according to the distinctive morphological characters of leaf glands.

Correlations (Pearson correlation coefficients and their *P*-values) between trait means of provenances of wild cherry and geographical data are given in Table 11. There was strong statistically significant positive relationship between gland number and hardiness zone index ($r = 0.60$, $P = 0.03$). The moderate or strong positive correlations, i.e. between gland maximum number and hardiness zone index, tree height in spring of 2011 and longitude, were not sufficiently significant (Table 11).

Table 11. Pearson correlation coefficients (and their *P*-values *in italics*) between provenance trait means at Dubrava nursery trial and geographical and ecological data at provenances' origin locations. Strongest or significant correlations are **in bold**

Trait	Hardines zone	Latitude	Longitude
Tree height at the end of 2010 (H_{2010})	-0.008	0.232	0.059
	0.976	*0.371*	*0.822*
Tree diameter in 2010 (D_{2010})	0.023	0.236	0.034
	0.932	*0.361*	*0.898*
Ratio of H_{2010} to D_{2010} (H/D)	-0.063	0.023	0.002
	0.811	*0.930*	*0.993*
Tree height in spring of 2011 (H_{2011})	-0.348	0.338	**0.464**
	0.170	*0.185*	*0.061*
Tree height loss due to frost damage (HL_{2011})	0.455	0.090	-0.458
	0.118	*0.770*	*0.116*
Diameter of strongest branch or side stem (D_{br})	0.201	0.242	-0.237
	0.439	*0.350*	*0.360*
Branchiness ratio of D_{br} to D_{2010} (D_{br}/D)	0.198	0.103	-0.312
	0.445	*0.694*	*0.223*
Autumn over-coloration of shoot tips (TiOc)	0.211	-0.178	-0.013
	0.416	*0.495*	*0.959*
Gland pigmentation (GlPi)	0.403	-0.119	-0.311
	0.108	*0.649*	*0.225*
Gland colour (GlCo)	0.377	-0.278	-0.282
	0.135	*0.280*	*0.272*
Gland max. length in relation to petiole width (GlLm)	0.310	0.125	-0.272
	0.226	*0.632*	*0.291*
Gland length in relation to petiole width (GlLe)	0.271	0.231	-0.271
	0.293	*0.371*	*0.294*
Gland maximum number (GlNm)	**0.517**	-0.406	**-0.484**
	0.070	*0.169*	*0.094*
Gland number (GlNu)	**0.601**	-0.302	**-0.511**
	0.030	*0.315*	*0.074*

Discussion and conclusions

The genetic diversity of *P. avium* has been shown to be weakly spatially structured (Mariette et al. 1997, Mohanty et al. 2001). The pattern of genetic variability in this species implies that forest reproduction material should be collected from unrelated trees spread out over large enough areas (Jarni et al. 2012). Since *P. avium* is an entomophilous species, high pollen flow which would homogenize the populations is improbable, even if wild cherry pollen is easily located by insects (Frascaria et al. 1993, Gömöry and Paule 2001). Earlier study in wild cherry indicates that the vast majority of seed was dispersed no further than 50 m from the mother tree (Turcek 1968). Variability inside selected seed stands, of which the area is very limited, is not large (Fernandez et al. 1994), because natural suckering of wild cherry leads to clones covering varying areas (Frascaria et al. 1993): as a consequence, seeds are effectively harvested on very few genotypes in selected seed stands. So, the test material for our study was collected from the broad area of species' distribution range. The EUFORGEN gene conservation strategy for wild cherry recommends using a minimum of 50 clones per seed orchard which should be regionally structured by the ecological conditions (Kleinschmit and Stephan 1997). Based on izozyme studies of distribution of wild cherry clones in populations, it is recommended to select and use in plantations a mixture of at least 5 to 10 clones, mostly from different origins, in order to improve heterogeneity and self-sustainability (Ducci and Santi 1997).

The preliminary results, which give the first indications of the improvement potential for wild cherry in Lithuania in relation to introduction and which confirm some results obtained by Santi et al. (1998), are encouraging. It is also necessary to incorporate studies on susceptibility to bacterial canker and cherry leaf spot in the future. Cherry leaf spot (*Blumeriella jaapii* (Rehm) Arx.) has been recognized as the most serious sanitary problem of wild cherry (grown for timber) in some European countries (Motta et al. 1994, Santi et al. 1998), which results in premature leaf defoliation, vigour decrease, especially in diameter, and winter hardiness reduction, which can even induce tree death due to low winter temperatures (Wharton et al. 2003). Bacterial canker (*Pseudomonas syringae* Van Hall, 1904) is a major cause of dieback in wild cherry plantations (Santi et al. 2004). Both diseases thrive in moist and cool conditions (Eisensmith and Jones 1981, Hirano and Upper 2000), so the projected increase of atmospheric moisture content in northern latitudes (Frei et al. 2000) may benefit the diseases in Lithuania.

Our interest was in selecting the vigorous trees with small branches. Branches with large diameter or very fastigiated result in bigger wounds and necessitate rapid and severe pruning (Santi et al. 1998). There is an indication of breeding possibility of fast growing trees while retaining relatively slim branches as the correlation between tree height and tree branchiness ratio was very weak (see Table 3). The related unfavourable correlation was reported by Curnel et al. (2003) that the tallest clones of wild cherry tended to be more forked.

A significant clone × site interaction had no negative impact on genetic gain at first multisite clonal test of wild cherry in Belgium (Curnel et al. 2003). Studying the clones for the characters where the G × E interaction is detectable allows the breeder for the determination of the relative stability of the clones (Curnel et al. 2003). Statistically significant effects of provenance and provenance × block interaction revealed in the analysis of variance in our study (presented in Table 2) indicates a presence of genetic differences in populations' general performance and in ecological reaction norms. It means that the development of locally adapted lines for the evaluation of future tests is required (Hajnala et al. 2007).

Muranty et al. (1998) concluded that selection for vigour can be done based on an index combining height growth and girth growth in order to obtain the highest precision in the evaluation of genetic values for vigour. Importantly, tree height in spring of 2011 (H_{2011}) was negatively correlated with ratio of H_{2010} to D_{2010} in this study, which shows that early selection on height after one year of growth in nursery would not be efficient. It is in agreement with the clonal study by Muranty et al. (1998). Our data indicate that height growth or height loss estimates can be used both for breeding for growth and for adaptation/survival.

Juvenile age is most decisive period for survival, establishing and adaptation in new environments therefore studies at this age are of primary importance. Studies of progenies of black and wild cherries have shown moderate to strong age-age correlations (r = 0.37?0.77) for growth performance (Gerhold 1987, Stanton et al. 1983, Nocetti et al. 2012). Such correlations allows for forecasting of progeny future performance based on early age assessments. Current study is part of a cherry breeding strategy mainly focused on developing cultivars that have to be well adapted to future climatic conditions. However, the principal difficulty to this approach is our inability to test the trees under putative environmental conditions.

Most *Prunus* species have a dual dormancy induction control system, securing timely growth cessation and dormancy induction in autumn (Hemery et al. 2009). An exception to this is *P. avium*, which maintains growth in short days at intermediate temperatures and stops growing only at low temperatures (Heide 2008). This behaviour could affect normal winter bud development or cause delayed or erratic bud burst in spring. This is reflected in the results of the study. The *CV*s of tree height to upper alive bud were from 3.1 to 13 times greater in the spring of 2011 in comparison to the autumn of 2010 (see Table 9). According to this trait (CV_{2011}/CV_{2010}) progenies of wild cherry lined up as follows (starting with the progeny showing most erratic CV_{2011}/CV_{2010} of tree height): BeM (13), GbH (9), ItBF (6.2), De127 (6.1), De129 (6), De131 (5.4), AtK (5.2), DkF (4.7), EsCL (4.5), ItMB (4.5), ItL (4.3), LtT (3.8), PlZ (3.8), PlK (3.6), DkS (3.5), AtT (3.1), DkNZ (2.9).

The results of the study showed that, conversely to the pigmentation of shoot tips, induction of cherry gland pigments is not subjected to stress. Anthocyanins may be developmentally permanent in this case. The red coloration of shoot tips and leaves in many woody plants occurs in tandem with the onset of dormancy and cold hardiness due to induction of anthocyanins (Chalker-Scott 1999), nevertheless, securing timely growth cessation and dormancy induction in autumn are missing among *P. avium* species (Hemery et al. 2009). The red coloration of cherry shoot tips is probably based on anthocyanin biosynthesis, which is caused by stress like drought (Balakumar et al. 1993), nutrient deficiencies (Rajendran et al. 1992), wounding (Ferreres et al. 1997) or pathogen infection (Dixon et al. 1994).

It must be noted statistically significant positive relationships between the leaf gland length and the rest of wild cherry traits, except last year autumn overcoloration of shoot tips (Table 3). It means the greater length of the glands the better. In general, it may be stated that those conditions which produce vigorous vegetative growth favour gland development, since on old trees or on trees subjected to unfavourable growth conditions, the petiolar glands become much reduced, sometimes even disappearing, although normally present in the varieties (Dorsey and Weiss 1920). Finally, we have found that gland number is the best indicator of initial hardiness of transferred provenances.

Wild cherry possesses high level of genetic variation (Russell 2003). It is therefore likely that cherry is capable to adapt successfully with some shift in climate space. The results of this study approved our expectations that some individuals of wild cherry could be able to succeed even outside their current range of hardiness and thus show viability in long distance transfer. We have found few Italian ItBF individuals originating from provenances from hardiness zone 8, which showed no height loss due to frost damage at hardiness zone 5 at all. Moreover, the survival rate for this progeny was close to that of local Lithuanian LtT provenance (see Table 9).

In general, the uniformity of the data observed for some traits of European wild cherry (transferred from hardiness zones 6, 7, 8, and 9) suggests some tendency for its putative hardiness at central part of Lithuania (hardiness zone 5). According to the *CV*s calculated for the mean values of spring height (H_{2011}) the similar progenies showing the best uniformity of the data (or the lowest *CV*s), i.e. Polish PlZ and PlK from hardiness zone 6, were also the best survivors (see Table 9). The similar progenies showing the worst uniformity of the data (or the highest *CV*s), i.e. Belgian BeM and German De127 from hardiness zone 8 and 7 correspondingly, were the worst survivors. In conclusion, forest reproductive material from Poland (PlK and PlZ from hardiness zone 6) and Austria (AtK and AtT from hardiness zone 7) is candidate for further testing for the potential introduction of most fitted populations of wild cherry to the western and central parts of Lithuania (hardiness zone 6 and 5).

Using provenances instead of progenies has downsides as not allows for estimating genetic parameters, however, it brings in valuable information on ability of populations to survive in different environments (important issue when assessing effects climate change to forestry), and is low cost method to improve growth and quality of tree species where more costly breeding efforts are not possible.

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СОХРАНЕНИЕ ПОТОМСТВА ЧЕРЕШНИ (*PRUNUS AVIUM* L.) НА СЕВЕРНОМ ПРЕДЕЛЕ ЕЕ ЕСТЕСТВЕННОГО АРЕАЛА ПРИ ПЕРЕМЕЩЕНИИ В ЛИТВУ

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Резюме

Целью данного исследования было проанализировать возможность обогащения местных популяций черешни (*Prunus avium* L.) интродуцированным материалом, способствующим существованию при значительных отклонениях от оптимума вида. Потомства черешни из девяти стран Европы были испытаны на северном пределе ее естественного ареала. Данные сохранения потомства здесь относятся к потере высоты из-за ущерба от заморозков и к определенной вариабельности признаков деревьев. Исследования потомства черешни проводились на испытательном участке в центральной Литве в возрасте двух и трех лет. *F*-отношения фиксированных эффектов происхождения и блока, коэффициенты корреляции Пирсона и Спирмена, различия Тьюки были вычислены для следующего набора адаптивных и морфологических признаков: высота дерева осенью и весной, диаметр ствола дерева, соотношение этой высоты и диаметра осенью, диаметр сильнейшей боковой ветви или ответвления стебля, соотношение этого диаметра с диаметром дерева, осенняя окраска верхушек побегов, длина желез листьев по отношению к ширине черешков, цвет желез листьев.

Дисперсионный анализ большинства признаков показал, что эффекты происхождения, блока, и взаимодействия между происхождением и блоком были статистически значимыми. Это указывает на присутствие генетических различий между популяциями в общей производительности и в экологических нормах реакции. Очень слабая корреляция между высотой деревьев и соотношением ветвистости деревьев позволяет судить о возможности разведения быстрорастущих особей, сохраняя относительно тонкие ветви.

T-тест для независимых выборок и тест Левена на равенство дисперсий подтвердили связь между показателями роста выживших деревцев и признаками желёзок листьев. Определение изменений в морфологии выживших особей показало, что индукция пигментов желёзок не подвергается стрессу. Осенняя окраска верхушек побегов черешни считается показателем стресса в данном исследовании. Чем больше поврежденных деревьев было осенью, тем меньше высота дерева была следующей весной.

Была обнаружена сильная и значимая корреляция между числом желез и индексом климатической зоны в местах происхождения популяций (R = 0.60, P = 0.03). Положительные корреляции между максимальным количеством желез и индексом климатической зоны, высотой деревьев весной 2011 и долготой были умеренными, но недостаточно значимыми.

В общем, лесорепродукционный материал черешни из Польши и Австрии может быть использован для дальнейшего тестирования на потенциал интродукции наиболее приспособленных популяций в Литву.

Ключевые слова: *Prunus avium*, черешня, интродукция, сохранение, рост, морфология.