PRODUCTIVITATEA UNOR SOIURI DE MIGDAL IN DOBROGEA
PRODUCTIVITY OF SOME ALMOND VARIETIES IN DOBROGEA

Gavăt Corina[1], Militaru Mădălina[2], Dumitru Liana Melania[1], Opriță Alexandru[1], Miron Liliana[3]
[1]Research Station for Fruit Growing Constanta, Romania
[2]Research Institute for Fruit Growing Pitești, Romania
[3] Ovidius University Constanta, Romania

Abstract

The almond (*Prunus amygdalus* Batsch) is specific for Mediterranean climate, but was adapted in some zones of Romania, as Dobrogea, where can grow and fructify under normal conditions. In the last years at Research Station for Fruit Growing Constanta the behaviour of several local and foreign varieties and selections was studied. The best kernel yield was obtained for the following varieties: Autofertil 2 (5.06 t/ha), followed by Ferragnes (4.93 t/ha) and Tuono (4.74 t/ha). The highest kernel percentage was recorded for: Teteny Botermo (49.7), Preanîi (47.25) and Tuono (44.21).

Cuvinte cheie: înflorit, miez, *Prunus amygdalus*, producție de fructe
Keywords: blooming time, kernel, *Prunus amygdalus* Batsch, shell, yield

1. Introduction

Together with apricot and peach, almond is also a thermopile species that found optimal culture conditions in south-eastern part of the country. Almonds are very rich in fats, vitamins and minerals and are very appreciated for fresh consumption, but also for their numerous ways of use in food industry (Cociu, 1999).

A large number of almond varieties is cultivated worldwide. These are specific to various zones; In California, the region with most almond plantations, mainly soft-shelled varieties ('XYL', 'Non Pareil', 'Texas', etc) are cultivated, while in Spain and Portugal more hard-shelled varieties ('Marcona', 'Larguetas', 'Guara') are found; in Italy, late flowering and self-fertile varieties as 'Tuono', 'Genco' or 'Filippo Ceo' are spread out across the country (website: www http://www.frutas-hortalizas.com/Fruits/Types-varieties-Almond.html (accessed in January 25).

The varieties that bloom late and ripen early are considered as being very valuable from the biological and practical point of view, because the fruit buds differentiation for the next yield performs until late autumn; having a long dormant period these varieties are more resistant to temperatures variations arising at the end of winters and ensure high yields (Cociu, 2007).

Some studies found the period from full bloom (FB) to fruit maturity for individual cultivars of peach, nectarine, plum, and prune is influenced by daily temperatures between the start of blooming, FB and 30 days after FB (DAFB) (Marra et al., 2002). As with these related species, early fruit development in almond is also quite sensitive to spring air temperature. A high flower bud density has been shown to increase the possibility to endure a late frost during bloom (Kodad and Socias Company, 2005) because the presence of a high number of flowers increases the possibility of survival of some flowers after a frost, thus allowing an acceptable crop.

Almond is closely-related to peach, but the date of harvest is not always closely-related to the date of fruit maturity. Harvesting can be delayed until the fruits are dry enough to harvest, because of shortages of labour and equipment. The nuts are shaken from the trees and picked-up by machines from the orchard floor. A timely harvest is essential to maintain nut quality and to minimize post-harvest microbial contamination (Danyluk et al., 2007). Nuts from each cultivar must be harvested separately from other cultivars in order to optimize hulling, shelling, and marketing. Hence, the maturity dates of individual almond cultivars in the same orchard must be sufficiently different to prevent undesirable mixing of the nuts.

Consequently, harvest maturity is an important consideration when choosing cultivars for an orchard. In addition, the nuts of late cultivars can be difficult to dry on the ground due to shortened days, cool weather, or early rains. These can also reduce nut quality due to delays in harvesting and can increase harvesting costs by extending harvest operations and drying times (Tombesi et al, 2010).

Most cultivars are self-sterile and hence two or more cultivars are usually inter-planted (Asai et al, 1996).

As the kernel is the commercial part of the almond nut, its weight and shape are very important, as different sizes and shapes are required for different industrial applications (Berger, 1969).

At the Research Station for Fruit Growing Constanta (RSFG Constanta) there is a collection of almonds planted in the spring of 2007, consisting of 42 varieties and selections that have been studied from the point of view of the main phenophases dynamics and fruit productivity; 15 of them that have obtained the best results are presented in this study.

Although in the last two decades the culture of these species has been neglected in our country, we intend to bring it into the attention of fruit producers for the many advantages it offers when grown under favourable environmental conditions: precocity of fruiting, productivity, resistance to storage and high price of the fruit on the market. Some aspects of almond culture have not been yet enough approached in our region.

For almond varieties to be considered cost-effective, the production of core must be higher than 0.45 t/ ha in order to be considered profitable worldwide (Cociu, 1973).

The purpose of this paper is to bring new information data regarding the phenological phases in almond, especially for flowering and fruit maturation period under the current climate conditions nowadays in the south-eastern area of Romania, in order to establish a profitable variety assortment for almond revival.

2. Material and Method

The fruit trees were planted in 2007 using biological material obtained from Research Station for Fruit Growing Bihor from the city of Oradea and from RSFG Constanta. The studied varieties and hybrids have foreign and Romanian origin. The rootstock was bitter almond. Five fruit trees of each variety and hybrid were planted. The planting distance was 4m/4m (planting density was 833 trees/ha). The canopy shape was improved vase. The trees were cultivated under rainfed conditions, pruned every year and fertilized optimally; the phyto-sanitary treatments were applied uniformly in the field as recommended by the specialist in plant protection.

The soil is a Calcaro-Calcic Chernozem (World Reference Base for Soil Resources 2006) or Entic Haplustolls (Soil Taxonomy, 1999) with a loamy texture and alkaline pH in topsoil, which has a proper soil structure and fertility. Land slope is between 2.0 and 2.5% and soil bulk density ranges from 1.18 to 1.25 g cm^{-3}. The physical soil properties allow a proper water movement within the rooting system of the orchard.

RSFG Constanta is located in the south-eastern part of Romania, in the area between the Danube and the Black Sea and has specific steppe climatic conditions, with a relatively high aridity and low rainfall. The average annual temperature is around 11°C, but the annual average temperatures values recorded in the study period were above average, table 1. Absolute temperature beyond the limits of resistance of almond species, -26°C, and -30°C or above 40°C is rare (one year out of 20 or 30 years). Rainfall is not enough for the water tree water requirements, the average amount of rainfall is around 400 mm (table 1), with unequal distribution in the active growing season (April 1 to September 30). Frosts return is quite often in spring, affecting fruit trees (including almond) during early blooming.

One can note that the air temperatures were negative during January-February period, in all the years of study and the mean minimum temperatures ranged between -5°C and -8°C, specifically in 2012, figure 1.

Observations and measurements were done regarding phenological phases, i.e. fruit ripening time, trees vigour, kernel characteristics, in-shell yield (t/ha), average in-shell mass of fruit (g), kernel percent and kernel yield (t/ha) on almond plants.

The beginning of flowering was considered when the first open flower was visible and its end was noticed when the last petals of the flowers fell. The blooming intensity was noted from 0 (absent) to 5 (abundant), according to the research methodology of fruit tree breeding (Cociu, 1981).

The tree trunk cross sectional area (TTCSA) for each studied variety was determined by measuring the tree diameter in two pair of points marked permanently with metallic sensors. The values were recorded in autumn, during tree years (2010-2013). After calculating the mean values for each cultivar and by subtracting the measured values, the mean annual tree growth was obtained.

During 2012-2013 the fruit yield was recorded starting with the 6^{th} year after planting, when the fruit production was considered stable. The in-shell yield was evaluated by weighing the fruit of four almond trees of each variety (kg/tree) and then as kg/ha. The in-shell average was then calculated.

Following the measurements described, the shells were cracked to obtain the kernel and to determine the kernel percentage by weighing using an electronic balance.

The results were processed by analysis of variance and other functions of Microsoft Excel Programme.

3. Results and discussions

Blooming and ripening time

Data on the main phonological phases stress the fact that during the relatively mild winters and early springs, as there were in the years of experiment, flowering started on 3.03 ('Burbank' variety), followed immediately on 4.03 by 'Mary Dupuy' variety.

Most varieties were blooming in the middle of March, between 16.03 and 26.03, with the last one, the selection 'Autofertil 2' (8.04), figure 2.

The blooming duration was quite long, between 11 days ('Primorski') and 27 days ('Ferragnes', 'Tuono', 'Teteny Botermo') depending on varieties and temperatures.

The blooming developed gradually, and many flowers were not affected by low temperatures recorded in spring; this fact may explain the good fruiting of some varieties even the blooming occurred earlier. During the study, the blooming intensity was noted with 4 and 5, being considered abundant and very abundant.

"Hull-split" signals the beginning of fruit maturity in almond. The fruit ripening was gradually, between 20.08 ('Autofertil 2') and 8.10 ('Lovrin 18'), and many of studied varieties and selections were fit to ripen between 5.09 and 20.09, figure 3.

In-shell average yield

The fruit yield is the basic criterion in fruit varieties evaluation. Fruit mass in almond is considered as in-shell mass, including the kernel and the endocarp, but not the fleshy mesocarp which is normally eliminated at harvest. The best results were obtained for selection 'Autofertil 2' (5.06 t/ha), followed by 'Ferragnes' cv. (4.93 t/ha) and 'Tuono' cv. (4.74 t/ha), table 2. The first tree genotype had a highly significant increase and the other two a distinctively significant increase, respectively, versus the average of the varieties.

Kernel average yield

The analysis carried out on fruit (table 3) has shown that the percentage of the total weight of the kernel had values between 50% ('XYL' cv.) and 16% ('Mary Dupuy' cv.). A high percentage of kernel was obtained in the case of 'Teteny Botermo' (49.7), 'Preanîi' (47.25) and 'Tuono' (44.21) cvs.; however, those kernel yields were not the highest but had a high percentage of kernel, and this gave them a special practical importance versus the other varieties studied. Shell hardness/softness character was also analyzed and presented in table 3.

Soft-shelled varieties have the disadvantage that are usually attacked by birds before harvest and have a weaker ability to storage. There are also other inconveniences when shelling, e.g. breaking the kernel that is not met in the hard-shelled varieties. Regarding the kernel yield, 'Autofertil 2' selection (2.18 t/ha), XYL cv. (2.15 t/ha), 'Tuono' cv. (2.1 t/ha) and 'Preanîi' cv. (2.05 t/ha) showed significantly positive results versus the average (table 4); hence these selections and varieties could be recommended for spreading out in culture in the region studied. 'Autofertil 2' nuts free fall before harvest was very low, but nuts fell easily when shaken, and that is considered a quality.

TTCSA

The analysis of the main biometric measurements of tree (figure 4) in three years shows that the highest TTCSA (cm^2) was obtained for 'Ferragnes' variety, followed by 'XYL', and the lowest varieties were 'Primorsky' and 'Lovrin 18'. A higher TTCSA could induce a bigger shoot growth and consequently, a higher number of flowering buds.

Compared with the previously studied almond varieties (1970-1980) in the same area, the results of this paper highlight the behaviour of newly introduced varieties and selections in culture, in the last two decades.

As mentioned, some cultivars and selections (XYL, 'Touno', Burbank) proved to be better adapted to the natural conditions from the region, while others ('Pomorie') did not. For instance, 'Autofertil 2' and 'Autofertil 1' selections showed not only high yields, but also early ripening periods.

4. Conclusions

Most of the varieties and selections studied here have differentiated flower buds and showed high yields each year.

Although the almond is the first blooming of the thermopile fruit tree species, the flowers from the same tree bloom gradually, and that means that the flowers could not totally be affected by potential low spring temperatures and have a quite proper yield.

The studied cultivars and selections can be harvested between August 25 and September 15 ('Autofertil 2', 'Tuono', 'Filippo Ceo'), continuing until October 1 ('Preanîi', 'Burbank') with medium season varieties and with late varieties ('Ferragnes') ripening after the 1th of October.

The highest average yields were obtained in the case of 'Autofertil 2' selection (5.06 t/ha), followed by 'Ferragnes' (4.93 t/ha) and 'Tuono' (4.74 t/ha), which could be recommended for orchards.

The higest kernel percentage was obtained by: 'Teteny Botermo' (49.7), 'Preanîi' (47.25) and 'Tuono' (44.21).

References

1. Asai, W.K., Micke, W.C., Ester, D. E. and Rough, D.,1996. The evaluation and selection of current varieties. In: Almond Production Manual . (Micke W.C., Ed.). University of California, Davis, CA, USA. 52–60.
2. Berger, P., 1996. Aptitudes a la transformation industrielle de quelques varieties d'amandes. Bull. Techn. Inf. 241: 577-580.
3. Cociu, V., Stanciu, Gh., 1973. Alunul si migdalul. Colectia Ceres, Bucuresti.
4. Cociu, V., 1999. Progrese in ameliorarea plantelor horticole din Romania. Vol. I, Ed. Ceres, Bucuresti.
5. Cociu, V., 2007. Nucul, alunul, migdalul. Ed. M.A.S.T., Bucuresti.
6. Danyluk, M.D, Nozawa-Inoue, M., Hristova, K.R., Scow, K.M., Lampinen, B. and Harris, L.J., 2007. Survival and growth of *Salmonella enteritidis* PT 30 in almond rchard soils. Journal of Applied Microbiology 104, 1391–1399.
7. Kodad, O., Socias, I., Company, R., 2006. Influence of genotype, year and type of fruiting branches on the productive behaviour of almond. Scientia Hort. 109: 297–302.
8. Marra, F.P., Inglese, P., Dejong, T.M. and Johnson, R.S., 2002. Thermal time requirement and harvest time forecast for peach cultivars with different fruit development periods. Acta Horticulturae 592, 523–529.
9. Tombesi, S., Scalia, R., Connell, J., Lampinene, B., Dejong, T.M., 2010. Fruit development in almond is influenced by early spring temperatures in California. In: Journal of Horticultural Science and Biotechnology 85(4): 317-322.
10. Soil Survey Staff (1999). Soil Taxonomy - A basic system of soil classification for making and interpreting soil surveys. USDA-SCS. Agric. Handbook 436.
11. World Reference Base for Soil Resources (2006). A framework for international classification, correlation and communication. Food and Agriculture Organization of the United Nations, Rome, 145 pp, ftp://ftp.fao.org/agl/agll/docs/wsrr103e.pdf (accessed March 29, 2013).
12. Almond, Amygdalus Communis / Rosaceae. website: www http://www.frutas-hortalizas.com/Fruits/Types-varieties-Almond.html accessed in January 25).

Tables and figures

Table 1. Climatic conditions during 2010-2012 at Research Station for Fruit Growing Constanta

Year	Tmean (°C)	Tmax (°C)	Tmin (°C)	RH (%)	Solar radiation (W/m^2)	Wind speed (km/h)	Precipitation (mm)
2010	12.55	17.92	7.15	77.72	174.98	1.29	653.6
2011	11.58	17.3	5.82	72.49	174.63	1.13	352.4
2012	12.85	18.97	6.71	70.2	183.87	1.22	394.9

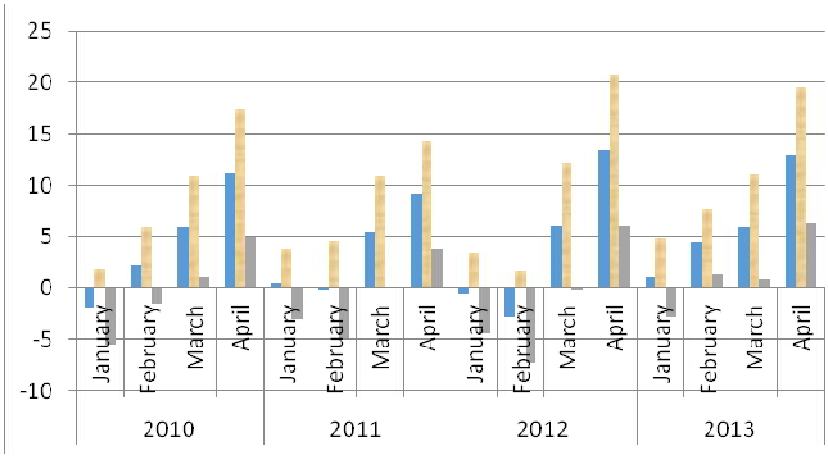

Fig. 1. Air temperature during the first four months in 2010-2013
(The first columns of each month represent the mean temperatures, the next ones the maximum temperatures, while the last columns are minimum temperatures)

Table 2. The dynamic of vegetative phases and blooming intensity of the studied almond varieties (2011-2013)

Genotype	Vegetative phases		Blooming intensity
	Beginning of vegetative budding	Beginning of shoots growing	
Burbank	25.02	2.04	5
XYL	25.02	2.04	4
Ferragnes	25.02	31.05	5
Autofertil 2	25.02	10.04	5
Tuono	26.02	1.04	5
Budateteny	27.02	30.03	4-5
Teteny Botermo	27.02	9.04	4-5
Fillipo Ceo	27.02	5.04	5
Preanîi	28.02	3.04	4-5
Pomorie	29.02	5.04	4-5
Autofertil 1	29.02	3.04	5
Mary Dupuy	3.03	3.04	5
Primorski	5.03	7.04	4-5
Lovrin 18	10.03	8.04	4-5
Tohani 13/8	21.03	3.04	4-5

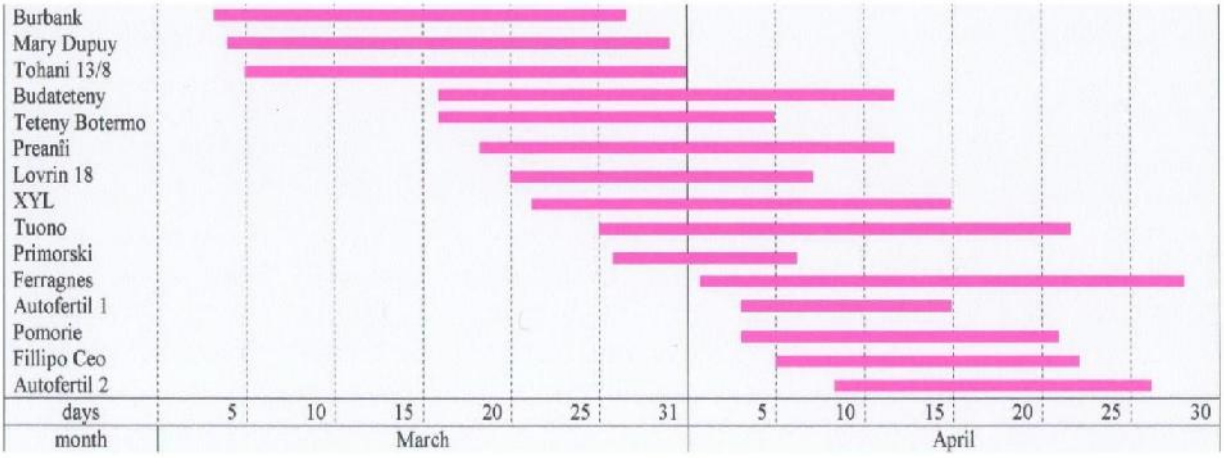

Fig. 2. The dynamic of flowering to almond varieties

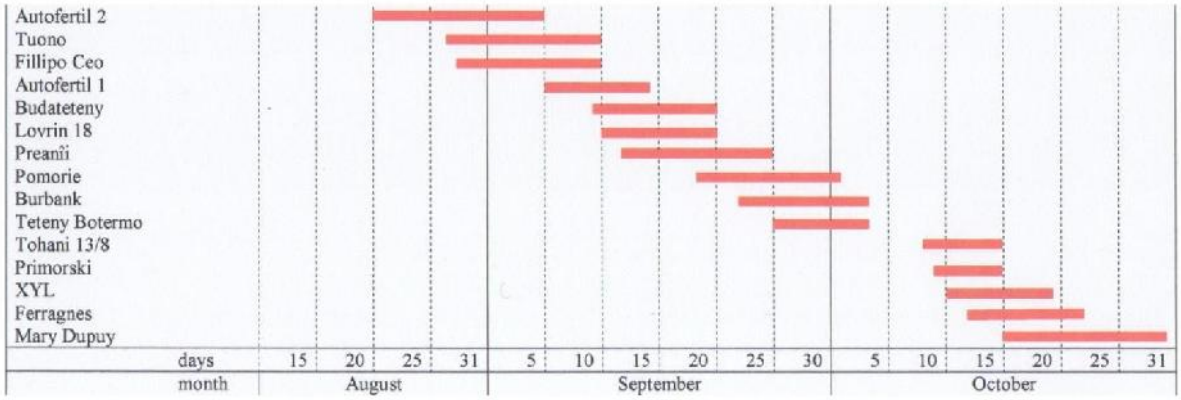

Fig. 3. Dynamic ripening time of almond varieties

Table 3. In-shell average yield for almond varieties (2012-2013)

No.	Genotype	In-shell average yield (t/ha)	Difference from the average	Significance
1.	Autofertil 2	5.06	+1.82	***
2.	Ferragnes	4.93	+1.68	**
3.	Tuono	4.75	+1.51	**
4.	XYL	4.68	+1.44	**
5.	Preanîi	4.32	+1.75	*
6.	Autofertil 1	4.06	+0.82	-
7.	Mary Dupuy	3.61	+0.37	-
8.	Fillipo Ceo	3.5	+0.26	-
9.	Burbank	3.12	-0.12	-
10.	Primorski	2.12	-1.12	o
11.	Budateteny	2.02	-1.22	o
12.	Teteny Botermo	1.81	-1.43	oo
13.	Pomorie	1.68	-1.56	oo
14.	Lovrin 18	1.56	-1.68	oo
15.	Tohani 13/8	1.43	-1.81	ooo
Average		3.24		

5% LSD = 1.039; 1% LSD=1.386; 0.1% LSD= 1.805

Note here and in the following tables that LSD is the least significant difference for various levels of probability: 5%, 1% and 0.1% respectively; * means higher than and ^{o} means lower than the reference average

Table 4. The average value of the main physical characteristics of almond fruit: mass of a shell, kernel efficiency, kernel yield, shell character; 5% LSD= 0.682; 1% LSD=0.909; 0.1% LSD= 1.184

Genotype	Average mass of a shell (g)	Kernel efficiency (%)	Kernel yield (t/ha)	Difference from the average	Significance	Shell character
Autofertil 2	5.9	43.08	2.18	+0.85	*	soft
XYL	4.2	50.0	2.15	+0.82	*	hard
Tuono	4.5	44.21	2.1	+0.77	*	hard
Preanîi	4.5	47.45	2.05	+0.72	*	soft
Ferragnes	4.0	39.95	1.97	+0.64	-	soft
Autofertil 1	4.8	33.25	1.35	+0.02	-	hard
Burbank	5.5	41.66	1.3	-0.03	-	hard
Fillipo Ceo	2.9	30.85	1.08	-0.25	-	hard
Primorski	2.7	46.7	0.99	-0.34	-	soft
Teteny Botermo	2.4	49.7	0.9	-0.43	-	soft
Budateteny	2.7	43.56	0.88	-0.45	-	hard
Tohani 13/8	3.0	49.65	0.71	-0.62	-	hard
Pomorie	2.0	40.5	0.68	-0.65	-	soft
Mary Dupuy	2.5	16.0	0.58	-0.75	o	hard
Lovrin 18	4.6	26.0	0.4	-0.93	oo	hard
Average			1.33			

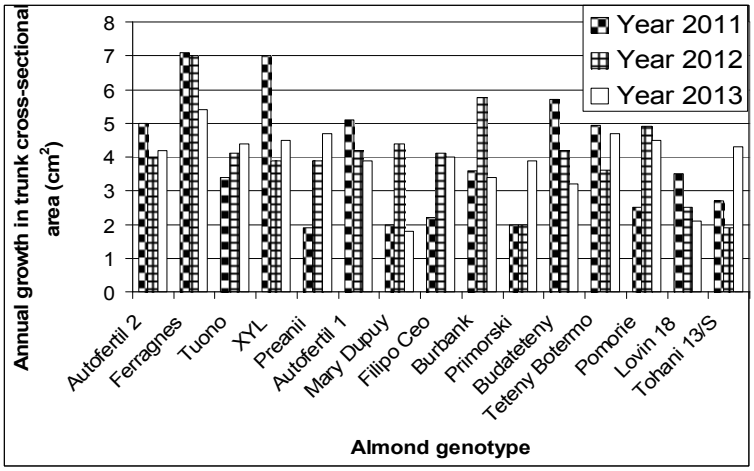

Fig. 4. The annual growth in tree trunck cross-sectional area for the studied almond genotypes during 2011-2013 period at Constanta