AGRONOMIC PERFORMANCE OF ALMOND CULTIVARS IN SERBIA

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Abstract

Almond production in Serbia is very small. The main reason for this is the frequent occurrence of late spring frosts during flowering. Present study was carried out to evaluate phenological characteristics (flowering and maturity times), productivity, and characteristics of the nut and the kernel (nut weight and dimensions, shell thickness, weight of kernel, kernel share, oil and protein contents) in 13 almond genotypes of a different origin growing in the region of Belgrade. The average flowering time was the second half of March and the first decade of April. The flowering began first in 'Nessebar', 'Selection 25', and 'Tétényi kedvenc' (16th of March), and latest in 'Francoli', and 'Texas' (29th of March). Beginning of the fruit maturity was recorded in the range of 13 days, from August 15th ('Tétényi bőtermő' and 'Tétényi keményhéjú') to August 28th ('Glorieta'). The average productivity was the lowest in 'Glorieta' and 'Francoli' and the highest in 'Tuono'. In March 2017 late spring frost that significantly reduced yield in early flowering cultivars was recorded. Nut weight ranged from 1.95 g ('Budatétény') to 5.58 g ('Marcona'). Shell thickness varied from 1.71 mm ('Budatétény') to 5.06 mm ('Marcona'). Kernel weight was the lowest in 'Selection 25' (0.80 g) and 'Tuono' (0.81 g), and the highest in 'Texas' (1.30 g). Kernel share was the lowest in 'Selection 25' (16.03%), and the highest in 'Budatétény' (57.93%). Oil content ranged from 44.35% ('Glorieta') to 57.52% ('Budatétény'), and protein content ranged from 21.72% ('Budatétény') to 30.51% ('Selection 25'). Obtained results indicate that Belgrade region is suitable for growing of late flowering almond cultivars.

Keywords: *Prunus dulcis, flowering, maturation, productivity, nut and kernel characteristics.*

Introduction

Almond [*Prunus dulcis* (Mill.) D.A.Webb syn. *Prunus amygdalus* (L.) Batsch] is a species of genus *Prunus* and subgenus *Amygdalus* (*Rosaceae,* subfamily *Prunoideae*). It originated from Central Asia and dispersed through cold and xeric environments in the mountainous areas and deserts of western China into Iran (Watkins, 1976). Over the time, the almond culture has extended to colder areas. In the winter rest period, the almond can tolerate temperature of -20 to -24°C, thus it is also grown in countries with a more severe climate, such as Hungary, Czech Republic, Bulgaria and Romania (Bulatović, 1985). Almond cultivation in Serbia is limited to a small number of locations, including Slankamen Hill (Čolić and Zec, 2007; Čolić et al., 2009). Due to early flowering and a weak growing tradition, Serbia has very small areas under almonds. Commercial almond production in Serbia is low considering the demand and economic potential. In Serbia, except early-flowering cultivars, in the experimental trials are also present late-flowering cultivars, which bloom after apricot cultivars (Zec et al., 1999). The most intensive studies were performed on the almond population in the area of Slankamen hill (Čolić and Zec,

2007; Čolić et al. 2009, 2012), while Zec et al. (1999) and Milatović et al. (2013, 2017) evaluated agronomic characteristics of introduced almond cultivars grown in the area of Belgrade. The aim of this study was to evaluate phenological traits, yield and fruit characteristics of 13 almond cultivars originated from several European countries. The best performing cultivars will be recommended for growing in the region of Belgrade, as well as in other regions with similar environmental conditions.

Materials and methods

Study was carried out in the almond orchard at the experimental station 'Radmilovac' of the Faculty of Agriculture in Belgrade, in the period 2017 - 2019. The orchard was planted in 2014. The study included 12 introduced almond cultivars: 'Budatétény', 'Tétényi bőtermő', 'Tétényi kedvenc', 'Tétényi keményhéjú' and 'Tétényi rekord' from Hungary; 'Francoli', 'Glorieta', 'Marcona' and 'Masbovera' from Spain, 'Nessebar' from Bulgaria; 'Texas' from USA; 'Tuono' from Italy and 'Selection 25' from Serbia. All cultivars were grafted on the clonal rootstock 'GF 677' and were represented with five trees. Training system is open vase, and planting distance is 5 × 3.5 m. Flowering was monitored according to the recommendations of the International Working Group for Pollination: beginning of flowering - when 10% of flowers open, full flowering - 80% of open flowers, and the end of flowering - when 90% of petals fall off (Wertheim, 1996). The samples of 30 fruits per tree were randomly harvested at full maturity (hulls fully desiccated and opened along the suture). Yield was determined by ranking from 0 to 5. Nut and kernel length, width and thickness were measured with a digital calliper, whereas nut and kernel were weighted on a digital scale. Kernel/nut ratio was expressed as a percentage. The oil content was determined by extraction with petroleum ether in a Soxhlet apparatus (Faithfull, 2002.). The nitrogen content in the kernel was determined by the Kjeldahl method, and the content of crude protein was obtained by calculation, multiplying by a factor of 5.18 (Faithfull, 2002). The data for nut characteristics were statistically analyzed using analysis of variance. The significance of differences between mean values was determined using Duncan's multiple range test at 0.05 level of probability.

Results and discussion

Almonds are characterized by a short period of deep winter dormancy and early flowering time. Almond bloom lasts 5 to 25 days depending on the cultivar, rootstock and the temperature (Bulatović, 1985). In our study significant differences in flowering time were observed (Table 1). Cultivars 'Nessebar' and 'Tétényi kedvenc' as well as 'Selection 25' began to bloom the earliest (March 16th) whereas the cultivars 'Francoli' and 'Texas' had the latest (March 29th) beginning of flowering. Zec et al. (1999) recorded that the cultivar 'Texas' in the conditions of the Pančevo started to bloom on April 5th. A significant difference in the flowering time could be influenced by micro location and climate change. The difference between the earliest and the latest flowering time was 13 days which is five days shorter compared to the results obtained by Milatović et al. (2017). Segura et al. (2017) state that almonds have the widest range of flowering time among of all fruit and nut trees. Almond nuts are ready for harvesting when the hull separates from the shell easily. Hungarian cultivars 'Tétényi bőtermő' and 'Tétényi keményhéjú' had the earliest harvesting time (August 15th). The latest harvesting time was recorded for 'Glorieta' (August 28th). Cultivars 'Marcona' and 'Texas' also had a late ripening

time (August 27th), only one day before 'Glorieta'. All the observed cultivars were harvested prior to autumn rains. According to Zec et al. (1999) cultivars 'Marcona' and 'Texas' under the conditions of Pančevo had an average ripening time 7 days later in comparison with the obtained results. Observed differences were caused by the location climate differences.

Table 1. Phenological characteristics and productivity of almond genotypes (2017-2019 average).

Genotype	Origin	Start of flowering	End of Flowering	Duration of flowering (days)	Date of harvest start	Yield (0-5)*
Budatétény	HUN	March, 18	April, 1	14	August, 16	3.3
Francoli	ESP	March, 29	April, 12	14	August, 23	3.0
Glorieta	ESP	March, 26	April, 8	13	August, 28	3.0
Marcona	ESP	March, 23	April, 5	13	August, 27	3.8
Masbovera	ESP	March, 25	April, 8	14	August, 23	3.5
Nessebar	BGR	March, 16	March, 29	14	August, 18	3.8
Selection 25	SRB	March, 16	March, 30	15	August, 18	3,7
Texas	USA	March, 29	April, 11	13	August, 27	4.0
Tétényi bőtermő	HUN	March, 19	April, 2	14	August, 15	3.3
Tétényi kedvenc	HUN	March, 16	March, 29	13	August, 17	3.5
Tétényi keményhéjú	HUN	March, 17	April, 1	14	August, 15	3.8
Tétényi rekord	HUN	March, 20	April, 3	14	August, 18	3.2
Tuono	ITA	March, 24	April, 6	13	August, 24	4.5

*Scale: 0-without yield, 1- very low, 2-low, 3-good, 4-very good, 5-high.

The average yield was the lowest in 'Glorieta' and 'Francoli' (score 3.0) and the highest in 'Tuono' (score 4.5). In March 2017 late spring frost was recorded, which significantly reduced yield in early flowering cultivars. The majority of the tested cultivars (7) had medium yield, above 3.5.

Table 2. Characteristics of the nut of almond genotypes (2017-2019 average)

Genotype	Weight (g)	Length (mm)	Thickness (mm)	Width (mm)	Shell thickness (mm)
Budatétény	1.95 d	35.7 ab	17.8 b	12.3 d	1.71 e
Francoli	3.53 cd	34.3 abc	20.7 b	15.3 bc	3.80 c
Glorieta	4.98 a	38.9 a	24.8 a	17.8 a	4.70 ab
Marcona	5.58 a	31.5 bc	25.4 a	18.4 a	5.06 a
Masbovera	4.30 b	38.2 a	24.8 a	17.8 a	4.06 bc
Nessebar	2.30 d	30.9 bc	18.6 b	12.4 d	2.48 de
Selection 25	5.00 a	35.1 ab	20.8 b	15.2 bc	3.79 c
Texas	3.92 bc	32.6 bc	19.3 b	12.8 cd	3.63 c
Tétényi bőtermő	2.24 d	38.8 a	19.2 b	14.9 bc	2.69 d
Tétényi kedvenc	2.55 d	34.9 ab	18.7 b	13.9 bcd	2.52 de
Tétényi keményhéjú	3.20 d	31.9 bc	20.3 b	13.1 cd	3.61 c
Tétényi rekord	3.44 cd	37.8 a	20.3 b	15.2 bc	3.54 c
Tuono	3.50 cd	29.2 c	20.2 b	16.0 a	3.30 cd

Mean values followed by the same letter within a column do not differ significantly according to Duncan's multiple range test at $P \leq 0.05$.

Data for nut characteristics (Table 2) showed large differences for the weight, dimensions of the nut and shell thickness. The fruit weight varied from 1.95 g ('Budatétény') to 5.58 g ('Marcona'). The highest values of the nut dimensions were recorded in 'Glorieta' and 'Marcona'. The 'Tuono' had the smallest fruit length, while the width and thickness of the nut were smallest in 'Budatétény'. The shell thickness varied from 1.71 mm ('Budatétény') to 5.06 mm ('Marcona').

Table 3 shows characteristics of the kernel of almond cultivars. The kernel weight was lowest in the 'Selection 25' (0.80 g) and highest in the 'Texas' (1.30 g). According to the classification given by Socias i Company et al. (2008) the largest number of examined varieties (eight) had a medium-sized kernel (weight 1.1-1.4 g). Three cultivars ('Francoli', 'Glorieta' and 'Tétényikeményhéjú') were classified to the group of genotypes with a small kernel (0.9-1.1 g), while the cultivars with a very small kernel (below 0.9 g) were 'Tuono' and 'Selection 25'.

Table 3. Characteristics of the kernel of almond genotypes (2017-2019 average)

Genotype	Kernel weight (g)	Kernel share (%)	Oil content (%)	Protein content (%)
Budatétény	1.13	57.93	57.52	21.72
Francoli	0.91	25.88	50.21	25.72
Glorieta	1.07	21.43	44.35	24.48
Marcona	1.16	20.78	55.19	28.00
Masbovera	1.25	29.10	52.87	23.45
Nessebar	1.04	45.35	53.87	23.23
Selection 25	0.80	16.03	48.00	30.51
Texas	1.30	33.08	54.52	22.72
Tétényi bőtermő	1.12	49.73	51.11	21.81
Tétényi kedvenc	1.11	43.26	47.10	27.78
Tétényi keményhéjú	1.00	31.26	55.13	24.62
Tétényi rekord	1.17	34.08	46.60	25.51
Tuono	0.81	23.26	47.57	27.58

The kernel share varied from 16.03% ('Selection 25') to 57.93% ('Budatétény'). Based on the kernel share and according to the classification given by Batlle et al. (2017) five studied cultivars have a very hard shell (kernel share below 30%), four cultivars have a hard shell (kernel share 30-40%), three cultivars ('Nessebar', 'Tétényibőtermő' and 'Tétényi kedvenc') have a semi-soft shell (kernel share 40-50%), while the cultivar 'Budatétény' was characterized by soft shell (kernel share 50-60%).

The oil content in the kernel varied in the range from 44.35% ('Glorieta') to 57.52% ('Budatétény'). According to the classification given by Torabi et al. (2011) only kernels of the 'Budatétény' have a very high oil content (above 55%), five cultivars have a high oil content (50-55%), and four cultivars fall into the category with a medium oil content (45-50%). Our results are in range with data reported by Kodad (2017) and reviewed by Čolić et al. (2019) which showed variability from 20 to 67.5% for commercial and local almond cultivars/selections.

Among the nut fruits, almonds are considered to be a good source of high-quality proteins. Protein contents of the commercial almond cultivars ranged from 13% to 29% on a dry weight basis (Kodad, 2017). Drogoudi et al. (2013) analysed variation in the protein content among 72 almond genotypes found in Greece, France and Italy, and concluded that protein content depends

on the genotype rather than the origin. The analysis of results for protein content indicates significant differences among cultivars, varied from 21.72 to 30.51%. This is similar to results of Askin et al. (2007), where in the study of almond selection from Elazig (Turkey), the obtained values varied from 16.07 to 31.46%.

Conclusions

The average flowering time of the examined almond varieties was in the second half of March and the beginning of April. The latest flowering time and good yield had the varieties 'Texas', 'Marcona' and 'Tuono', which were introduced a long time ago and therefore are well adapted to the agro-ecological conditions in Serbia. Other late-flowering varieties ('Francoli' and 'Glorieta') had lower yields, so they cannot be recommended for cultivation. The 'Texas' and 'Masbovera' varieties had the largest kernel weight, but also medium kernel share (about 30%). Varieties 'Budatétény', 'Nessebar', 'Tétényi bőtermő' and 'Tétényi kedvenc' had high kernel share and can be recommended as parents for hybridization with late flowering genotypes.
Based on obtained results 'Texas', 'Marcona' and 'Tuono' can be recommended for growing in the wider surroundings of Belgrade. Due to the limited almond assortment in Serbia, introduction and evaluation of newer late-flowering genotypes should be continued.

Acknowledgements

This work was created as a result of research within the contract of the realization and financing of scientific research work in 2021 between the Ministry of Education, Science and Technological Development of the Republic of Serbia and Faculty of Agriculture, University of Belgrade (contract number:451-03-9/2021-14/200116) as well as Institute for Science Application in Agriculture (contract number: 451-03-9/2021-14/ 200045).

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