Arch. Biol. Sci., Belgrade, 61 (4), 619-622, 2009 DOI:10.2298/ABS0904619O

PHENOTYPIC CHARACTERISTICS OF TREES AND SEEDS AS THE BASE FOR IMPROVEMENT AND CONSERVATION OF THE HORSE CHESTNUT GENE POOL

MIRJANA OCOKOLJIĆ and NADEŽDA STOJANOVIĆ

Faculty of Forestry, University of Belgrade, 11000 Belgrade, Serbia

Abstract — This study deals with individual and group variability of horse chestnut trees cultivated in urban cenoses in Belgrade, Zemun, and Pančevo, Serbia. The trees were selected according to their morphological-aesthetic properties and yield variability. In view of size of the study populations, it can be considered that the trees were cultivated in more or less uniform ecological conditions and that individual intra-population variability is mostly the result of genetic properties. The study results can serve as the base for selection of genotypes significant for application in urban cenoses, especially for the establishment of tree rows.

Key words: *Aesculus hippocastanum* L., conservation, polymorphism, selection, gene pool

UDC 582.546.56:630:575

INTRODUCTION

Ornamental woody species are cultivated for garden, park, and landscape architecture according to aesthetic criteria depending on their future application. Major aesthetic criteria are: crown shape and crown size; leaf number, form, and color; timing, intensity, and color of flowers; color and form of fruits; reaction to pruning for special purposes; etc. Many ornamental cultivars have been selected and improved with special emphasis on aesthetic characteristics (Josifović, 1973; Vukićević, 1998; Ocokoljić et al., 2003).

In many countries, line populations (tree rows) are an intensive and very much applied method of tree cultivation. The aim of the establishment of tree rows in urban conditions is to grow large stout trees and enhance the effect of numerous functions, from aesthetic to sanitary, which make the life of citizens more pleasant and humane (Ocokoljić et al., 1998). Previously obtained results indicate that horse chestnut, as one of the most beautiful ornamental woody species in Europe, is suitable for the above uses (Em, 1959).

Detailed investigation of the scope of variability of several morphological and eco-physiological parameters, as well as study of the yield abundance and regularity of horse chestnut in tree rows of Belgrade, Zemun, and Pančevo over a four-year period resulted in a more precise knowledge of the genetic potential of horse chestnut trees grown in urban conditions. This knowledge is significant for enhancement of their use in urban cenoses.

MATERIALS AND METHODS

This study deals with cultivated horse chestnut trees in urban cenoses. Group and individual variability of these trees was monitored in a period encompassing three ends of vegetative growth and two complete vegetative growth seasons. Forty trees were selected from tree rows in Belgrade, Zemun, and Pančevo. Variability of the selected trees served as the base for a closer study of the genetic potential of their original populations.

The trees were selected according to the following phenotypic characteristics: tree height, diameter at breast height, crown shape, branch insertion, spiral grain, straightness, fullness of the bole, bark structure, and bark color. The assessment was performed using formulas for the description of test trees. In analyzing variability of tree height and diameter at breast height, tree height was measured

with a Blume-Leiss hypsometer, while diameters at breast height were measured with standard callipers. Yield abundance was evaluated by the method of quantification of phenological features into classes of from 0 to 5. Also, the number of seeds per kilogram and the mass of 100 seeds were measured for each test tree.

The arithmetic mean ($\bar{x}$), standard deviation (S), coefficient of variation (V), and their mean errors (S, $\bar{x}$, Ss, Sv) were determined by biometric analysis of properties. Correlation analysis was performed in order to assess the relationship and interdependence of tree height, diameter at breast height, and seed size.

RESULTS AND DISCUSSION

The study populations in Belgrade, Zemun, and Pančevo are polymorphic and characterized by phenotypic and genetic diversity conditioned by environmental and hereditary factors. Ecological factors within each population are presumed to be uniform, as they are present on relatively small areas. Individual variability can primarily be ascribed to differences in genetic constitution of test trees

Table 1. Variability of studied horse chestnut properties.

Locality \ Properties	Tree crown			Bark					Straightness	
	Šk	K	Š	G	Pl	I	Ss	Ts	M	R
	Frequency									
Pančevo	2 :	2 :	6	5 :	3 :	2	5 :	5	4 :	6
Zemun	4 :	1 :	5	3 :	2 :	5	2 :	8	7 :	3
Nemanjina Street	2 :	1 :	7	6 :	3 :	1	8 :	2	2 :	8
Topčiderska Zvezda	3 :	2 :	5	2 :	5 :	3	4 :	6	4 :	6

Table 2. Variation of tree height and diameter of horse chestnut test trees in study populations.

Locality	Min. – Max.	$\bar{x} \pm S_{\bar{x}}$	$S \pm S_S$	$V \pm S_V$
		Tree height (m)		
Pančevo	6 – 15	10.41 ± 1.07	3.38 ± 0.75	32.48 ± 7.26
Zemun	6 – 10	8.09 ± 0.35	1.11 ± 0.24	13.80 ± 3.09
Nemanjina Street	6 – 11	8.91 ± 0.54	1.70 ± 0.38	19.13 ± 4.28
Topčiderska Zvezda	7 – 10	8.58 ± 0.38	1.20 ± 0.27	14.00 ± 3.13
		Diameter at breast height (cm)		
Pančevo	11 – 40	22.35 ± 2.58	8.17 ± 1.82	36.57 ± 8.18
Zemun	11 – 26	19.26 ± 1.65	5.22 ± 1.68	27.10 ± 6.06
Nemanjina Street	10 – 28	17.87 ± 1.75	5.54 ± 1.24	31.00 ± 6.94
Topčiderska Zvezda	11 – 33	23.32 ± 2.49	7.87 ± 1.76	33.77 ± 7.55

Table 3. Statistical parameters of analyzed seed properties.

Localities	$\bar{x} \pm S_{\bar{x}}$	$S \pm S_S$	$V \pm S_V$
	mass of 100 seeds (kg)		
Zemun	2.11 ± 0.07	0.24 ± 0.05	11.40 ± 2.55
Nemanjina Street	1.71 ± 0.09	0.29 ± 0.06	17.17 ± 3.84
Topčiderska Zvezda	1.64 ± 0.06	0.18 ± 0.04	11.58 ± 2.59
	number of seeds per kilogram		
Pančevo	59 ± 3	9.28 ± 2.08	15.87 ± 3.55
Zemun	50 ± 2	6.17 ± 1.38	12.21 ± 2.73
Nemanjina Street	61 ± 4	14.27 ± 3.19	23.38 ± 5.23
Topčiderska Zvezda	62 ± 3	8.69 ± 1.94	13.91 ± 3.11

(Tucović, 1983). However, differences in inter-population variability of the same properties, along with differences in the genetic constitution of trees, are also conditioned by micro-site differences.

The study populations of horse chestnut are characterized by group variability (polymorphism) in a series of properties. This study deals with the following properties: crown shape, bark type and color, and straightness of the stem. Three phenogroups are based on crown characteristics: trees with wide (Š), wide conical (Šk), and conical (K) crowns. With respect to the characteristics of dead bark, there are three phenogroups: trees with smooth (G), shallowly fissured (Pl), and fissured (I) bark. There are two phenogroups based on bark color: trees with gray-brown (Ss) bark and trees with dark-brown (Ts) bark. There are also two phenogroups based on stem straightness and branching pattern: trees with monopodial growth (M) and forked trees (R), including ones with low, medium, and high forking. Variability of the studied horse chestnut properties is presented in Table 1.

Measurement of tree height and diameter at breast height in the study populations shows inter-individual variability of these properties within and between populations. Table 2 gives values of statistical parameters indicating variability of the studied properties, which are predominantly genetically determined.

In horse chestnut test trees, height varied from 6.1 m in tree number 10 in Pančevo to 14.5 m in tree number 4, also in Pančevo. Diameters at breast height varied from 10.9 cm in tree number 48 in Nemanjina Street in Belgrade to 39.4 cm in tree number 9 in Pančevo. Variation coefficients were applied to determine individual variability and assess differential properties because these coefficients reflect the hereditary potential in a satisfactory manner.

Differences in variability of the same properties between populations and differences in the genetic constitution of test trees are also conditioned by differences in ecological factors.

The yield of horse chestnut in populations in Belgrade, Zemun, and Pančevo was assessed in September by the standard method of yield quantification into classes of from 0 to 5. In the studied vegetative growth periods, the yield of all the test trees was abundant and differences in the yearly yield were insignificant. Adopting the criterion of evaluation without decimals, the yield was evaluated as 3 in 2% of trees, 4 in 50% of trees, and 5 in 46% of trees, respectively. In the populations in Pančevo, 40% of trees had yields evaluated as 4 and 60% had yields evaluated as 5; in Zemun, 40% of trees had a mark of 4 and 60% had a mark of 5; in Nemanjina Street, 50% of trees had a mark of 4, 40% had a mark of 5, and 10% had a mark of 3; in Topčiderska Zvezda, 60% of trees had a mark of 4 and 40% had a mark of 5.

The studied populations of horse chestnut differed in the number of seeds per kilogram and the mass of 100 seeds, such differences being recorded between individuals in each population and between populations (Table 3).

Inter-population differences in the number of seeds per kilogram and seed mass should be ascribed not only to differences in genetic constitution of the trees, but also to differences in ecological factors at the study sites. Variability of the analyzed seed characteristics is also confirmed by the values of variation coefficients in this biometric analysis.

Correlation analyses were performed in order to determine the relationship and interdependence of tree height, diameter at breast height, and seed size. There is a significant positive correlation between tree height and diameter at breast height, which is indicated by a correlation coefficient of $r = 0.37$. The positive correlation emphasizes the fact that diameter at breast height increases with height increment. Correlation coefficients calculated for the dependencies of tree height and seed size and diameters at breast height and seed size are not significant (correlation coefficients of $r = 0.05$ and $r = 0.04$), i.e., these variables are not interdependent.

CONCLUSIONS

The results of multiannual analyses at both the population level and the individual level contribute to a better knowledge of the genetic potential of horse

chestnut grown in urban conditions. The applied study methods provided more detailed information about knowledge of variability of the initial line populations and the selected test trees with the aim of more intensive use of the horse chestnut genetic potential and improvement of seed and seedling production for the establishment of cultural communities in urban zones. For this reason, the present study considered group and individual variability based on a sample of 40 trees in tree rows in Pančevo, Zemun, and Belgrade.

Comparative analysis of several morphological and physiological properties of trees and seeds yielded information on:

- the degree of individual variability;
- specific genotypes; and
- possibilities of further improvement and production of nursery stock for urban cenoses.

This study points to a considerable genetic potential of this species, which has not been sufficiently utilized. Ecological factors within each of the four study populations are uniform, so the proved individual variability can be ascribed to differences in genetic constitution of the test trees. Differences at the inter-population level and differences in genetic constitution of the trees are also conditioned by ecological factors.

Especially significant is the great adaptibility of horse chestnut, which is proved by good phenotypic properties of test trees growing in very unfavorable conditions in an urban environment – trees in tree rows are surrounded by concrete and exposed to drought, high temperatures, and intensive air pollution. The results of studying the variability of test tree properties can serve as the base for selection of genotypes to be used for urban greenery, especially for tree rows.

The assessed scope of variability of the analyzed properties of horse chestnut trees in line populations is a contribution to research aimed at the planned transformation of this species for purposes of forestry and landscape architecture.

REFERENCES

Em, H. (1959). Diviot ili konskiot kosten vo NR Makedonija. *God. Zborn. Zemj.-Šum. Fak.* (*Skopje*) **12,** 3-34.

Josifović, M. (1973). *Flora SR Srbije*, 200 pp. SANU, Belgrade.

Ocokoljić, M., Kovačević, N., and V. Isajev (1998). Prilog proučavanju divljeg kestena (*Aesculus hippocastanum* L., Hippocastanaceae). *Arh. Farm.* **3,** 215-223.

Ocokoljić, M., and J. Ninić-Todorović (2003). *Priručnik iz dekorativne dendrologije*, 168 pp. Faculty of Forestry, Belgrade.

Tucović, A. (1983). Oplemenjivanje šumskog drveća, In: *Šumarska Enciklopedija*, Vol. 2, 549-562. Zagreb.

Vukićević, E. (1997). *Dekorativna dendrologija*. Belgrade.

ФЕНОТИПСКА СВОЈСТВА СТАБАЛА И СЕМЕНА КАО ОСНОВА ЗА ОПЛЕМЕЊИВАЊЕ И ОЧУВАЊЕ ГЕНОФОНДА ДИВЉЕГ КЕСТЕНА

МИРЈАНА ОЦОКОЉИЋ и НАДЕЖДА СТОЈАНОВИЋ

Шумарски факултет, Универзитет у Београду, 11000 Београд, Србија

Резултати спроведених вишегодишњих истраживања су допринос бољем упознавању генетског потенцијала дивљег кестена у урбаним условима. Упоредном анализом више морфо-физиолошких својстава стабала и семена добијене су информације о степену индивидуалног варијабилитета и постојању специфичних генотипова. У оквиру сваке анализиране популације може се претпоставити уједначеност еколошких фактора а доказани индивидуални варијабилитет приписати разликама у генетским конституцијама кестена. Посебно се истиче адаптивност дивљег кестена, коју потврђују добра фенотипска својста тест стабала која егзистирају у неповољним условима (окружена бетоном, изложена суши, високим температурама и јаком аерозагађењу). Добијени резултати су основа за селекцију генотипова који су погодни за озелењавање насеља. Практична страна утврђене променљивости је омогућавање спонтане и планске трансомације ове алохтоне врсте.