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GENETIC ANALYSIS OF GROWTH AND FRUIT BEARING TRAITS OF 'OBLAČINSKA' SOUR CHERRY CLONES

Dragan Nikolić[1*], Dragan Milatović[1], Vera Rakonjac[1], Aleksandar Radović[2], Jugoslav Trajković[3]

[1]University of Belgrade, Faculty of Agriculture, Belgrade-Zemun, Serbia
[2]University of Niš, Faculty of Agriculture, Kruševac, Serbia
[3]Academy of Vocational Studies Southern Serbia, Department of Agricultural and Food Studies, Prokuplje, Serbia
[*]Corresponding author: nikolicd@agrif.bg.ac.rs

ABSTRACT
During the three-year period of investigation, the trunk circumference, yield per tree, and yield efficiency in 13 'Oblačinska' sour cherry clones were studied. Significant differences among the studied clones and years of testing were determined for all investigated traits, while interaction clone × year showed no significant differences. The lowest trunk circumference and yield per tree were found in the clone 13 (23.2 cm; 7.6 kg), and yield efficiency in clone 3 (0.09 kg/cm^2). Clone 3 had the highest trunk circumference (53.9 cm), clone 6 had the highest yield per tree (23.3 kg), and clone 10 had the highest yield efficiency (0.18 kg/cm^2). The lowest coefficients of genetic and phenotypic variation were determined for the yield efficiency (16.69%; 20.46%), and the highest for the yield per tree (33.28%; 34.89%). The coefficient of heritability ranged from 66.20% for the yield efficiency up to 98.37% for the trunk circumference.

Key words: clonal selection, heritability, *Prunus cerasus*, vigour, yield.

INTRODUCTION
In the commercial production of fruit in Serbia, sour cherry rank third place, after plum and apple (Milatović et al., 2015). 'Oblačinska' sour cherry is an autochthonous cultivar that in sour cherry orchards in Serbia is represented with the largest number of trees. The general feature of 'Oblačinska' sour cherry is self-fertilization and high and regular yielding (Gvozdenović, 1995). It bears fruit already in the third year, and in the fourth it gives a yield of 4 to 6 kg/tree. In the fifth year, it gives 10 kg/tree, which enables a yield of over 10 t/ha. According to Milatović et al. (2015) 'Oblačinska' sour cherry can yield over 20 t/ha. Its fruit is small (about 3 g), round, quite uniform in size and ripening time. The skin is dark red and thin. Mesocarp is red, medium firm, juicy, quite sour, aromatic, good quality, and suitable for processing into various products (Mratinić, 2002).

'Oblačinska' sour cherry is not a pure cultivar, but a mixture of many clones (genotypes). For this reason, there are problems with its reproduction and exploitation, so clonal selection requires the choice of genotypes with the best traits. Through clonal selection first of all, genotypes should be singled out which in addition to less vigour of the tree and good bearing, will have large fruits with a high soluble solids and organic acids content, as well as different ripening times and resistance to biotic and abiotic stress factors (Nikolić et al., 2020).

The clonal selection of 'Oblačinska' sour cherry in Serbia was mainly done by Milutinović et al. (1980), Ogašanović et al. (1985), Nikolić et al. (1996, 2005, 2011), Miletić et al. (2005, 2008), Fotirić (2009) and Miletić & Paunović (2015) who selected a large number of clones for cultivation and further breeding work. Clonal selection is successful because sour cherry, unlike sweet cherry, have a rather unstable genotype and are prone to mutation. Somatic mutations are most often manifested in the time of flowering and ripening, largeness and quality of fruit, bearing, character of growth and fruiting (Milatović & Nikolić, 2011). Changes occur especially on older trees and on individual branches, and rarely on the whole tree.

Among the many features of sour cherry tree, as important for production, they are can highlight the vigour, shape and branching of the tree. In modern production, knowing the vigour of varieties is very important for designing the optimal planting distance and determining the intensity of pruning. Sour cherry bearing is also a complex trait that depends on a large number of factors. The yield is significantly influenced by the number of fruits, fruit weight, number of flower buds and the number of fruit set (Chang et al., 1987).

For clonal selection of 'Oblačinska' sour cherry, which is based mainly on quantitative traits, adequate studies on the expression of these properties are necessary. The trunk circumference is the most important indicator of the vigour of some variety, and fruit bearing is one of the most important production and technological traits. They largely depend on the biological characteristics of variety, and then the ecological conditions of cultivation, applied agricultural techniques, etc. (Nikolić et al., 2020). In order to successfully improve quantitative traits such as tree characteristics and bearing, the effects of genetic and environmental factors must be evaluated (Dieters et al., 1995).

The aim of this paper was to do genetic analysis of growth and fruit bearing traits in 13 'Oblačinska' sour cherry clones.

MATERIALS AND METHODS

As a material for investigation, thirteen 'Oblačinska' sour cherry clones which selected from production orchards in southern Serbia were used. The researches were carried out in the collection orchard of 'Oblačinska' sour cherry on the Experimental Station "Radmilovac" of the Faculty of Agriculture, University of Belgrade. The orchard was planted in spacing of 4×3 m. The rootstock is the Mahaleb cherry (*Prunus mahaleb* L.) and the training system is the open vase. Growth and fruit bearing traits were studied in tested clones during the three-year period.

Trunk circumference (at 20 cm from the graft union) was measured by meter after the end of the vegetation, just before winter pruning. The yield per tree was obtained by measuring the weight of all fruits for each individual tree, and yield efficiency was determined from the ratio of yield per tree and cross-sectional area of trunk. The cross-sectional area of trunk was calculated based on trunk circumference, using the form $r^2\pi$.

The significance influence of studied factors on the variability of the studied traits was assessed by F-test. Individual testing significance of differences between the tested clones and years was performed using LSD test.

The variance components were calculated from the variance analysis model of the two-factorial random block system. The following variance components were calculated: error variance (S^2_e); variance of the clone × year interaction (S^2_{cy}); year variance(S^2_y); clone variance - genetic variance (S^2_c) and phenotypic variance (S^2_f). Variation coefficients (genetic - CV_g; and phenotypic - CV_f) were calculated as relative indicators of variability. Heritability coefficient in the broad sense (h^2) was calculated as the ratio between genetic and phenotypic variance.

Data analysis was performed using the statistical software package STATISTICA, Version 8 (StatSoft, Inc., Tulsa, Oklahoma, USA).

RESULTS AND DISCUSSION

Based on the results shown in Table 1, it can be seen that clone 13 had the smallest trunk circumference (23.2 cm). The largest trunk circumference was found in clone 3 (53.9 cm). High trunk circumference values (>40.0 cm) were also found in clone 5 (41.1 cm) and clone 6 (47.1 cm). The average value of trunk circumference for all clones was 36.4 cm. Fotirić (2009) determined a slightly lower average value for trunk circumference (28.6 cm) in all tested clones of 'Oblačinska' sour cherry during the three years of investigation.

The lowest yield per tree was for clone 13 (7.6 kg). Clone 6 had the highest yield per tree (23.3 kg). A high yield per tree was also found in clone 4 (19.0 kg), clone 5 (17.1 kg) and clone 10 (18.1 kg). In research by Fotirić (2009), the yield per tree of 'Oblačinska' sour cherry clones varied from 4.22 kg to 14.53 kg. Nikolić et al. (2005) in 'Oblačinska' sour cherry clones determined the yield per tree from 5.1 kg to 20.6 kg, Nikolić et al. (2011) from 7.9 kg to 19.8 kg, and Rakonjac & Nikolić (2008) from 6.0 kg to 25.8 kg. In the conditions of Germany, 92 sour cherry varieties were studied, and among them was 'Oblačinska' sour cherry. The productivity of this variety was medium and had a rating of 4 (out of a possible 1-9 points). The stalk separated well from the fruit at the time of full maturity, which allowed mechanized harvesting (Hilsendegen, 2003).

Table 1. Trunk circumference, yield per tree and yield efficiency of 'Oblačinska' sour cherry clones (three-year average).

Clone	Trunk circumference (cm)	Yield per tree (kg)	Yield efficiency (kg/cm^2)
1	29.3	9.6	0.14
2	31.3	14.7	0.17
3	53.9	10.1	0.09
4	37.9	19.0	0.16
5	41.1	17.1	0.11
6	47.1	23.3	0.14
7	35.5	12.4	0.12
8	36.7	16.0	0.15
9	31.1	10.3	0.13
10	36.5	18.1	0.18
11	30.5	8.2	0.11
12	38.5	11.5	0.10
13	23.2	7.6	0.13
Average	36.4	13.7	0.13
$LSD_{C\ 0.05}$	2.9	4.06	0.04
$LSD_{C\ 0.01}$	3.8	5.38	0.05
$LSD_{Y\ 0.05}$	1.4	1.95	0.01
$LSD_{Y\ 0.01}$	1.8	2.59	0.02

On average, for all three years of testing, the lowest yield efficiency was found in clone 3 (0.09 kg/cm^2), and the highest in clone 10 (0.18 kg/cm^2). In research by Fotirić (2009), the yield efficiency varied from 0.068 kg/cm^2 to 0.244 kg/cm^2. The yield efficiency in selected clones of the Kütahya sour cherry variety was examined by Burak et al. (2005) and found that it ranged from 0.16 to 0.61 kg/cm^2.

The results of the analysis of variance (Table 2) show that there are very significant genetically determined differences between the studied clones for trunk circumference, yield per tree and yield efficiency. A very significant influence of the year on the variability of these traits was also found. The interaction (C×Y) was not significant. These results completely match the results of Fotirić (2009) and the results of Nikolić et al. (2011) who found very significant differences only between 'Oblačinska' sour cherry clones. Nikolić et al. (2005) studied 10 'Oblačinska' sour cherry clones on the basis of pomological-technological characteristics in order to select the most promising one for further multiplication and spreading in production. In their work, very significant differences between the studied clones were found for yield, fruit weight, stone weight, fruit stalk length and content of total acids.

Table 2. Means of squares from the analysis of variance for the studied traits of 'Oblačinska' sour cherry clones.

Sources of variation	df	Trunk circumference	Yield per tree	Yield efficiency
Repetition	2	15.65^{ns}	8.72^{ns}	0.00109^{ns}
Clone (C)	12	571.38^{**}	204.99^{**}	0.00639^{**}
Year (Y)	2	145.75^{**}	142.23^{**}	0.03773^{**}
Interaction (C×Y)	24	2.14^{ns}	17.76^{ns}	0.00213^{ns}
Error	76	9.43	18.79	0.00170

$^{**}P<0.01$; ns-not significant.

Genetic variability (82.83%) contributed the most to the total phenotypic variability of trunk circumference. The variability caused by year was 4.82%, and the variability due to random environmental factors and experimental error was 12.35% (Table 3). Variability conditioned by the clone × year interaction did not exist.

Table 3. Variance components, coefficients of variation and heritability for the studied traits of 'Oblačinska' sour cherry clones.

Indicator	Trunk circumference	Yield per tree	Yield efficiency
S^2_c (%)	82.83	48.62	14.60
S^2_y (%)	4.82	7.46	28.26
S^2_{cy} (%)	0.00	0.00	4.35
S^2_e (%)	12.35	43.92	52.79
CV_g (%)	21.84	33.28	16.69
CV_f (%)	22.03	34.89	20.46
h^2 (%)	98.37	90.87	66.20

The total variability of yield per tree was affected by genetic variability with 48.62%, variability conditioned by year with 7.46%, variability conditioned by random environmental factors and experimental error with 43.92%, and variability conditioned by clone × year interaction did not exist. In the total variability of the yield efficiency, genetic variability participated with 14.60%, variability conditioned by year with 28.26%, variability conditioned by the interaction clone × year with 4.35%, and variability conditioned by random environmental factors and experimental error with 52.79%. Rakonjac & Nikolić (2008) found a high genetic share in the total phenotypic variability of yield per tree (58.0%), examining 'Oblačinska' sour cherry clones. The share of genetic variability in total phenotypic variability in research by Fotirić (2009) for yield per tree was 30.9%, and for yield efficiency 31.8%.

The coefficients of genetic and phenotypic variation for trunk circumference were 21.84% and 22.03%, respectively. The coefficients of genetic and phenotypic variation for yield per tree and yield efficiency were quite different and were 33.28% and 34.89% for yield per tree, and 16.69% and 20.46% for yield efficiency. Rakonjac et al. (2010) found a coefficient of phenotypic variation of 33.1% for the yield per tree, and 45.2% for the yield efficiency.

The heritability coefficient values for all these three traits were relatively high and ranged from 98.37% for trunk circumference, 90.87% for yield per tree, and 66.20% for yield efficiency. The high values of the coefficients of heritability for all studied properties indicate that the selection process for these traits can be successful.

CONCLUSIONS

Significant differences among the studied clones and years of testing were determined for all investigated traits, while interaction clone × year showed no significant differences. The largest share of genetic in the total phenotypic variability was determined for trunk circumference (82.83%) and yield per tree (48.62%). The lowest coefficients of genetic and phenotypic variation were determined for the yield efficiency (16.69%; 20.46%), and the highest for the yield per tree (33.28%; 34.89%). The coefficient of heritability ranged from 66.20% for the yield efficiency up to 98.37% for the trunk circumference. The obtained results are importance for selection of the best ‘Oblačinska’ sour cherry clones.

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