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BIOLOGICAL AND POMOLOGICAL CHARACTERISTICS OF SUPERIOR WALNUT SELECTIONS

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As late spring frosts are a limiting factor to successful growth of walnuts, attention was focused on walnut selection in years when late spring frosts occur after bud swelling. This particulary refered to the years of 1998 and 2002, and partly 2001. In those years, 32 walnut trees were found to produce satisfactory yield in regions severely affected by strong spring frosts and were subjected to careful observation in the following years. Of that number, 11 trees were found exceptional. They were characterized by luxuriance, vigour, satisfactory resistance to walnut antracnose, and yielding capacity. Fruits had good quality and favourable characteristics of the shell (smooth, thin, light-coloured, easily separable) and kernel (relatively smooth, light-coloured, tasty). Fruit mass measured 18.0-9.3 g, kernel mass 8.6-4.1 g, and kernel content 55.0-47.0%. The kernel contained 67.0-61.1% oil, 19.3-14.5% crude proteins and 2.65-2.12% mineral matter. All investigated selections had been grafted. They were grown in identical conditions, in collection, and the ones found best for commercial growth were selected.

Key words: walnut, population, selection, yield capacity, low temperature

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INTRODUCTION

Walnut selection aims at singling out genotypes characterized by good-quality fruits, late beginning and short duration of vegetation, stable yield capacity, and resistance to low winter temperatures and parasites. These criteria of walnut selection have been emphasised by KORAĆ *et al*. (1976), PAUNOVIĆ and GAVRILOVIĆ (1971), UNOHINI and VALII (1990), SZENTIVANI (1990), GERMAIN *et al*. (1983; 1997), MITROVIĆ (2003). Besides, late spring frosts pose a serious problem and limitation to walnut growth, as observed by HLIŠČ (1980; 1985) in studies of walnut phenological characteristics, and OGAŠANOVIĆ *et al*. (1991) in investigation of the susceptibility of shoots to early autumn and winter frosts. Similar research has been reported by KORAĆ and CEROVIĆ (1980), in which a relationship was established between the phenological characteristics of cultivars and walnut selections, and damage caused by early autumn, winter and late spring frosts. Special attention is therefore being devoted to walnut selection in years characterized by late spring frosts after the beginning of vegetation, such as reported by NENADOVIĆ-MRATINIĆ (1994).

Walnut population of Timočka krajina is very abundant and heterogenous. Besides, walnut is an anemophilous species characterized by high polymorphism, MILETIĆ (1994). As walnut selection is based on the available gene pool in walnut populations, our objective was to record, select and study some superior selections characterized by high yield capacity in years when late spring frosts occur.

MATERIALS AND METHODS

Recording, description and evaluation of walnut fruit quality was carried out during vegetation following late spring frosts of 1998, 2001 and 2002. Selection was carried out in localities in which walnut grows in large numbers and frosts are particularly severe. No fruit species in the localities, including the walnut population, bear fruit after late spring frosts. During the selection procedure, 32 walnut trees of satisfactory yield capacity were recorded. The subject of this investigation is the 11 of them that were found especially outstanding.

The main characteristics of the tree (vigour, habit, crown density, catkin abundance, number of female flowers) and fruit (shape, shell roughness and thickness, suture height, kernel colour), as well as the condition relating to a parasite (*Gnomonia leptostyla*), were evaluated employing the UPOV method. Fruit size was determined by calliper square and mass weighed on a Mettler precision scale. Kernel oil content was determined by nuclear magnetic resonance (NMR), crude proteins by the Kjeldhal method, and mineral matters by incineration. The results presented here are average values of the data collected over a number of years and statistically processed by analysis of variance and Duncan's multiple range test.

RESULTS

As mentioned above, late spring frosts occurring at different stages of development in the region of Timočka krajina have been causing considerable damage to buds, catkins and walnut fruit embryos. In such cases, walnut yields have been missing. In January and February of 1998, unusually high air temperatures initiated bud swell and beginning of vegetation. On March 10th, however, temperature dropped to -11.0°C, and continued measuring -9.0°C and -10.0°C the following days. At the beginning of April 2001, considerable damage caused by late spring frost (-5.0°C) was recorded during the bud swell phase and the beginning of foliation. The following year, late spring frosts were recorded on March 31st and April 8th, measuring minimum temperatures of -5.1°C and -6.1°C, respectingly, at the beginning of walnut vegetation.

The selected trees were characterized by different degrees of vigour, mostly high, and upright growth with high and very high branching density. The abundance of catkins and female flowers was high or medium. During the selection process, special attention was focused on early symptoms of walnut antracnose (*Gnomonia leptostila)*. Highly susceptible trees were eliminated, so that the selected ones were characterised by low or medium susceptibility to the disease, Table 1.

Table 1. Biological characteristics of the selections

Sel. No.	Vigour	Crown shape	Crown density	Catkin abundance	Flower No	Susceptibility to Gnomonia
8/98	very high (9)	Half-spread (9)	Very dense (9)	High (3)	Many (3)	Low (3)
22/98	high (7)	Upright (3)	Dense (7)	High (3)	Many (3)	Low (3)
29/01	Low (3)	Upright (3)	Sparse (3)	Moderate (2)	Medium (2)	Very low (1)
18/01	high (7)	Upright (3)	Very dense (9)	High (3)	Medium (2)	Moderate (5)
27/01	Moderate (5)	Upright (3)	Dense (7)	High (3)	Many (3)	Moderate (5)
12/02	very high (9)	Half-spread (5)	Very dense (9)	Moderate (2)	Many (3)	Very low (1)
14/02	High (7)	Upright (3)	Dense (7)	Moderate (2)	Many (3)	Moderate (5)
30/02	Moderate (5)	Upright (3)	Medium (5)	High (3)	Medium (2)	Low (3)
35/02	Moderate (5)	Upright (3)	Dense (7)	High (3)	Many (3)	Moderate (5)
24/02	High (7)	Half-upright (5)	Medium (5)	Moderate (2)	Medium (2)	Low (3)
31/02	High (7)	Upright (3)	Medium (5)	Moderate (2)	Medium (2)	Moderate (5)

Fruits were medium or large in size, Table 2. Fruit length ranged between 28.5 mm (14/02) and 42.3 mm (12/02), thickness between 28.2 mm (8/98) and 38.0 mm (12/02), and width between 26.8 mm (8/98) and 35.6 mm (12/02 and 31/02). Highly significant differences were found between most selections. The roundness index was 1.0-1.3, meaning that the fruits mostly had elongated shape. The shell was slightly wrinkled, smooth or rough, medium in thickness, and with medium suture.

Table 2. Fruit size and appearance

Sel. No.	Fruit (mm)			Index	Shape factor	Shell appearance	Shell thickness	Suture height
	Lenght	Thickness	Width					
8/98	34.3e	28.2f	26.8e	1.2	Elliptic (8)	Slightly wrinkled (2)	Thin(3)	Low (3)
22/98	41.8ab	33.5c	32.1b	1.2	Elliptic (8)	Wrinkled (3)	Thin (3)	High (7)
29/01	36.7c	29.6e	29.4d	1.2	Elliptic (8)	Smooth (1)	Medium (5)	Low (3)
18/01	41.8ab	33.5c	32.1b	1.2	Trape-zium (5)	Slightly wrinkled (2)	Medium (5)	Medium (5)
27/01	36.3cd	33.2c	29.3d	1.1	Elliptic (8)	Very wrinkled (4)	Thick (7)	Medium (5)
12/02	42.3a	38.0a	35.3a	1.1	Trpe-zium (5)	Slightly wrinkled (2)	Medium (5)	Medium (5)
14/02	28.5f	28.4f	28.5d	1.0	Elliptic (8)	Smooth (1)	Thin (3)	High (7)
30/02	35.0de	32.6c	31.0c	1.1	Trian-gular (2)	Wrinkled (3)	Thin (3)	Medium (5)
35/02	37.0c	29.0ef	29.0d	1.3	Elliptic (8)	Smooth (1)	Medium (5)	Medium (5)
24/02	40.2b	31.2d	30.4c	1.0	Elliptic (8)	Slightly wrinkled (2)	Thin (3)	High (7)
31/02	40.3b	36.0b	35.3a	1.1	Trian-gular (2)	Wrinkled (3)	Thin (3)	High (7)

*Duncan's multiple range test was used to compare different genotypes, P< 0,05

Fruit mass measured 9.3 (30/02) to 13.3 (31/02), and kernel mass 4.1 (18/01) to 8.6 (12/02), kernel content 47.0% (12/02) to 55.5% (8/98). Four selections were found to have characteristic low-mass fruits (8.1-10.0 g), while others had fruits of medium, high and very high mass, which is the special and valuable characteristic of the chosen selections. The case is similar regarding kernel contents. Five selections were found to have very high (50.1-55.0%), and seven high kernel content (45.1-50.0%). Besides, highly significant and significant differences were found among most selections regarding those characteristics.

Walnut kernels were mostly found to be of good-quality light or yellow colour, although selections of a darker hue were found as well. Oil content in the kernel was high (60-70%) for all selections, i.e. 61.1 (22/98) to 67.0% (35/02), while crude proteins were medium (15.1-20.0%) between 14.5% (24/02) and

19.3% (8/08). Regarding these characteristics, highly significant and significant differences were found. On the other hand, mineral matter content was low or medium, measuring 2.1% (22/98) to 2.6% (35/02), and no statistical differences were found,

Table 3. Fruit mass and kernel characteristics

Sel. No.	Fruit mass (g)	Kernel mass (g)	Kernel content (%)	Kernel colour	Oil content (%)	Crude proteins (%)	Mineral compaunds (%)
8/98	8.1gh	4.5def	55.5a	Light brown (4)	65.1b	19.3a	2.2a
22/98	11.4d	5.6bc	49.1ef	Yellow (3)	62.5cd	15.5e	2.1a
29/01	11.3d	5.3cd	47.0g	Light yellow (2)	61.1e	16.1de	2.3a
18/01	8.0h	4.1f	51.2cd	Light yellow (2)	61.9de	18.4ab	2.5a
27/01	12.3c	5.8bc	47.1g	Light yellow (2)	64.8b	16.0e	2.4a
12/02	18.3a	8.6a	47.0g	Yellow (3)	63.2c	17.0cd	2.1a
14/02	8.9fg	4.4ef	49.4de	Light yellow (2)	66.6a	17.2c	2.5a
30/02	9.3cf	5.0cde	53.8ab	Yellow (3)	64.4b	17.8bc	2.4a
35/02	10.0e	5.0cde	50.0de	Yellow (3)	67.0a	18.5ab	2.6a
24/02	11.0d	5.8bc	52.7bc	Dark (5)	62.2d	14.5f	2.2a
31/02	13.3b	6.3b	47.4fg	Light yellow (2)	62.5cd	17.7bc	2.4a

*Duncan's multiple range test was used to compare different genotypes, P< 0,05

Most indicators for commercial cultivation point at the selections 24/02, 35/02, 22/98 and 8/98 as standing out. The others may be used for planned hybridization as they have some good-quality characteristics.

DISCUSSION

Timočka krajina has a potential for becoming a major walnut growing area. Relatively favourable agro-ecological conditions, generative reproduction, natural selection and human activities have produced a very rich and heterogenous walnut population of over 180,000 fruit-bearing trees, MILETIĆ (1994). A special value of the population is its best known domestic walnut cultivar Šampion (selected by KORAĆ *et al*., 1986). Working in the area, JELENKOVIĆ (1974) had singled out and described five, and MILETIĆ (1986; 1996) 16 and 26 good-quality and promising selections, respectingly. This, however, hardly exhausts all possibilities as new generations are growing up in the changed agro-ecological conditions, enlarging the local walnut population and improving its quality.

In natural populations, selection takes place under the influence of many different environmental factors. New gene sets are thus being formed as the population adjusts to new environmental conditions, BOROJEVIĆ (1986). The chosen

selections may therefore be marked by various favourable characteristics, including a pronounced resistance to low winter temperatures or very late beginning of vegetation. That, however, has not been established as a certainty in hitherto *ex situ* conditions. Under similar conditions existing after late spring frosts in the area of Mt. Kopaonik, NENADOVIĆ-MRATINIĆ (1994) had singled out eight selections of walnuts with different pomological characteristics and tolerant to low temperatures. The selections had different sizes, fruit mass ranging from 5.67 g to 14.28 g, mesocarp content from 43.51 to 54.48%, and oil content from 59.11% to 70.78%. The selection Viktor was characterised by early, homogametic flowering, a tendency to apomictic fruit-bearing, small fruits and high kernel content. On the other hand, selection No. 2 was characterised by early flowering, protandry, large fruits and high kernel content. OGAŠANOVIĆ *et al*. (1991) had reported different degrees of damage caused by low temperature to shoots of different walnut cultivars and selections. The author found cultivars and selections originating from regions of the former USSR, Romania and Eastern Serbia to show greated tolerance. However, cultivars and selections of a later time of foliation show high susceptibility to low winter temperatures, which adds to our doubts about the causes of the high yield capacity of the chosen selections. In accordance with these results are those reported by FORDE (1975) that walnut cultivars originating from the Balkans demonstrate the highest tolerance to low winter temperatures. Similar findings have been reported by GERMAIN *et al*. (1989), showing that French cultivars are more susceptible to winter temperatures than those found in the Balkans.

As age, luxuriance and vigour were not uniform regarding the chosen selections and they grow in different localities without any particular care and cultivation, the more detailed comparisons are hardly reliable. This especially refers to phenological characteristics and tolerance of low temperatures at different stages. Whether it has been precisely those characteristics that have ensured high fertility after late spring frosts, or some other, such as primarily parthenocarpy and lateral flowering, remains to be established after collectivisation and parallel growth with conventional cultivars and selections under identical conditions. The same applies to the chosen walnut selections characterised by favourable traits.

CONCLUSIONS

Thirty-two walnut trees of satisfactory yield capacity were found after late spring frosts in the area of Timočka krajina. Among them, 11 selections were found to stand out regarding pomological characteristics.

The chosen selections were characterised by different degrees of vigour, mostly high, upright habit with dense or very dense branching, high or medium abundance of catkins and female flowers, and low or medium susceptibility to antracnose.

Fruits were found to be of medium or large size. Index of roundness was 1.0 to 1.3, giving the fruits mostly an elongated shape. The shell was slightly wrinkled, smooth or rough, medium in thickness and with medium suture.

Fruit mass was measured to be 9.3-13.3 g, kernel mass 4.1-8.6 g and kernel content 47.0-55.5%. Kernel was mostly light coloured or yellow and containing 61.1-67.0% oil, 14.5-19.3% crude proteins and 2.1-2.6% mineral matter.

According to most indicators, the selections 24/02, 35/02, 22/98 and 8/98 are especially adequate for commercial growth. The others may the used for planned hybridization.

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BIOLOŠKO-POMOLOŠKE OSOBINE SUPERIORNIH SELEKCIJA ORAHA

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Izvod

Pojava poznih prolećnih mrazeva je ograničavajući činilac uspevanja oraha. Iz ovih razloga posebna pažnja poklanja se selekciji oraha u godinama kada se nakon bubrenja pupoljaka pojave pozni prolećni mrazevi. To se posebno odnosi na 1998 i 2002, a delom i na 2001. godinu. U ovim godinama, na područjima gde su prolećni mrazevi bili posebno izraženi i gde su posledice bile posebno izražene, evidentirana su 32 stabla zadovoljavajuće rodnosti. Ova stabla su detaljnijije praćena narednih godina. Od ovog broja odabrana su 11 koja se posebno ističu. Odlikuju se bujnošću, vitalnošću, zadovoljavajućom otpornošću prema sivoj pegavosti lišća i rodnošću. Plodovi su kvalitetni sa povoljnim osobinama ljuske (gladka, tanka, svetle boje, lako se razdvaja) i jezgre (relativno gladka, svetle boje, ukusna). Masa plodova ovih selekcija je od 18.0 do 9.3 g, masa jezgre 8.6 do 4.1 g, a sadržaj jezgre od 55.0 do 47.0%. Jezgra sadrži 67.0 do 61.1% ulja, 19.3 do 14.5% sirovih proteina i 2.65 do 2.12% mineralnih materija. Sve evidentirane selekcije su okalemljene kako bi se kolekcionisanjem u istim uslovima izdvojile najbolje za komercijalno gajenje.

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