SECTION 4: FRUIT GROWING

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INFLUENCE OF THE FOLIAR FERTILIZATION ON QUALITY CHARACTERISTICS AND ECONOMIC EFFICIENCY OF APPLE CULTIVAR SMOOTHIE

Iliyana Radomirska[1*], Dimitar Sotirov[1]

[1]Institute of Agriculture, Kyustendil, Bulgaria
[*]e-mail: radomirska@yahoo.com

Abstract
The effect of the foliar fertilization with Biohumax and Humustim, applied in different rates (50, 100, 150 ml/da), on the yield and fruit quality of Smoothie apple cultivar was studied at the Institute of Agriculture-Kyustendil. The trees were grafted on rootstock MM 106 and planted at distances 4.5 x 2.5 m on leached cinnamonic forest soil (Chromic Luvisols). Average for the period the best results were obtained in the treatment with Humustim in dose of 50 ml/da, followed by Biohumax – 100 ml/da. The additional costs were minimal and did not affect economic efficiency. The examined rates of the foliar fertilizers did not have a significant impact on the fruit weight, content of dry matter, total sugars and titratable acids in the fruits of Smoothie.
Key words: apple, foliar fertilization, yield, economic efficiency.

Introduction

An attitude towards the positive effect of the foliar fertilizers application on the vegetative and productive manifestations of the apple trees, as well as the quality and storage capability of their fruits prevails in the scientific literature (Casero *et al*, 2002; Ciavatta and Benedetti,2002; Maur and Schröder,2002). There are also opinions of lack or even a negative effect on some biometrical indices (Perya, 2002).

Fertilization is one of the main agricultural activities associated with the intensification of fruit and impacts directly on the overall economic efficiency of apple production. In optimizing this factor it is possible to obtain high production and economic results (Krinkov, *et al*, 1990). According to Porro *et al*. (2002) developing effective combinations of fertilizers, as well as identifying the most appropriate phases of development of fruit trees for their implementation will enhance the effect of their application. These authors tested different variants of fertilization in apple orchard and found that combined fertilization (soil and foliar) reduced the occurrence of bitter spots and decay, and the concentration of Ca, Fe, Mn and Zn in the leaves increased. The content of these nutrients was higher in the fruits of this option, only the concentration of B was lower than that of the control.

It has been shown that foliar fertilization improves fruit quality, changes total acidity, pH, and their color (Policarpo *et al*, 2002; Stampar *et al*, 2002). It increases the content of glucose, sorbitol, solids, malic and citric acid and potassium in fruits (Hudina and Stampar, 2002). In foliar feeding with Vegaflor, apple yield increased by 19.7% (Hudska, 1976).

The aim of the investigation was to establish the effect of the organic fertilizers Biohumax and Humustim, used as foliar application in different rates, on the yield, fruit quality and economic efficiency of apple cultivar Smoothie.

Material and methods

The investigation was carried out during the period 2004-2006 with apple trees of the cultivar Smoothie, grafted on the clonal rootstock MM106. The experimental plantation was created in 1986. The soil was chromic luvisols with a slightly acid reaction (pH). The planting distances were 4.5 x 2.5 m. The soil surface was cultivated regularly, the irrigation was performed through drip irrigation equipment and plant protection was applied according to the schemes accepted at the Institute of Agriculture - Kyustendil.

The influence of two foliar organic fertilizers applied every year three times in 10-12 days intervals during May-June in the following variants was examined:

V1 – Humustim – 50 ml/da;
V2 – Humustim – 100 ml/da;
V3 – Humustim – 150 ml/da;
V4 – Biohumax - 50 ml/da;
V5 – Biohumax - 100 ml/da;
V6 – Biohumax - 150 ml/da;
V7 – the control (without treatment with organic foliar fertilizers);

The following indices were measured and analyzed: Fruit yield per tree, kg; Average fruit weight, g; Fruit quality - extra, first quality, second quality, according to ordinance № 108/12.09.2006 of MAF. Chemical composition of the fruits - content of dry matter (%, refractometrically), organic acids (%, titermetrically with 0,1n NaOH), and the total sugars (%, by Shoorl) (Stanchev et al., 1988). The chemical composition was determined on the basis of pooled samples of each option in the harvest every year; Additional gross production and net income, lv/da.

The results were statistically evaluated by analysis of variance (ANOVA) and LSD test was used for the identification of the significance of differences.

Results and discussion

Over the separate years there was no clear trend for the unidirectional influence of foliar fertilization on the average yields. Total for the period the application of both foliar fertilizers increases the yield compared to the control variant (Table 1). Variant 1 (Humustim–50 ml/da) is characterized by the highest fruitfulness and the total yield increase the control with 28.42%. With the increase of the Humustim dose to 100 and 150 ml/da (V2 and V3), while the second and third year yields are higher than V1 and control, the average for the period these variants are with lowest values. The differences between the different variants and the control were statistically significant. The treatment with Biohumax at a dose of 100 ml/da (V5) gives the best results and leads to increased yield by 27.8% compared to the control. Variants with 50 ml/da (V4) did not differ from the control, while that of 150 ml/da (V6) leads to an increase in the average yield of 11.12%.

The results of the biometric measurements analysis show that the examined doses of foliar fertilizers applied during the period May-June do not have a significant effect on the average fruit weight. Average for the period, the variation in the weight of the fruit is 92 to 109 g, indicating that foliar fertilization had no significant effect on their on-growing. The low average fruit weight is probably due to the extremely unfavorable weather conditions during the summer of 2005 (hot and very low relative humidity), which reduced yield and fruit size. The nutrients in this period are used mainly for shoot growth and increase of the leaf mass, and to a lesser degree - for size increase of

the still young fruit set. Moreover, during this period nutrients are mostly used for growth of shoots and increase foliage and to a lesser extent for the still-growing young ovaries. Differences between the variants and control are statistically unproven.

Table 1. Average yield (kg) and average fruit mass (g)

Variants	Year			Total kg/tree	% of the control	Average fruit mass, g
	2004 kg/tree	2005 kg/tree	2006 kg/tree			
V 1 - Humustim - 50 ml/da	146.85	7.95	81.11	235.91	128.42	94
V 2 - Humustim -100 ml/da	109.82	11.88	87.17	208.87	113.70	109
V 3 – Humustim -150 ml/da	111.99	11.15	87.15	210.29	114.47	100
V 4 – Biohumax -50 ml/da	97.11	5.65	82.4	185.16	100.79	92
V 5 – Biohumax - 100 ml/da	122.85	11.88	100.1	234.83	127.83	102
V 6 – Biohumax - 150 ml/da	100.89	12.34	90.89	204.12	111.12	98
V 7 - control	104.62	5.75	73.33	183.70	100	97
LSD 0.05	*18.03*	*4.7*	*24.78*			
0.01	*24.73*	*6.446*	*33.98*			
0.001	*33.66*	*8.774*	*46.25*			

The production qualification, average for the period of investigation, shows that the fruits of Extra quality are from 34.18 to 45.25%, the First quality fruits are about 19-27%, and the Second quality fruits - from 28.14 to 46.87% of the total harvest (Fig.1). The largest quantity of extra quality fruits is obtained in variant V5 (45.25%), followed by variant V2 (44.12%) and V6 (41.13%). The lower is the percentage variations in V1, V3 and V4, compared with the control V7 (39.72%).

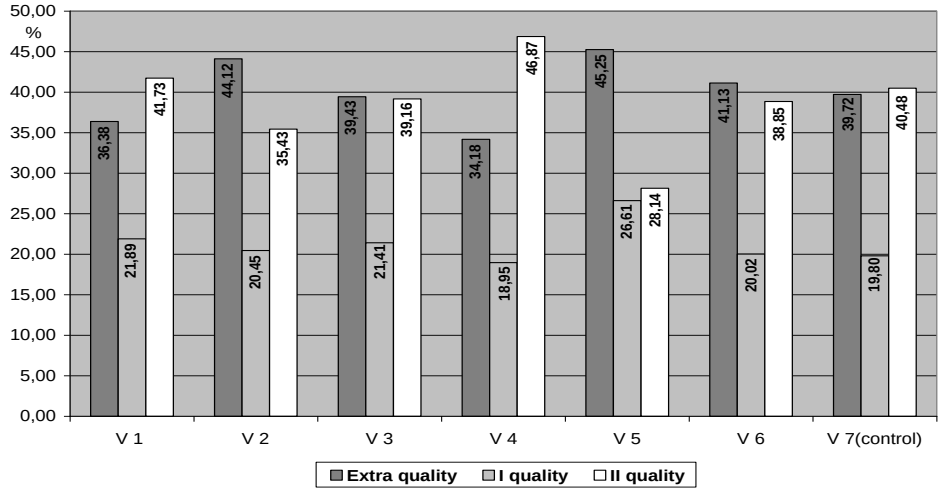

Figure 1. Quality of the fruits, average for the period 2004-2006

The influence of Humustim and Biohumax on the chemical composition of apple fruit is reflected in Table 2. Average for the period dry matter has higher values for the three variants of fertilization

with Biohumax compared to control. Upon treatment with a dose of 50 ml/da (V4) it is the highest (14.80%), which is 0.73% more than the control variant. Following in the variant with 150 ml/da (V6) - 14.27%, and the lowest is with the use of 100 ml/da (V5) - 14.23%. When using Humustim at 100 ml/da (V2) the values of dry matter were higher than the control by 0.63%. For the variant of 50 ml/da (V1) its content was equal to the control, and at V3 (150 ml/da) it had lower rates than the control variant by 1.3%.

Table 2. Chemical composition of the fruit, average for the period 2004 -2006

Variants	Dry matter (%)	Titratable acids (%)	Total sugar (%)
V 1 - Humustim - 50 ml/da	14.00	0.33	8.99
V 2 - Humustim -100 ml/da	14.70	0.35	9.14
V 3 – Humustim -150 ml/da	13.37	0.31	8.55
V 4 – Biohumax -50 ml/da	14.80	0.34	9.32
V 5 – Biohumax - 100 ml/da	14.23	0.32	9.24
V 6 – Biohumax - 150 ml/da	14.27	0.31	9.10
V 7 - (control)	14.07	0.34	9.13

The total sugars, in % to the fresh mass of the fruit, varied slightly among the different variants. When using Humustim they ranged from 8.55% (V3) to 9.14% (V2). In Biohumax variation of sugars is from 9.10% (V6) to 9.32% (V4), showing almost no difference between them as well as in comparison to the control. The content of titratable acids is not significantly influenced by applied foliar fertilizers. The differences between the tested variants are minimal and varied in the range from 0.31 to 0.35%.

The economic efficiency of foliar fertilization, average for the period 2004-2006 is presented in Table 3. The data show that compared with the control (without treatment with organic foliar fertilizers) when using Humustim a higher yield is produced which ranged from 746.71 to 1548.9 kg/da, and of Biohumax - from 43.31 to 1516.86 kg/da. The additional fruit production is related to the increase in the cost of harvesting - from 3.92 to 51.46 lv/da, while the extent of additional gross output obtained is from 23.82 to 851.89 lv/da. The overall economic effect of foliar fertilization of cultivar Smoothie can be judged by the resulting net income for the different variants. The treatment with Humustim - dose of 50 ml/da (V1) led to the highest additional net income - 800.43 lv/da, which is 32.4% more than the control. Follows the Biohumax variant at 100 ml/da (783.82 lv/da), where the increase was 31.8%. The least is the increase in net income in the treatment with the lowest dose Biohumax (V4) - 19.30 lv/da or 0.81% compared to the control.

Table 3. Economic efficiency of foliar fertilization, average for the period

Variants	Additional yield, kg/da	Additional costs, lv/da	Additional received	
			Gross production, lv/da	Net income lv/da
V 1 - Humustim - 50 ml/da	1548.90	51.46	851.89	800.43
V 2 - Humustim -100 ml/da	746.71	27.02	410.69	383.67
V 3 – Humustim -150 ml/da	788.84	28.68	433.86	405.18
V 4 – Biohumax -50 ml/da	43.31	3.92	23.82	19.90
V 5 – Biohumax - 100 ml/da	1516.86	50.45	834.27	783.82
V 6 – Biohumax - 150 ml/da	605.79	24.08	333.19	309.11

Conclusions

The organic fertilizer Humustim, used through foliar application on apple trees of cultivar Smoothie increases the yield from 13.7 to 28.4%, depending on the dose used. The influence of the other organic fertilizer Biohumax is less pronounced compared with the control and yields increased from 0.8 to 27.8%. Fruit quality is not affected significantly by the applied doses of foliar fertilization. The highest percentage of extra quality fruit is obtained by variants at 100 ml/da used for both fertilizers. The most economically effective is the treatment with Humustim at 50 ml/da, where the received additional gross production is 851.89 l v/da and the additional net income - 800.43 lv/da. Approximately the same efficiency is obtained by the use of Biohumax at 100 ml/da.

References

Casero, T., Benavides, A., Recasens, I. and Rufat, J. (2002). Preharvest calcium sprays and fruit calcium absorption in golden "apples". Acta Hort.594:467-473.

Ciavatta, C. and Benedetti, A. (2002). Foliar fertilizers: legislative aspects in Europe. Acta Hort. 594:269-276.

Hudina, M. and Stampar, F. (2002). Effect of Phosphorus And Potassium Foliar Fertilization On Fruit Quality Of Pears. Acta Hort. 594:487-493.

Hudska, G. (1976). Pouriti listovych hnojiv u ovocnych druhu. Agrochemi, 5.

Krinkov, H., Jovtchev, I., Karageorgiev, D. (1990). Efficiency resulting from foliar dressing with complex mineral fertilizer in horticulture. Rural economics amn management, vol. XXXV, 1:83-87.

Mayr, U. and Schröder, M. (2002). Influence of calcium sprays with different concentrations; spray timing and combinations with prohexadione-ca on the mineral content in "Boskoop" and "Elstar" apples. Acta Hort. 594:553-556.

Perya, F.J. (2002). Properties and performance of boron spray products for apple. Acta Hort. 594:211-215.

Policarpo, M., Di Marco, L., Farina, V. and Tagliavini, S. (2002). Effect of foliar nutrition on peach (*prunus persica* l. batsch) yield and fruit quality as related to different crop loads. Acta Hort. 594:659-666.

Porro, D., Dorigatti, C. and Ramponi, M. (2002). Can foliar application modify nutritional status and improve fruit quality results on apple in northeastern italy. Acta Hort. 521-526.

Stampar, F., Hudina, M., Usenik, V., Sturm, K., Veberic, R. and Veber, G. (2002). Experience with foliar nutrition in apple orchard. Acta Hort. 594:547-552.

Stanchev, L., Gurov, G., Mashev, M. (1988). Guide for chemical analysis of plants, soils and fertilizers, Plovdiv.

ВЛИЈАНИЕ НА ФОЛИЈАРНОТО ЃУБРЕЊЕ ВРЗ КВАЛИТАТИВНИТЕ КАРАКТЕРИСТИКИ И ЕКОНОМСКАТА ЕФИКАСНОСТ КАЈ СОРТАТА НА ЈАБОЛКО СМУТИ (SMOOTHIE)

Илијана Радомирска, Димитар Сотиров

Апстракт

Ефектот на фолијарното ѓубрење со Biohumax и Humustim, аплицирани во различни количини (50, 100, 150 ml/da), на приносот и квалитетот на плодовите на сортата на јаболко Smoothie беше спроведено на Институтот за Земјоделство – Ќустендил. Овошките беа калемени на подлогата ММ 106 и садени на растојание од 4.5 x 2.5 m на процедна циметна шумска почва (Chromic Luvisols). Просечно најдобри резултати беа постигнати при третирање со Humustim во доза од 50 ml/da, проследено со Biohumax во доза од 100 ml/da. Дополнителните трошоци беа минимални и не се одразија на економската ефикасност. Испитаните дози од фолијарните ѓубрива немаа големо влијание врз тежината на плодовите, содржината на суви материи, вкупните шеќери и титрациска киселина во плодовите на сортата Smoothie.

Клучни зборови: јаболко, фолијарно ѓубрење, принос, економска ефикасност.

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Review paper

APPLE AREAS AND PRODUCTION IN BULGARIA AND CHINA

Iliyana Radomirska[1*], Dimitar Sotirov[1], Song Laiqing[2]

[1]Institute of Agriculture, Kyustendil, Bulgaria
[2] Fruit Tree Institute of Yantai Agricultural Academy, Yantai, Shandong, China
[*]e-mail: radomirska@yahoo.com

Abstract
The present paper is a review, describing the harvesting areas and apple production in Bulgaria and China for the period 2001 – 2010. The soil, climatic and topographical conditions in most regions of these countries are favourable for apple growing and production of high quality fruits. The total apple plantation areas in the world are 4 696 259 ha and production is 69 511 975 tons for 2010. The main apple producer is China, which produces about 48% of total quantity. The areas of apple plantations in Bulgaria have constantly increased up to 1968 when they reached 30421 ha, but recently the areas planted with apple trees has decreased considerably and at present there are about 5239 ha. One of the reasons for the reduction of the planted areas is the land reform and the change of the ownership of the land.
Key words: apple, production, area, state, trends.

Introduction

The apple (*Malus domestica* L.) is one of the most profitable fruit crops, occupying one of the first positions of harvesting area and fruit production in the world. Compared to other fruit species of the temperate climate zone, it is characterized by great adaptability to different soil and climatic conditions, high yield, variety diversity, good storage and transport. Using appropriate varieties with different ripening time and sufficient capacity of cold storage equipment, can lead to year-round supply of fruits to the apple market (Djouvinov *et al*., 2002; Radomirska, 2008). The fruits contain valuable nutrient substances (pectin, sugars, acids, aromatic substances and mineral salts) and rank between the best organic and diet ffoods. They have multi-use - fresh consumption, juices, concentrates, dried fruits, jars, production of pulp, pectin and others (Velkov *et al*, 1970). The total apple plantation areas in the world for the period 2001-2010 gradually decreased - from 5 112 829 ha (2001) to 4 696 259 ha (2010). The decrease for the ten-year period was 416 570 ha (Fig.1). At the same time the apple production, with some fluctuations over the years, increase - from 55 196 632 t to 70 767 702 t, due to improved breeding technologies and increasing average yields per unit area.

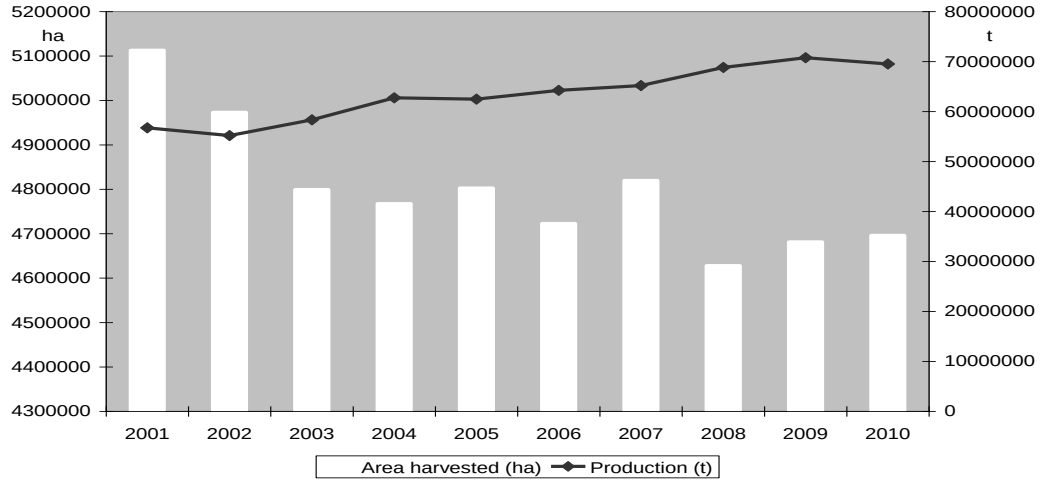

Figure 1. Area harvested (ha) and apple production (t) in the world, 2001 -2010

Apple production in Bulgaria

The Republic of Bulgaria is situated in South-Eastern Europe, in the eastern half of the Balkan Peninsula (41-45^0 northern latitude and 22-29^0 eastern longitude). It has a territory around 111 sq.km. The landscape is diversified – more than 2/3 of the area is situated up to 600 m above sea level. The climate is moderately continental with the Black Sea influence on East and the Mediterranean – on South. The average annual temperatures in the main fruit production regions are 11-12 ^{o}C. The coldest month is January (average temperature is –2^{o}C). The warmest month is July (average temperature 25^{o}C). The frost-free period for the above mentioned regions lasts for about 190-215 days or from 12-25 April to until 5 -15 November. The mean annual precipitation sum is from 450 to 850 mm. The most precipitation occurs in May and June. The relative air humidity is about 65-75%.

The climatic and topographical conditions in the valleys and the hilly regions are favorable for apple growing and production of high quality fruits. Total for the period 2001-2010 the harvested apple area in Bulgaria decrease with 47%. The trend for decrease is more noticeable in 2005, and then there are some fluctuations (Fig. 2). In 2010 apple trees in farms are 5239 ha and their distribution by region is as follows: South Central region - 37%, followed by the Southwest - 22% South East region - 18%, North and Northwest regions - 8% and North Central - 7%.

Bulgaria's production was only 0.06 % of world's production. This small share was due to change in ownership and nature of use of agricultural lands since 1989, leding to destructive processes, reducing the apple areas, average yields and total production of fruits. The main reasons for the unsatisfactory state of apple production were disrepair and expired depreciation period of plantations and low quality or lack of agricultural practices in their growing. The created new plantations were insufficient to replace the old ones (Makariev et al, 1994; Doychinova, 2000; Onchev, 2000; Todorova 2000; Domozetov, 2005). The observed trend of decreasing total apple production in 2004 retained until 2008, after which there was a significant growth and production reached levels higher than in 2001 (Figure 2). Production in 2001 was 42 710 t, in 2010 - 43 235 t, which is 1.2% higher. For the ten-year period 2008 is the year with the lowest production - 23 500 t.

With the accession of Bulgaria to the EU and the launching of programs for rural development the interest of farmers in creating new fruit plantations, is expected to strengthened, which will lead to increased areas and production.

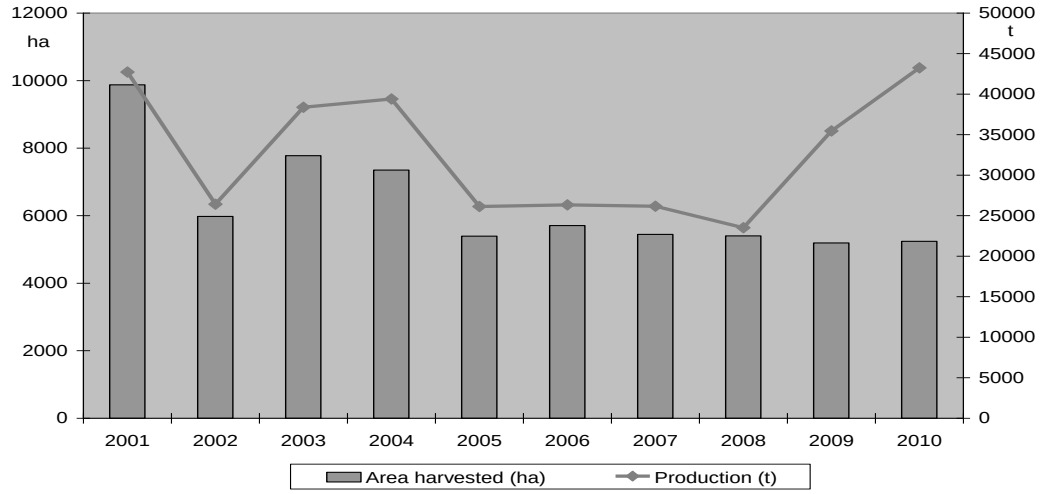

Figure 2. Area harvested (ha) and apple production (t) in Bulgaria, 2001 -2010

In the recent years the main apple cultivars represented in Bulgaria are: Golden Delicious, occupying 19.62% of the area, followed by Red Delicious by 9.29%, Granny Smith - 8.51%, Florina - 7.68% and Melrose - 6.26% (Figure 3). As result introduction activities of the Institute the following cultivars are also introduced and covered, but in a smaller size: Gloster, Mutsu, Djonagold, Molis Delicious, Fuji, Prima, Sharden etc. (Blagov, 1995; Djouvinov, 2002).

At present research work is being done on the improvement and diversification of cultivar assortment with the purpose for all-year-round supply of Bulgarian market with own fresh fruits. Special attention is being paid to the introduction of cultivars, which are virtually resistant to the key diseases – apple scab and powdery mildew. Several cultivars have been created in Bulgaria – Stoyanova krasavitsa, Rumyana, Trakiiska ranna, Trakiiska slava, Albena, Chervena jubileina and Trakiiska kasna, but they have not taken serious positions in our apple production.

In 2010, the latest Bulgarian apple cultivars created at the Institute of Agriculture – Kyustendil were approved - Besapara, Marlena, Martinica, Elegia and Gorana. They possess valuable biological and economic qualities and are expected soon to be fully included in our apple production cultivar lists. In the breeding of the new cultivars a special attention has been paid to their resistance to the major economically significant diseases (scab, powdery mildew and fire blight).

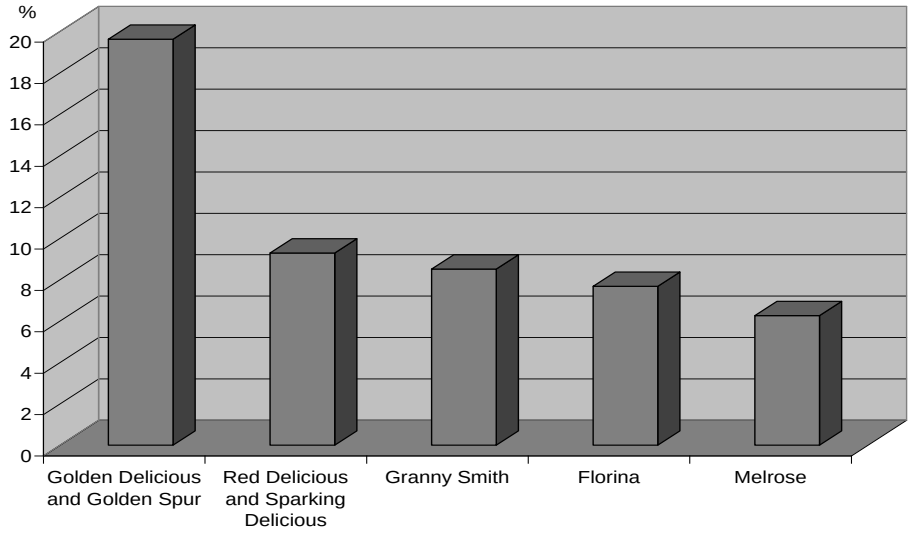

Figure 3. The most widespread apple varieties in Bulgaria, %

Apple production in China

China's climate is mainly dominated by dry seasons and wet monsoons, which lead to a pronounced temperature differences between winter and summer. In the winter, northern winds coming from high-latitude areas are cold and dry; in summer, southern winds from coastal areas at lower latitudes are warm and moist. The climate in China differs from region to region because of the country's extensive and complex topography.

Shandong province, which is one of the major production areas of apples in China, is located at the east part. It is between northern latitude 34° 25' and 38° 23'. Eastern latitude is between 114° 36' and 122° 43'. It belongs to the northern sphere middle latitude zone. The total area is 156 000 sq.km. East part of Shandong province face to ocean, west part is adjoining mainland. It belongs to a warm zone and season wind climate type. Rainfall concentrating, rainfall and hot time are same season. Four seasons are evident. Annually average temperature is 11-14°C, rainfall is between 550-2890 mm. Shandong province sunlight resource is abundant, average sunlight time is from 2300 to 2890 hour per year.

China is the main producer of apples in the world and this species is one of the most important fruits in the country. The proportion of cultivars grown and their ripening seasons however are not suitable for the fruit market. The production of early and mid season cultivars is only occupied by around 15% of the total apple production, while the production of late cultivars amounts to 85% of the total production. Based on the achievements of apple breeding for early and mid season cultivars in the past twenty years in China the authors would suggest that more attention should be paid to early and mid season cultivar development in future, some newly-bred early cultivars are also introduce (Guo Guo Nan *et al*., 2009).

In 2003, the apple output in China amounted to 35.4% of worldwide apple production, while the apple production in the developed countries amounted to 41.4%. In 2002 to 2003 China had exported apples of 440 thousand ton and concentrated apple juice of 417 thousand ton (Zhai Heng

et. al. 2005). Total for the period 2001-2010 apple fruit production has increased from 20,022,763 to 33,265,186 t, which is 66%, while the areas maintained a constant level of approximately 2,000,000 ha (Fig. 4).

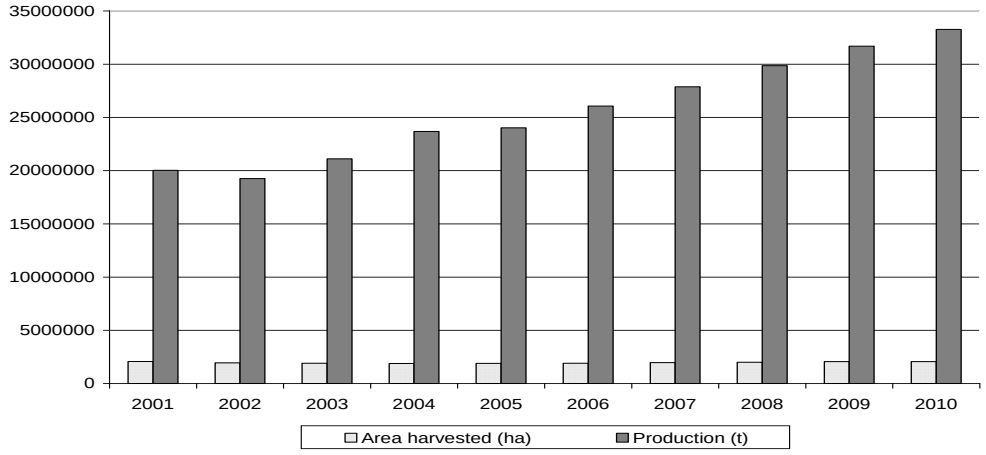

Figure 4. Area harvested (ha) and apple production (t) in China, 2001 -2010

Yantai is one of the two major production areas of apples in the province Shandong. In 2010, the occupied areas by the crop in the region were about 9% of the apple trees in China. Yantai's apples are known worldwide for its distinctive qualities - equal in shape, particle size and color. The fruits are aromatic, sweet, juicy and crunchy flesh. The main cultivars distributed there are: Fuji, Gala and Red Genaral (Table 1). The largest share of Apple Production falls on Fuji variety, occupying 82% of the total area and 81.7% of the apple production. Other varieties occupy a minor position in their share of the total area of apples in the country is as follows: Gala - 9.9%, Red Genaral - 5.4%, Jonagold and Shasa below 1%. Rate of production is almost the same as in the areas.

Table 1. Apple areas and production in Yantai in 2010

Varieties	Area, ha	Rate of area, %	Production, t	Rate of production, %
Fuji	145 807.3	82.06	3 700 000	81.71
Gala	17 600.9	9.91	351 000	7.75
Red Genaral	9 560.5	5.38	249 600	5.51
Jonagold	1 553.4	0.87	43 700	0.97
Shasa	893.4	0.5	18 800	0.42
Others	2 086.8	1.18	70 300	1.55
Total	177 675.6	100	4 528 000	100

It is believed that Chinese apple industry is entering a very important turn period from big apple production to a powerful apple production in the world. The future trend of Chinese apple industry is to keep the current acreage, to advance the yield per unit, to improve the quality of apple products and to encourage the development of the secondary and third industry. In the future, the

developmental focuses must be laid on the following aspects: establishing the modern cultural technical system, the modern storage and processing system and the transport distribution; enhancing science and technique support to the industry, improving the technical service method and meshwork and science and technique training for growers; elevating the standardization production; establishing the CHINA-GAP (Good Agricultural Practice),forming the traceability system in apple culture section; putting the quality control system and HACCP (Hazard Analysis Critical Control Point) into effect; establishing national apple association as soon as possible and assisting growers to organize themselves in association or cooperation; speeding up the research on international marketing of apple industry, and establishing public information service and professional consultant system/institution (Zhai Heng *et al.*, 2007).

Conclusions

Despite the favorable climatic conditions the share of Bulgaria in World Apple Production is extremely unsatisfactory. It is necessary both: an increase the apple areas and improvement of technologies to obtain higher yields.

In Bulgaria the most widespread apple cultivars are: Golden Delicious, Red Delicious, Granny Smith, Florina and Melrose but in the new plantations must be included and some of the newer varieties, particularly resistant to the most economically important diseases.

China is a major manufacturer of apple fruit in the world. Since 2001, apple production tends to steadily increase while keeping the area due to higher yields per unit area.

The largest production area in China is Shandong Province and major variety used is Fuji.

In the future will need to pay greater attention to the quality of the produced apple fruits in China.

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References

Djouvinov, V., Radulov, D., Penev, R. (2002). The apple orchard, Zemisdat, Sofia, pp. 376

Guo GuoNan; Yan ZhenLi; Zhang HengTao; Zhang ShunNi; Liu ZhenZhen (2009). Current situation of production of early and mid season apple cultivars in China and progress in breeding for early and mid season apple cultivars. Journal of Fruit Science , Vol. 26 No. 6 pp. 871-877.

Onchev, N., (2000). About the Bulgarian Agriculture Crisis. Agricultural Economics and Management, 4, pp. 13-20.

Radomirska, I. (2008). Economic evaluation of different apple orchard establishment and growing technologies, Dissertation, pp. 153.

Slavova, Y., Atanasova, M. (2007). Structural Changes in Bulgarian Agriculture and the Common Agricultural Policy. Agricultural Economics and Management, 3, pp. 62-68.

Todorova, S. (2000). Regional Differences of the Bulgarian Agricultural Reform. Agricultural Economics and Management, 4, pp. 26-31.

Velkov, V, Iliev, I., Vasilev, V., Chistov, L., Strandjev, Al. (1970). Agrobiological and chemical-technological characteristics of the fruit varieties, pp. 7-59.

Zhai Heng, Zhao Zhengyang, Wang Zhiqiang and Shu Huairui (2005). Analysis of the development trend of the world apple industry. Journal of Fruit Science, issue 1, pp. 44-50.
Zhai Heng; Shi Da-chuan; Shu Huai-rui (2007). Current status and developing trend of apple industry in China. Journal of Fruit Science, issue 3, pp. 361-364.
FAO (2010) www.faostat.fao.org/

ПОДРАЧЈА И ПРОИЗВОДСТВО НА ЈАБОЛКО ВО БУГАРИЈА И КИНА

Илијана Радомирска, Димитар Сотиров, Сонг Лаигинг

Апстракт
Во овој труд е претставен описот на подрачјата за производство на јаболко и производство на јаболко во Бугарија и Кина во периодот од 2001 – 2010. Почвените, климатските и топографските услови во повеќето региони на овие земји се поволни за одгледување и производство на висококвалитетно јаболко. Вкупната површина под јаболко во светот е 4 696 259 ha а вкупното производство е 69 511 975 тони за 2010. Најголем производител на јаболко во светот е Кина, која произведува околу 48% од вкупното светско производство. Површините под јаболкови насади во Бугарија постојано се зголемуваа од 1968 , кога достигнаа 3 421 ha, но во последно време површините под јаболко значајно се намалија, и во моментот има ококу 5 239 ha. Една од главните причини за намалување на површините под јаболко е пренамена на земјиштето и промена на сопствениците на површините.
Клучни зборови: јаболко, производство, подрачје, држава, тренд.

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Original scientific paper

THE PRODUCTION AND THE CONSUMPTION OF FRUIT IN SLOVENIA OVER THE LAST TEN YEARS

Marjeta Pintar[1*], Barbara Zagorc[1]

[1]Agricultural Institute of Slovenia, Ljubljana
[*]e-mail: marjeta.pintar@kis.si, barbara.zagorc@kis.si

Abstract
The production and the consumption of fruit in Slovenia were estimated on the basis of supply balances of fruit. The fruit supply balance includes all fruit (fresh and processed) and all types of fruit species. It is made up of individual supply balances for fruit species. The supply balance of fresh fruit (includes only fresh fruit) was also prepared. Due to the importance of apples in the Slovenian fruit production the supply balance of apples (fresh and processed) and the supply balance of fresh apples are also presented in this paper. The results of the prepared supply balances are the self-sufficiency rate and the human consumption per capita. In the period 2002-2011 the fruit production depended on weather conditions and also on the impact of alternative fertility in extensive orchards. Slovenia is a net importer of fruit. In the structure of fruit foreign trade between 50 and 60% are citrus fruits and bananas. After 2002 the import and export of fruit was increasing rapidly. In the period 2002-2011 the domestic use of fruit fluctuated between 245 and 350 thousand tons of fruit annually of which more than a third were apples. The self-sufficiency rate of fruit was between 38 and 59%. In the period 2002-2011 each inhabitant of Slovenia on average consumed between 100 and 150 kg of fruit (half in fresh form) of which 30 to 45 kg were apples (around 25 kg were consumed in fresh form).
Key words: fruit, apples, supply balance, production, human consumption.

Introduction

Over the last ten years between 8.9 and 12.3 thousand hectares or a little less than 2% of utilised agricultural area was devoted to fruit production in Slovenia. In the structure of orchards extensive orchards with 55% prevail. As it may be seen from the Graph 1, the share of areas devoted to fruit production has been decreasing on account of the decrease of extensive orchard areas. In the total value of agricultural production fruit has contributed between 4 and 7% in the past few years. The yearly yield depends very much on the weather conditions and beside that it is influenced by alternative fertility of extensive orchards. In Slovenia, between 132 and 191 thousand tons of fruit yearly were produced in the past ten years. The three major fruit species, i.e. apples (82%), peaches (9%) and pears (4%) accounted for 95% of all fruit produced on the average of the last ten years (Zagorc *et al*., 2012).

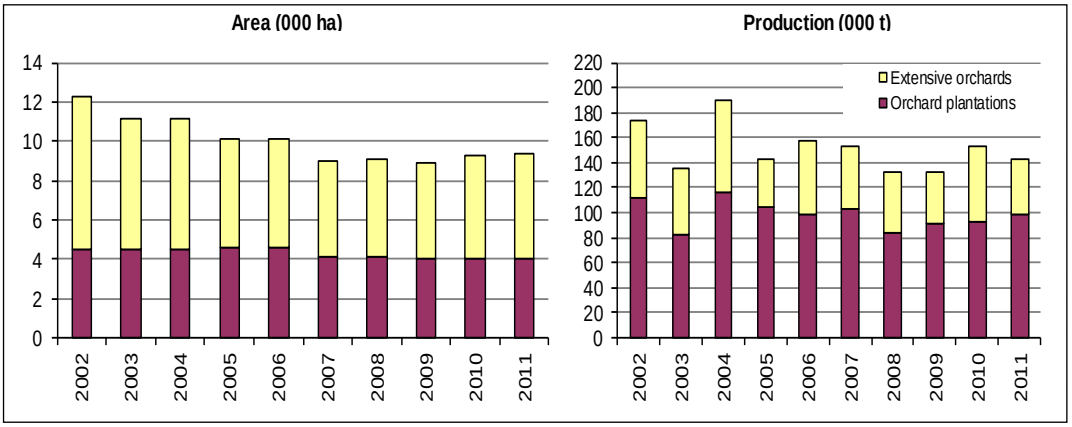

Figure 1. Area and production of fruit in Slovenia; 2002-2011

Table 1. Fruit production in Slovenia; 2002-2011

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Production - total (000 t)										
Fruit	173,9	135,7	190,6	142,2	157,9	152,4	132,3	132,8	153,7	142,4
Apple	135,9	101,6	139,9	106,2	119,2	114,5	102,9	95,7	117,6	105,4
Pear	12,9	11,3	14,2	8,2	11,4	11,8	9,3	11,5	10,9	11,4
Peach	10,0	6,0	14,4	13,3	11,2	9,3	6,8	10,0	8,0	8,6
Other fruit	15,1	16,7	22,0	14,4	16,1	16,9	13,4	15,8	17,2	17,0
Production – orchard plantations (000 t)										
Fruit	112,5	81,8	116,4	105,2	99,0	103,7	84,2	91,4	92,8	99,3
Apple	93,9	70,2	92,9	84,5	79,9	87,0	71,6	72,6	77,3	81,3
Pear	5,9	3,6	5,3	3,1	4,1	4,3	3,1	4,7	3,8	4,6
Peach	8,9	5,4	13,3	12,5	10,2	8,1	5,8	8,9	6,9	7,6
Other fruit	3,7	2,7	4,8	5,1	4,8	4,4	3,6	5,2	4,9	5,7

Source: SURS (Statistical Office of the Republic of Slovenia)

On the average, 65% of fruit in Slovenia is produced in orchard plantations. After 2001 between 70 and 94 thousand tons of apples, between 5 and 13 thousand tons of peaches, between 3 and 6 thousand tons of pears and from 2 to 6 thousand tons of other fruit were produced in these plantations yearly.

Slovenia is a net importer of fruit. In spite of a bit lower fruit import in the past two years a pronounced trend of increasing fruit import has been observed, along with the fact that the import of processed fruit has been increasing more than that of fresh fruit. The fruit export has also been increasing since 2002. In the structure of fruit foreign trade between 50 and 60% are citrus fruits and bananas. Among the continental fruit species apple trade is the major one accounting for 15 to 20% in the structure of foreign trade over the last ten years. The export of apples (the majority of them are fresh apples), which depends very much on the production influenced by weather conditions and alternative fertility, has increased in the last ten years. The import of apples has increased in that period as well, mainly on account of the processed apples (apple juice). In spite of

all that, in Slovenia apples are one of the rare agricultural products with a positive foreign trade balance (Zagorc *et al*., 2012).

Table 2. Foreign trade of fruit in Slovenia; 2002-2011

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Import										
Fruit	158,6	160,5	177,3	221,1	205,1	254,5	324,9	318,4	276,7	271,5
Apple	19,3	10,5	15,3	27,2	19,6	29,4	39,1	40,4	39,9	38,3
Pear	2,3	2,8	2,9	5,6	5,6	6,8	6,7	6,8	6,5	6,3
Peach	8,4	7,2	9,9	13,9	11,5	11,8	15,4	14,0	12,4	11,6
Export										
Fruit	39,8	51,9	39,8	71,6	61,3	94,0	105,4	105,3	102,8	110,7
Apple	16,1	25,2	17,8	28,1	22,0	37,5	28,9	25,0	35,3	41,0
Pear	1,1	0,8	1,2	1,0	1,4	1,7	2,3	2,0	2,3	1,5
Peach	0,1	0,1	0,1	0,6	1,1	1,4	2,7	2,0	1,7	1,5

Source: SURS

Data on fruit yield together with data on foreign trade with fruits are the basis of the so-called fruit supply balance. The notion supply balance of fruit is a complex of standardised information on the supply and demand for fruit referring to the country as a whole. The two results of the prepared balance are the two indicators, i.e. the self-sufficiency rate (to what degree the domestic use is covered by the domestic production) and human consumption per capita (the quantity of fruit available to individual inhabitant in a certain period) that allow the comparison with other agricultural products and comparison with other countries. The self-sufficiency rate and the human consumption of fruit and/or apples in Slovenia has already been reported by several sources (Ministrstvo za kmetijstvo, gozdarstvo in prehrano, 1993, Žibrik, 1997, Alič, 2004, FAO, 2012, Gutman Kobal, 2012), however, for the time being there does not exist any official supply balance of fruit and/or individual fruit species.

The supply balances of major agricultural products are made following the uniform Eurostat methodology (Eurostat, 2001). The latter does not include a general fruit supply balance but only the supply balances of certain fruit species or fruit groups (apples, pears, fresh peaches, processed peaches, table grapes, oranges, citrus fruits, dried fruits) (Eurostat, 2002, Eurostat, 2009).

The knowledge about human fruit consumption is necessary for the monitoring of structure and development of fruit market and the assurance of information required for making agricultural policy decisions. The current experiment presents a basis for future official fruit supply balance and supply balances of individual fruit species. The current paper comments on the production and consumption of fruit based on the prepared supply balances exposing apples that are the major fruit species in Slovenia.

Material and methods

The term supply balance presents a synthesis of a great number of different statistical and other data from the field of agriculture and food industry. The fruit supply balance consists of individual supply balances of fruit species. Since the Eurostat methodology includes only supply balances of

some fruit species the missing fruit species supply balances were made and they were joined in a common fruit supply balance. When making supply balances the data on yield, production of industrial products and foreign trade with fruit were drawn from Statistical Office of the Republic of Slovenia (SURS) while numerous data refer to estimates provided by experts. Here it would be worthwhile drawing attention to fruit production in kitchen gardens which is widely spread in Slovenia but not included in supply balances since there do not exist any data on fruit production in kitchen gardens in Slovenia. The supply balances were made for the period 2002-2011 and they are expressed in the equivalents of fresh fruit. For the current paper the *fruit supply balance* including all fruit (fresh and processed) and all fruit species was made. Since from the aspect of nutrition it is very important to know data on the quantity of fruit consumed in the fresh form, further on a *supply balance of fresh fruit* is presented. Opposite to the former one the latter includes only fresh fruit since fruit intended for processing (puree, jam, dry fruit, juices) has been excluded from this balance. As similar supply balances are not made in other European countries, for the sake of comparison we have prepared one balance in the way that it is done in Austria. The *fruit supply balance according to Austrian methodology* includes fresh fruit and all processed products except juices (the processing of fruit into juices is excluded). Due to the importance of apples in the Slovenian agriculture the same way was used to present *apple supply balance* (fresh and processed apples), the *fresh apple supply balance* (without processed products) and *supply balance of apples according to Austrian methodology* (fresh apples and processed products without juices).

Results and discussion

Estimates based on the prepared fruit supply balances and fresh fruit supply balances show that between 245 and 350 thousand tons of fruit were consumed in Slovenia yearly after 2002 of which about 85% on the average were used for food. The remaining part of the consumption was estimated to have been used for industrial purposes (vinegar and brandy production) or they were lost as waste. The lowest consumption was recorded in 2003 when the yield suffered considerably from drought and the fruit import did not increase essentially in spite of a much lower production. The highest consumption was recorded in 2008 in spite of the low production because this was the year that witnessed the highest fruit import ever. The yearly consumption of apples in the period 2002-2011 ranged between 85 and 140 thousand tons presenting a good one third of domestic use of fruit in Slovenia. The consumption of fruit fluctuated the most severely between the drought year 2003 and the year 2004 when the fruit witnessed an extremely rich crop. Among the major continental fruit species apple consumption is the one to come the closest to its production. After 2001 about three quarters of apples were used for food on the average, which is a bit less than the other fruit species since the share of apples intended for processing into vinegar and brandy is higher if compared with the other fruit species.

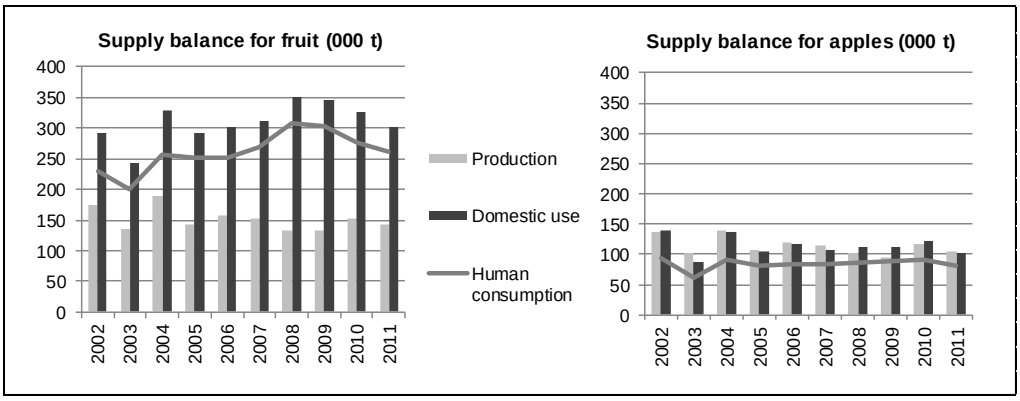

Figure 2. Fruit and apple production and consumption in Slovenia; 2002-2011

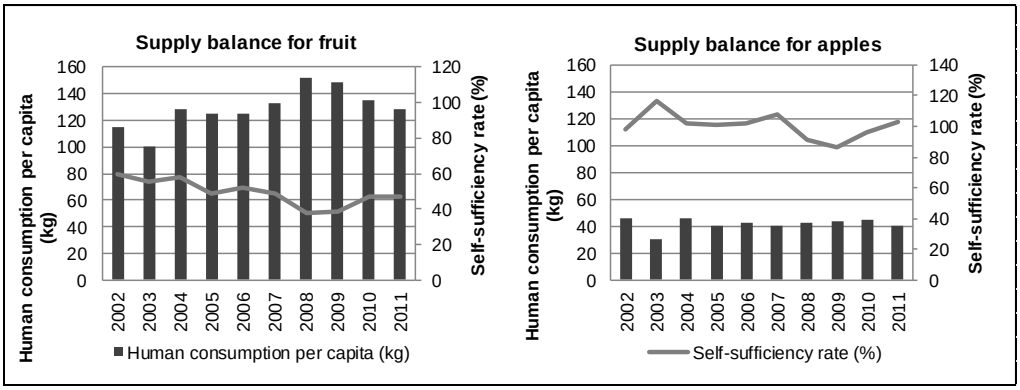

Figure 3. Human consumption of fruit and apples per capita and self-sufficiency rate of fruit and apples in Slovenia; 2002-2011

In the years between 2002 and 2011 an inhabitant of Slovenia consumed on the average from 100 to 150 kg of fruit in any form (calculated into the fresh fruit equivalent), of which between 30 and 45 kg were apples. If the extreme year 2003 is excluded in this period each inhabitant consumed 132 kg of fruit on the average (in the fresh fruit equivalent), of which 43 kg of apples.

There are relatively few international data on fruit consumption or they are often incomparable since for the estimation of fruit consumption different methodologies are used (Eurostat, 2002, Eurostat, 2009, Grüner Bericht, 2011, FAO, 2012). It is therefore interesting to compare the consumption of fresh fruit together with the processed fruit (juices excluded) with the neighbouring country Austria which was made possible by the supply balances for fruit and apples prepared on the basis of Austrian methodology. According to the calculations made, one fifth more fruit were consumed in Slovenia than in Austria (about 100 kg) on the average in the period 2006-2011 and the apple consumption in Slovenia was being higher by 15% (about 24 kg). The fruit production in Slovenia after 2002 covered between 38 and 59% of domestic use. The higher self-sufficiency rate on principle was reached in the years with good apple yield attained in extensive orchards and, opposite to that, the lower self-sufficiency rate was reached in alternative fertility years. In 2008 and

2009 when the self-sufficiency rate was the lowest, the fruit foreign trade balance was the most unfavourable, too.

Important information from fruit supply balances covers the question of what part of fruit was consumed in the form of fresh fruit. In the years 2002 to 2011 between 204 and 285 thousand tons of fresh fruit or between 83 and 132 thousand tons of fresh apples were consumed in Slovenia yearly. In the period mentioned above a good 150 thousand tons of fresh fruit were used for food, of which about 50 thousand tons of fresh apples. According to the first estimates the average of 60% of fruit and apples as well were used for food in the fresh form.

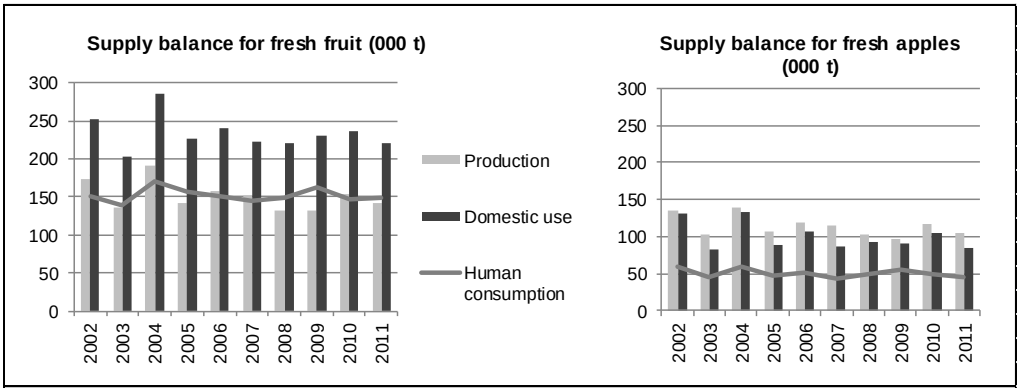

Figure 4. Fresh fruit and fresh apple production and consumption in Slovenia; 2002-2011

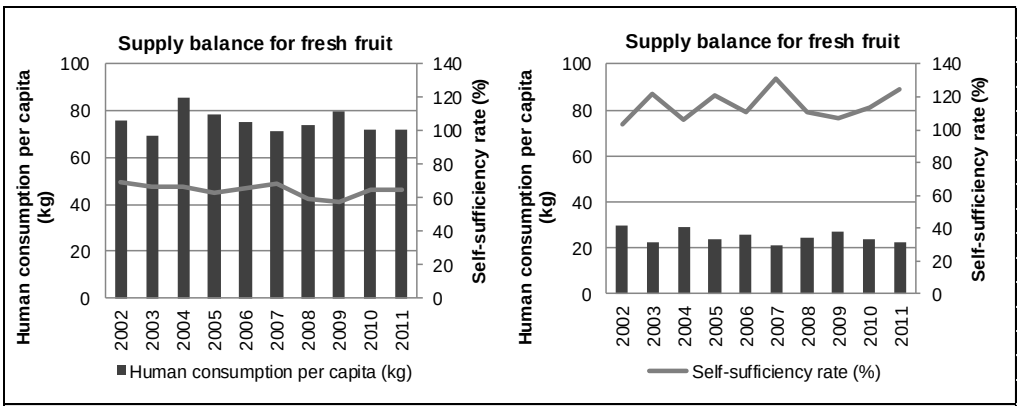

Figure 5. Human consumption of fresh fruit and fresh apples per capita and self-sufficiency rate of fresh fruits and fresh apples in Slovenia; 2002-2011

After 2002 an inhabitant of Slovenia consumed on the average between 70 and 85 kg of fresh fruit yearly, of which about 25 kg of fresh apples on the average.

About two thirds of domestic needs for fresh fruit in Slovenia are covered by domestic production reached by agricultural holdings. Apples are one of the rare agricultural products (Volk *et al.*, 2012a, Volk *et al.*, 2012b), of which the self-sufficiency rate both in the total (in some years) and the fresh consumption exceeds 100. The self-sufficiency rate of apples in the period starting from 2002 amounted to 86 and 117% and that of fresh apples to 103 and 131%.

Conclusions

In the period 2002-2011 the fruit production in Slovenia was considerably fluctuating since the height of yield depended on weather conditions and it was influenced by alternative fertility of extensive orchards. Slovenia is a net importer of fruit. In spite of a little lower import of fruit in the last two years a pronounced trend of its increase has been noticed. Also, the export of fruit has been increasing since 2002. The first estimates prepared on the basis of fruit supply balances and fresh fruit supply balances point out that the domestic use of fruit in Slovenia exceeds the domestic production. After 2002, between 245 and 350 thousand tons of fruit were consumed yearly, of which a good third were apples. In the years from 2002 to 2011, between 132 and 191 thousand tons of fruit were produced in Slovenia satisfying between 38 and 59% of domestic needs for fruit. In the period mentioned, between 96 and 140 thousand tons of apples were produced in the extensive orchards and apple orchards plantations. According to supply balance estimates the production mentioned above covered between 86 and 117% of domestic needs for apples in individual years while the self-sufficiency rate with fresh apples amounted to 103 and 131%. In Slovenia about 85% of fruit used on the average are intended for human consumption. An inhabitant of Slovenia consumed between 100 and 150 kg of fruit in all forms (calculated into fresh fruit equivalent) on the average in the years between 2002 and 2011, of which between 30 and 45 kg of apples. Data on the fresh fruit consumption are important above all from the nutritional point of view. According to the first estimates, in Slovenia 60% of fruit are consumed in the fresh form on the average.

References

Alič, V. (2004). Spremembe izvoznih pogojev za slovenska jabolka na trgih bivših držav Jugoslavije. In: Zbornik referatov 1. slovenskega sadjarskega kongresa z mednarodno udeležbo. Krško 2004, pp. 551-556.

Eurostat, (2001). Handbook to compile supply balance sheets – General information, concepts, Doc.ASA/PE/635. September 2001, Eurostat, Luxembourg: 23 pp.

Eurostat, (2002). Handbook for compiling supply balance sheets – Fruits, Doc.ASA/PE/641rev2. September 2002, Eurostat, Luxembourg: 18 pp.

Eurostat, (2009). Handbook for compiling supply balance sheets – Fruits, Doc.ASA/PE/641rev3WPM. September 2009, Eurostat, Luxembourg: 21 pp.

FAO. Food Supply, Crops primarly equivalent.
http://faostat.fao.org/site/609/DesktopDefault.aspx?PageID=609#ancor (13.07.2012)

Grüner bericht, (2011). http://www.agraroekonomik.at/index.php?id=789 (13.07.2012)

Kobal Gutman, Zlatka. 2012. Pridelava sadja v Sloveniji. http://www.spodezelja.si/index.php?option=com_content&view=article&id=1093:pridelava-sadja-v-sloveniji&catid=112:strokovnapriloga&Itemid=621 (13.07.2012)

Ministrstvo za kmetijstvo, gozdarstvo in prehrano (1993). Strategija razvoja slovenskega kmetijstva. Ljubljana: 85 pp.

SURS (2012). Statistical Office of the Republic of Slovenia (different databases). http://www.stat.si (12.06.2012)

Volk, T. (ed.) *et al*. (2012a). Poročilo o stanju kmetijstva, živilstva, gozdarstva in ribištva v letu 2011. Ljubljana, Ministrstvo za kmetijstvo in okolje, Kmetijski inštitut Slovenije, http://www.kis.si/pls/kis/!kis.web?m=36&j=SI#nav (23.07.2012)

Volk, T. (ed.) *et al*. (2012b). Poročilo o stanju kmetijstva, živilstva, gozdarstva in ribištva v letu 2011 – Statistične priloge. Ljubljana, Ministrstvo za kmetijstvo in okolje, Kmetijski inštitut Slovenije, http://www.kis.si/pls/kis/!kis.web?m=36&j=SI#nav (23.07.2012)
Zagorc, B., Volk, T., Pintar, M., Moljk, B. (2012). Poročilo o stanju kmetijstva, živilstva, gozdarstva in ribištva v letu 2011 - Pregled po kmetijskih trgih. Ljubljana, Ministrstvo za kmetijstvo in okolje, Kmetijski inštitut Slovenije, http://www.kis.si/datoteke/file/kis/SLO/EKON/Porocilo2011/ZP-2011_trgi.doc
Žibrik, N. (1997). Sadjarstvo. In: Erjavec, E., Rednak, M., Volk, T. (ed.), Slovensko kmetijstvo in Evropska unija. Kmečki glas, Ljubljana, pp. 290-298.

ПРОИЗВОДСТВО И ПОТРОШУВАЧКА НА ОВОШЈЕ ВО СЛОВЕНИЈА ВО ПОСЛЕДНИВЕ ДЕСЕТ ГОДИНИ

Марјета Пинтар, Барбара Загорч

Апстракт
Производството и потрошувачката на овошје во Словенија беа пресметани на база на балансот на снабдување со овошје. Балансот на снабдување со овошје ги опфаќа сите типови на овошје (свежо и обработено) и сите овошни видови. Направен е индивидуален баланс на снабдување за секој овоштен вид. Балансот на снабдување со свежо овошје (вклучува само свежо овошје) исто така е направен. Поради големото значење на јаболкото за Словенија, балансот на снабдување со јаболко (свежо и обработено) и балансот на снабдување со свежо јаболко исто така е презентиран во овој труд. Во периодот од 2002-2011 производството на овошје зависеше од временските услови. Словенија е нето увознк на овошје. Од увезеното овошје од 50- 60% се банани и цитруси. После 2002 увозот и извозот на овошје рапидно се зголемил. Во периодот 2002-2011 домашната употреба на овошје вариираше во границите помеѓу 245 и 350 илјади тони на овошје годишно од кои една третина беа јаболка. Стапката на само – задоволување со овошје беше помеѓу 38 и 59%. Во периодот 2002-2011 секој жител на Словенија просечно конзумирал од 100 до 150 kg на овошје (половина во свежа состојба) од кои 30 до 45 kg се јаболка (околу 25 kg беа конзумирани во свежа состојба).
Клучни зборови: овошје, јаболка, баланс на снабдување, производство, конзумирање.

UDC:634.22-152.7
Original scientific paper

THE SELECTION OF VEGETATIVE ROOTSTOCKS FOR PLUM

Gorica Paunovic[1*], Ljiljana Boskovic-Rakocevic[1], Miljan Cvetkovic[2]

[1] Faculty of Agronomy Cacak, University of Kragujevac
[2] Faculty of Agriculture, University of Banja Luka
[*]e-mail: gorica@tfc.kg.ac.rs

Abstract
Modern plum cultivation involves the use of selected vegetative rootstocks, primarily those exhibiting lower vigour. Balkan region has a large fund of autohtonic cultivars and genotypes of stone fruits of the *Prunus* genus, which can be presumably used in the development of high-quality vegetative rootstocks. The present paper examines the possibility of vegetative rootstock selection in seven genotypes of autochthonous plums of different species of the *Prunus* genus, being as follows: *Prunus domestica* L. and *Prunus cerasifera* Ehrh. Plum vegetative rootstocks were propagated by mounding as a type of vegetative propagation. The rooting potential was very low in genotypes derived from *P. cerasifera* Ehrh. (2.8% and 3.5%). Relatively good regenerative ability was exhibited by the genus *P. domestica* L. The five genotypes showed a highly variable percentage of mother bushes responding to rooting, ranging from 10.4% to 90%.
Key words: plum, vegetative rootstocks, autochthonous genetic material.

Introduction

The selection for growing plum is currently of great concern. One of the main preconditions for successful cultivation plums is choise rootstock. Rootstock selection gains increasingly high importance due to current problems in the cultivation of the plum (plum pox virus). In stone fruit cultivation, vegetative rootstocks should be given priority over generative ones. A good rootstock is expected to be easily propagated (vegetatively or generatively); to be able to create a straight smooth tree that can be easily grafted; to be compatible with cultivated varieties; not to produce root shoots; to produce grafted fruit trees characterized by the lowest possible vigour, precocity and abundant cropping; to result in uniform fruit tree behaviour in the orchard; to have a good anchoring ability and adequate tolerance to mineral deficiency, these are general objectives of fruit tree rootstock selection (Misic, 1984).

The selection of rootstocks for plum cultivation is crucial to longevity, productivity, quality and maturation of the fruit of grafted cultivars. When cultivating the plum, priority should be given to vegetative rootstocks, which have not come into wide use under this region agroenvironmental conditions, yet (Milosevic, 2002). The advantages of vegetative rootstocks over generative ones include the following: seedling uniformity in both the nursery and the orchard, precocity of grafted cultivars, simpler method of propagation etc. The primary disadvantage of vegetative rootstocks is risk of virus transmission, hence the necessity for a strict safety control of the seedlings grafted on vegetative rootstocks (Milosevic, 2002).

Material and methods

Over 1998-2003, examinations were conducted on the possibility of selecting vegetative rootstocks for stone fruits from autochthonous genetic material.

The possibility of selection of vegetative rootstocks from autochthonous genetic material of plum was studied in seven genotypes of different cultivars of autochthonous plums of the genus *Prunus*, i.e. *Prunus domestica* L. and *Prunus cerasifera* Ehrh.:

- genotype 1/8 - Belosljiva (*P.domestica* L.)
- genotype 3/8 - Crvena Ranka (*P.domestica* L.)
- genotype 7/8 - Crnošljiva (*P.domestica* L.)
- genotype 8/8 - Crnošljiva (*P.domestica* L.)
- genotype 10/8 - Crnošljiva (*P.domestica* L.)
- genotype 5/8 - Džanarika (*P.cerasifera* Ehrh.)
- genotype 6/8 - Džanarika (*P.cerasifera* Ehrh.)

The seedlings of the genotypes examined were used to create a mother plantation of the selection I where mounding was employed during the growing season for testing of the root regeneration ability.

Mounding was used as a type of vegetative rootstock propagation. At the end of the growing season, testing for rooting was performed.

The analysis of the rate of rooting at the mother plantation of the selection I included the following:

- the ability to emit rooted shoots (number of mother bushes showing response),
- average number of rooted shoots per mother bush,
- average shoot length per mother bush,
- singling out individual bushes with a positive rate of rooting
- assessment of predispositions of certain species of the *Prunus* genus and their genotypes to vegetative rootstock selection.

Results and discussion

The rooting ability was examined in the mother plantation of the selection I made up of seedlings of seven autochthonous plum genotypes studied (table 1). The rooted shoot emission ability was tested in 1362 mother plants. The response to rooting was registered in 144 mother plants (accounting for 10.6 % of the total number).

The results presented in table 1 suggest a great difference between certain species of the *Prunus* genus as well as between certain genotypes within the same genus. Regenerative abilities were different in certain species of the *Prunus* genus.

The rooting ability in genotypes derived from *Prunus cerasifera* was found to be very low (the percentage of mother bushes showing response to rooting was very low – 2.8% and 3.5%, respectively). The percentage of mother bushes responding to rooting was highly variable, ranging from 10.4% to 90%.

The long-term examination of regenerative abilities of autochthonous plums aimed at vegetative rootstock selection (Lucic et al. 1994) indicates that if the number of individuals within the same genotype displays positive response to the rooting test (10-15%), this can be considered a good result. The rate of rooting is a crucial, but not the only selection parameter. This is the reason why further investigations included all of the genotypes that responded to rooting.

Table 1. Rooting ability in the mother plantation of selection I

Item	Genotype	Origin	Total number of mother bushes	Number of mother bushes showing response	% of mother bushes showing response
1	1/8	*P.domestica* L.	243	36	14.8
2	3/8	*P.domestica* L.	192	20	10.4
3	5/8	*P.cerasifera* Ehrh.	543	15	2.8
4	6/8	*P.cerasifera* Ehrh.	312	11	3.5
5	7/8	*P.domestica* L.	28	25	89.3
6	8/8	*P.domestica* L.	20	18	90.0
7	10/8	*P.domestica* L.	24	19	79.2
∑	7		1362	144	

The assessment of the potential of certain species of the genus *Prunus* to develop root on the mounded part of the aerial system suggests that seven of the ten genotypes derived from *Prunus domestica* L. produced rooted shoots (Paunovic, 2008). The rooting ability was also registered with the species *Prunus cerasifera* Ehrh., *Prunus insititia* L. and *Prunus spinosa* L. The number of rooted mother bushes per individual genotype was higher in the species *Prunus domestica* L. as compared to the other ones. Therefore, the highest potential to develop vegetative progeny in the production of vegetative rootstocks by mounding was exhibited by the above species.

For the purpose of developing vegetative rootstocks, the selection of mother bushes displaying the best shoot rooting performance was conducted at the mother plantation of selection I. The selection of plants with the best rooting ability will be used in further selection and research. As the rate of rooting is not the only parameter of vegetative rootstock selection, due attention should be given to other parameters - shoot emission and vigour.

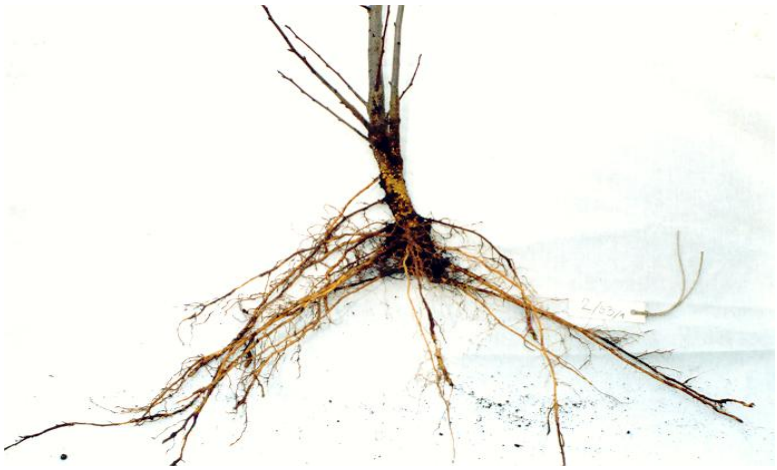

Figure 1. Rooted shoot of the *Prunus domestica* L

The average number and average length of the rooted shoots per mother bush are presented in table 2. The average shoot number per mother bush ranged from 2.4-4.1. The highest and lowest shoot numbers per mother bush were recorded in the genotypes 5/8 and 8/8, respectively. Lucic et al. (1994) report that the genotypes producing less than three shoots per mother bush are of no interest for further investigation as this is a small number of rooted shoots. Their further investigations involved genotypes with more than three shoots emitted. Kapetanović et al. (1972) examined vegetative progeny by mounding. The number of rooted shoots per mother bush in their research ranged from 6.1 in Ruzica to 13 in Banjalucka Bjelica. They reported that the number of rooted shoots was greatly dependent on climate conditions in the mounding period; namely, the rooting of mother bushes was determined to be lower during the drought period accompanied by high temperatures.

Apart from the number of rooted shoots, the above authors gave a review of the variations in the rooted shoot number per mother bush, suggesting that the number was rather high (ranging from 4.5-23 in Banjalucka Bjelica and from 2-11.5 in Ruzica).

As the number of rooted shoots per mother bush ranged in some genotypes, the selection of mother bushes with the highest production of rooted shoots to be used in further vegetative propagation should be conducted. The average length of the aerial part of the rooted shoots ranged from 29.7-44.3 cm (Tab. 2). The rooted shoots had lower height, which was favourable in terms of the selection of lower-vigour vegetative rootstocks. Kapetanovic and Prica (1976) reported good rooting per mother bush, but rather vigorous growth of rooted shoots, which was not favourable in terms of the selection of lower-vigour vegetative rootstocks.

Table 2. The average number and average length of rooted shoots per mother bush

Genotype	Number of mother bushes producing rooted shoots	Average number of rooted shoots per mother bush	Average length of rooted shoot aerial system (cm)
1/8	36	3.0	32.4
3/8	20	2.8	29.7
5/8	15	4.1	44.3
6/8	11	3.6	39.6
7/8	25	3.3	34.1
8/8	18	2.4	35.2
10/8	19	3.7	37.0

Conclusions

The long-term research results on the ability of selection of vegetative rootstocks for plums from autochthonous genetic material suggest the following:

Genotypes origin from *Prunus domestica* L. and *Prunus cerasifera* Ehrh. exhibited high variability in vegetative propagation.

The ability to develop new vegetative rootstocks from autochthonous genetic material was determined to be different in certain species of the *Prunus* genus. It was low among the *Prunus cerasifera* Ehrh. species and relatively good in *Prunus domestica* L.

All examined genotypes of the species *Prunus domestica* L. showed very different ability of root regeneration on the mounded shoot parts. Some autochthonous plum genotypes showing quite a wide range of the ability – from low (2.8-3.5%) to high (79.2-90%).
The rooted shoots had lower height (29.7-44.3 cm), which was favourable in terms of the selection of lower-vigour vegetative rootstocks.

References

Kapetanović, N., Buljko, M., Bulum, D. (1972). Vegetativno razmnožavanje domaćih šljiva za proizvodnju podloga. Jugoslovensko voćarstvo, 17-18, pp. 309-316.
Kapetanović, N., Prica, V. (1976). Proučavanje domaćih šljiva kao podloge za šljivu i kajisiju. Jugoslovensko voćarstvo, 37-38, pp. 255-263.
Lučić, P., Đurić, G., Mićić, N. (1994). New clonal rootstocks for plums on the basis of P.domestica L., P.cerasifera Ehrh. and P.insititia L. Acta Horticulturae 359, pp. 212-215.
Milošević, T.(2002). Šljiva-tehnologija gajenja. Agronomski fakultet, Čačak.
Mišić, D.P. (1984). Podloge voćaka, Nolit, Beograd.
Mišić, D.P. (1996). Šljiva. Partenon, Institut za istraživanja u poljoprivredi "Srbija", Beograd.
Paunović, G. (2003). Mogućnost selekcije vegetativnih podloga za šljivu na bazi autohtonog genetskog materijala i morfo-fiziološke karakteristike selekcionisanih podloga na toj osnovi. Doktorska disertacija, Agronomski fakultet, Čačak.
Paunović, G. (2008). The selection of vegetative rootstocks for stone fruits. Acta Agriculturae Serbica, 13(26), pp. 17-24.

СЕЛЕКЦИЈА НА ВЕГЕТАТИВНИ ПОДЛОГИ ЗА СЛИВА

Горица Пауновиќ, Љиљана Бошковиќ-Ракочевиќ, Миљан Цветковиќ

Апстракт
Модерното производство на слива вклучува употреба на селектирани вегетативни подлоги. Балканскиот регион изобилува со автохтони сорти и генотипови на коскесто овошје од родот *Prunus*, кои може да се искористат за развојот на висококвалитетни вегетативни подлоги. Во овој труд е прикажана можноста за селекција на вегетативни подлоги во седум генотипови од автохтоните видови сливи од родот *Prunus*, следниве видови се искористени: *Prunus domestica* L. и *Prunus cerasifera* Ehrh. Кореновиот потенцијал беше многу мал кај генотиповите добиени од *P. cerasifera* Ehrh. (2.8% и 3.5%). Релативно добра регенеративна способност имаа подлогите добиени од родот *P. domestica* L. Петте генотипови покажаа високо варијабилен процент на вкоренување, во границите од 10.4 до 90%.
Клучни зборови: слива, вегетативни подлоги, автохтон генетски материјал.

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CHARACTERISTICS OF MATURE APPLE FRUITS DEPENDING ON THE TRAINING FORM AND PRUNING SYSTEM

Cvetković Miljan[1*], Paunović Gorica[2]

[1] Faculty of Agriculture, University of Banja Luka
[2] Faculty of Agronomy, Čačak, University in Kragujevac
[*]e-mail: miljan.cvetkovic@agrofabl.org

Abstract
The paper aim was to analyze the influence of training form and pruning system on the characteristics of mature apple fruits. The research was performed in Eastern Herzegovina (Ljubinje) in the period 2005 - 2007. The study included the cultivar Idared, Gloster and Melroza being 20 years old and grafted on MM106 rootstock. With a certain number of trees there have been performed reconstructions of training form spindle with short pruning to training form central axis (solaxe) with long pruning system, in order to increase the level of productivity. Variety characteristics were comparatively studied through: distribution of fruit depending on the diameter of the fruit and average weight according to the average size of fruits in different training forms and pruning systems. The participation of fruits with optimum size, was higher in solaxe training form during the research period for all cultivars. Solaxe training form with long pruning system show a higher cumulative yield that ranged from 27.67% in the cv. Idared, 32.22% in cv. Melroza and 74.03% in cv. Gloster. Research has shown that studied cultivars have higher yield and fruit quality in growing form solaxe with long pruning in relation to training form spindle and short pruning system. Introduction of the training form solaxe and long pruning system within the reconstruction of spindle resulted in the differences in yields. The differences in yield indicate positive effects of introduction of those treatments within analyzed cultivars with the special economic results for Idared and Gloster.
Key words: variety, spindle, solaxe, pruning system.

Introduction

By definition orchard system includes a coherent set that consists of the following components: growing type, planting density and specific combination cultivar/rootstock under given growth conditions (Monney et al, 1993; Blaser, 1996; Micic et al, 1998, 2005). The introduction of slender spindles in fruit production during seventies start realization of the „pedestrian orchard" concept, as a new intensive and highly productive period in the development of fruit production (Micic et al, 1998, 2001, 2005).

Solaxe growing form is formed as a combination of a vertical axis, which was originally called the ax and Solen (Hucbourg et al., 1996, Lespinasse JM, et Lauri P. E, 1999.). This provides a compound solen+ax=solaxe or Sun axis (Stampar, 2000). Solaxe has a number of advantages (Yuri, 2007), which is particularly manifested by increased average yield (Hansen, 2009), which in certain

production conditions may be 20 to 30 % more when compared to a slender spindle (Stampar, 2007).

In intensive training forms a basis for economical fruit prodution is yield (Blazek and Hluščikova, 2007; Lukic et al, 2005; Oparanica et al, 2000; Cvetkovic, 2001) that can be achieved by regular fruiting (without the appearance of alternative cropping) in certain combinations of cultivar/rootstock (Micic and Djuric, 1994; Keserović et al, 2005).

Material and methods

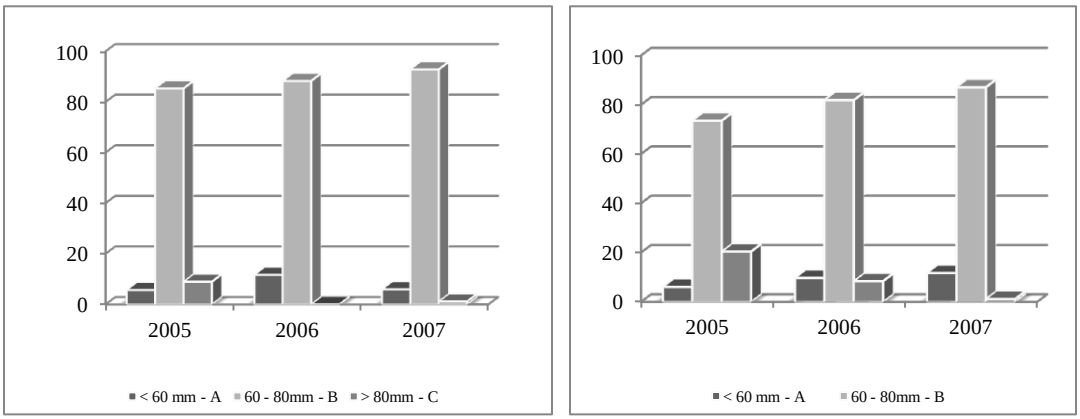
The research was performed in Eastern Herzegovina (Ljubinje) in the period 2005 - 2007. Study included the cultivars Idared, Gloster and Melroza, 20 years old grafted on MM106 rootstock. Orchard was establish in 1986. The planting distance is 4 × 1.3 m for all varieties. In plantation the standard agricultural practices was applied. Generally, trees are maintained in a "slender spindle" training form with the use of short pruning of productive tree. With a certain number of fruit trees (300) there have been performed reconstructions of training form being spindle with short pruning to training form central axis (solaxe) with long pruning system, in order to increase the level of productivity.

Characteristics of ripe fruit harvested from 20 trees grown in the form of spindle and central axis form, was analyzed during three years of research. The thinning of fruits was not implemented.

Distribution of the fruits in certain defined categories on fruit diameter base, and average weight of fruit in each category was measured. There are defined three fruit categories based on the size of fruit diameter: category B - fruit diameter from 60 to 80mm, which meets the standards of the first category and the extra fruit category; category A - fruit diameter less than 60mm and category C - fruit diameter greater than 80mm. Fruits from category A and C belong to second or outside of class. After fruit classification in the defined categories, for each category it was determined the average weight of fruit. All data were statistically analyzed and expressed in relative terms, and the mean structure with appropriate indicators of variations.

Results and discussion

Idared. Training form with long pruning system expressed the highest share of the fruits with optimal size when compared to the other two categories with a tendency to increase during the research period (data obtained from the central axis) (Graph 1). Share of small fruit (category A) was higher when compared to large fruit (category C). In the spindle training form with short pruning system there have been registered higher share of larger fruit within all years of study (except dominantly represented optimum sized fruit).



a. b.

Figure 1 (a, b). Distribution of fruit cv Idared depending on the diameter: a) central axis form – long pruning, b) slender form – short pruning.

Weight of fruits that are in the group with optimal diameter, is quite uniform regardless the growing form and pruning system and it is in the range of 129.50 to 154.73 g (Table 1). Special differences in fruit weight depending on the training form and pruning system are recorded in the group of large fruit (category C). Blazek and Hluscikova (2007) indicate that the average fruit weight of cv. Idared grafted on M9 rootstock in the first 10 years of fruiting ranged from 103.60 to 293.70 g, and the average fruit weight was 181,80 g. Examining the potential of cv Idared in Čačak in the previous period Cvetkovic (2001), states that the average fruit weight of cv Idared on the MM106 rootstock in an orchard 8 years of age was 184 g. Lukic et al. (2005), analyzing the properties of cv. Idared in Čačak in 2003-2004, were determined average fruit weight of 217.5 g.

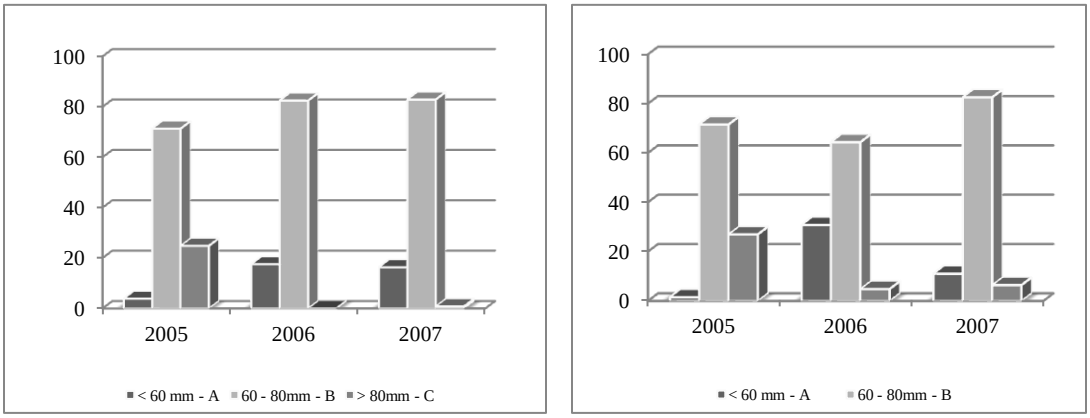
Table 1. The average fruit weight (g) cv. Idared depending on the average size of fruits in different growing form and pruning systems

	year	fruit diameter (mm)		
		< 60	60 – 80	80 – 100
spindle form – short pruning system	2005	89.71 ± 5.04	139.00 ± 5.21	198.30 ± 4.73
	2006	76.69 ± 4.34	133.30 ± 10.70	212.75 ± 4.98
	2007	82.66 ± 7.31	154.73 ± 6.27	204.48 ± 4.51
central axis form – long pruning system	2005	82.75 ± 4.48	129.50 ± 5.17	179.69 ± 2.55
	2006	83.00 ± 3.91	141.00 ± 7.36	–
	2007	70.69 ± 2.35	146.82 ± 4.31	179.42 ± 5.13

Oparnica et al. (2000), state the average weight of fruit from 169.72 to 189.00 g, depending on the type of fruit branches.

Gloster. In the central axis training form with long pruning system has highest percentage of fruits having optimal diameter with a tendency to increase participation during the study period (Graph 2). In 2006 and 2007, there where higher percentage of small fruits (category A) in relation to large fruits (category C). In spindle training form with short pruning system during the whole period of

research the highest percentage of fruits were with optimal diameter, with significant fluctuations over the years.



a. b.

Figure 2 (a, b). Distribution of fruit cv. Gloster depending on the diameter: a) central axis form – long pruning, b) slender form – short pruning

Weight of fruit cultivars Gloster in the group with optimal diameter is quite uniform, stating higher fruit weight in a spindle training form with short pruning. Fruit weight regardless training form and pruning system ranged from 77.25 to 240.19 g (Table 2).

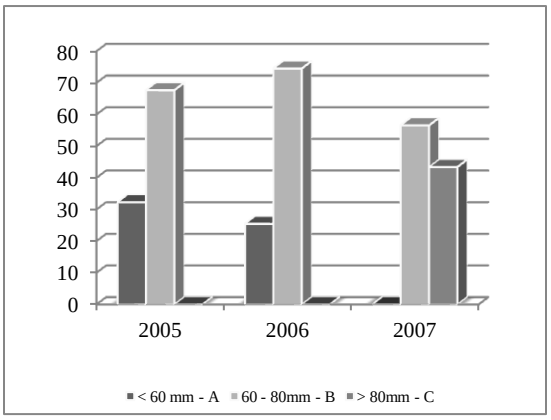
Table 2. The average fruit weight (g) cv. Gloster depending on the average size of fruits in different growing form and pruning systems

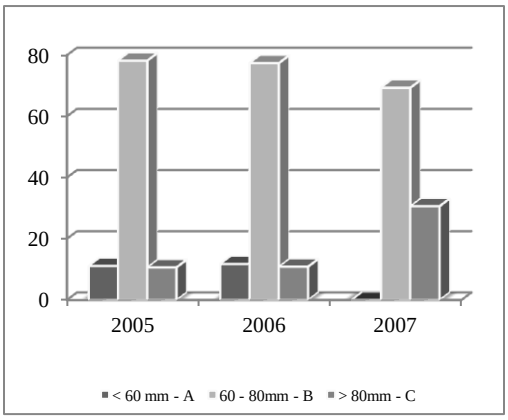
	Year	fruit diameter (mm)		
		< 60	60 – 80	80 – 100
spindle form – short pruning system	2005	91.25 ± 6.47	163.30 ± 4.11	240.19 ± 9.03
	2006	83.50 ± 4.63	148.62 ± 13.84	200.66 ± 6.17
	2007	79.86 ± 3.36	152.41 ± 7.79	198.30 ± 8.92
central axis form – long pruning system	2005	83.00 ± 3.18	144.80 ± 4.82	199.39 ± 4.97
	2006	77.25 ± 3.45	127.80 ± 6.29	–
	2007	83.18 ± 2.08	146.54 ± 6.28	208.89 ± 1.84

Blazek and Hluscikova (2007) report that the average fruit weight cv. Gloster in the first 10 years of fruiting ranged from 133.00 to 331.40 g, and the average weight for a period was 208.10 g. Cvetkovic (2001) states that the average fruit weight of cv. Gloster on M9 rootstock in the plantation age 3 years was 243 g. Oparnica et al. (2000), found the average weight of fruit from 216.14 to 246.36 g depending on the type of fruit branches.

Melrose. In both training form the share of the fruits with optimal size was the highest compared to the other two categories, especially in spindle. In growing form central axe there is indicated a

significant share of small fruits (category A) in 2005 and 2006 and large fruits (category C) in 2007 (Graph 3).





a. b.

Figure 3 (a, b). Distribution of fruit cv. Melrose depending on the diameter: a) central axis form – long pruning, b) slender form – short pruning

The average fruit weight of cv. Melrose ranged from 67.00 to 250.73 g, during the study period (Table 3).

Table 3. The average fruit weight (g) cv. Melrose depending on the average size of fruits in different growing form and pruning systems

	Year	fruit diameter (mm)		
		< 60	60 – 80	80 – 100
spindle form – short pruning system	2005	78.30 ± 5.71	150.10 ± 11.46	238.50 ± 28.50
	2006	67.00 ± 3.53	127.30 ± 10.46	222.80 ± 24.05
	2007	–	168.88 ± 6.27	250.73 ± 7.94
central axis form – long pruning system	2005	88.90 ± 3.44	145.78 ± 6.40	–
	2006	75.30 ± 3.44	122.69 ± 6.40	–
	2007	–	184.42 ± 5.81	220.93 ± 5.69

Blazek and Hluscikova (2007) report that the average weight of fruit varieties Melrose in the first 10 years of fruiting ranged from 144.80 to 343.70 g, and the average weight for a period of study was 227.10 g. Cvetkovic (2001) states that the average weight of fruit cv. Melrose from orchards 3 years of age was 215 g.

In all the cultivars there is a noticed higher yield in the central axis of training form in relation to the spindle. Percentage increase in yield ranged from 27.67 % in the cv. Idared, 32.22 % in the cv. Melorse to 74.03 % in the cultivar Gloster (Table 4). Absolute increase in Idared bringing the yield to 38.15 t/ha justified the reconstruction of training form and introduction of long pruning system. Blazek and Hluscikova (2007) reported that the average yield in the cultivar Idared in the first ten years with densities of 2500 trees/ha was at the level of 40.9t/ha which is consistent with the results

achieved in research. Studying the reconstructed Idared trees growing in spindle growing form (originally palmete) in Maribor, Štampar (2001), presents data on the average yield of 60 t/ha. Keserović et al (2005) reported data showing significant yield variation in cv Idared that varied from 3.65 to 60.42 t/ha. The average yield in the period was 25.52 t/ha.

Table 4. Average yields (t/ha) in different training forms and pruning systems

cultivar	year	spindle form – short pruning system	central axis form – long pruning system
Idared	2005	32.65 ± 2.91	26.52 ± 1.51
	2006	20.87 ± 1.92	49.47 ± 4.48
	2007	33.78 ± 2.39	35.46 ± 3.89
average		29.10	38.15
cumulative yield		87.30	111.45
difference in yield (%)		27.67	
Gloster	2005	11.01 ± 3.74	17.21 ± 4.34
	2006	15.01 ± 1.65	47.41 ± 6.23
	2007	30.94 ± 5.85	34.52 ± 4.85
average		18.98	33.05
cumulative yield		56.96	99.14
difference in yield (%)		74.03	
Melrose	2005	5.29 ± 0.99	12.15 ± 3.63
	2006	23.94 ± 4.27	25.23 ± 2.66
	2007	11.73 ± 1.85	16.79 ± 1.07
average		13.65	18.06
cumulative yield		40.96	54.17
difference in yield (%)		32.22	

Blazek and Hluscikova (2007) stateed that the average yield in the cultivar Gloster in the first ten years of cultivation and the planting density of 2500 plants per ha was 39.0 t/ha, which is slightly above average yields are get implemented in research.

Conclusions

Reconstruction of growing may be very successful in older fruit trees on vigorous rootstocks. During the three years it is possible to fully reconstruct the growing forms.

In all the cultivars increased yield was realized with central axe growing form with long pruning system in comparison with spindle growing form with short pruning system.

The difference in the cumulative yield ranges from 27.67 % in the cv. Idared to 74.03 % in the cv. Gloster. Absolute increase in yield has a special significance in cv. Idared.

In both growing forms for all cultivars fruit with optimal diameter constituted the largest percentage of total fruits. Slightly higher share of smaller and larger fruits were found in the spindle growing form. Average fruit weight in all cultivars was slightly lower than usual.

References

Blaser C., Monney P., Amsler P. (1996). Analyse comparative des performances economiques de differents systemes de verger. Revue suisse Vitic. Arboric. Hortic. Vol. 28, 2: 117-128.

Blažek J., Hlušičkova I. (2007). Orchard performance and fruit quality of 50 apple cultivars grown or tested in commercial orchards of the Czech Republic.Hort. Sci. (Prague), 34, 2007 (3): 96–106.

Cvetković M. (2001). Rodni potencijal jabuke gajene u sistemu vretena različitog stepena intenzivnosti. Magistarski rad. Agronomski fakultet, Čačak.

Keserović Z., Gvozdenović D., Lazić S., Hnatko Z. (2005). Biološka kontrola rodnosti sorte jabuke. Voćarstvo, Vol. 39. br. 151, 241–249.

Lespinasse, J.M., Lauri, P.E. (1999). Intégration des nouveaux concepts de conduite dans le système Solaxe. Revue suisse Vitic. Arboric. Hortic. Vol. 31, 93: 167-171.

Lukić M., Marić S., Radičević S., Mitrović M., Glišić I. (2005). Istraživanja u cilju uvođenja u proizvodnju novih sorti jabuke. Zbornik naučnih radova, Vol. 11 br. 5, 46-51.

Hansen Melissa. (2009). Solaxe so fruitful – The French tree training system is designed to minimize pruning and maximize production. Good Fruit Grower Magazine – Apples, Postharvest, st. 1 – 3.

Mićić N., Đurić G. (1994). Biološke onove rezidbe voćaka u rodu. Savremena poljoprivreda. Vol. 42, br. 1-2:121-128.

Mićić N., Đurić Gordana, Radoš Lj. (1998). Sistemi gajenja jabuke i kruške. Institut "Srbija", Poljoprivredni Institut, Poljoprivredni fakultet Banjaluka i Grafika "Jureš", Čačak.

Mićić N., Đurić Gordana, Radoš Lj. (2000). Sistemi gajenja jabuke i kruške. Institut "Srbija", Poljoprivredni Institut, Poljoprivredni fakultet Banjaluka i Grafika "Jureš", Čačak.

Mićić N., Đurić Gordana, Cvetković M. (2005). Sistemi gajenja i rezidba jabuke. Grafika "Jureš", Čačak.

Monney P., Blaser C., Widmer A., Krebs C. (1993). Les systemes de verger (2e partie). Revue suisse Vitic. Arboric. Hortic. Vol. 25, 3: 168-184.

Oparnica Č., Radivojević D., Veličković M. (2000). Vegetativni i generativni potencijal sorti jabuke kalemljenih na slabo bujnoj podlozi M9. Zbomik naučnih radova, 6, 251-254.

Štampar F. (2007). Voćarstvo Slovenije. Inovacije u voćarstvu i vinogradarstvu. Zbornik radova, br.2, 42-49.

Yuri J.A. (2007). Solaxe. Pomaceas – technical bulletin.Vol 7, 4: 1-4.

КАРАКТЕРИСТИКА НА ЗРЕЛИТЕ ПЛОДОВИ ОД ЈАБОЛКА ВО ЗАВИСНОСТ ОД СИСТЕМОТ НА ОДГЛЕДУВАЊЕ И РЕЗИДБАТА

Миљан Цветковиќ, Горица Пауновиќ

Апстракт

Целта на овој труд беше да се испита влијанието на системот на одгледување и резидба врз карактеристиките на зрелите плодови од јаболка. Истражувањето беше спроведено во Источна Херцеговина (Љубиње) во периодот од 2005 - 2007. Во истражувањето беа вклучени сортите Ајдаред, Глостер и Мелрозе стари 20 години и калемени на ММ106 вегетативната подлога. На одреден број на дрва беше изведена реконструкција од витко вретено во солакса (solaxe) со долг систем на резидба, се со цел да се зголеми нивото на продуктивност. Карактеристиките на сортите беа компаративно испитани преку: дистрибуција на плодовите во зависност од дијаметарот на плодовите и просечната тежина према просечната големина на плодовите во различни системи на одгледување и резидба. Највисоко учество на плодови со оптимална големина во текот на истражувањето кај сите сорти беше забележана кај системот на одгледување солакса. Солакса системот на одгледување со долг систем на резидба покажа повисок кумулативен принос кој се движеше од 27.67% кај сортата Ајдаред, 32.22% кај сортата Мелрозе и 74.03% кај сортата Глостер. Истражувањето покажа дека испитуваните сорти имаат поголем принос и квалитет на плодовите при системот солакса со долга резидба , во споредба со витко вретено и кратка резидба. Кај овошките кај кои беше воведен системот на одгледување солакса со долга резидба преку реконструкција на системот на одгледување витко вретено, покажаа разлики во приносот. Разликите во приносот покажаа позитивен ефект од воведувањето на овој систем на одгледување кај испитуваните сорти, со поволни економски резултати за сортите Ајдаред и Глостер.

Клучни зборови: сорта, витко вретено, солакса, систем на резидба.

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THE CHOICE OF A NUTRIENT MEDIUM FOR IN VITRO VEGETATIVE PROPAGATION OF A STEP SOUR CHERRY (PRUNUS FRUTICOSA, PALL)

Bijelić Sandra[1*], Gološin Branislava[1], Cerović Slobodan[1], Bogdanović Borivoje[1]

[1]Faculty of Agriculture, Novi Sad.
[*]e-mail: sbijelic@polj.uns.ac.rs

Abstract
The process of *in vitro* vegetative propagation depends on various factors – fruit species, the age of explants, size and type of isolated explants, the season of explant collection. A nutrient medium is one of significant factors for successful process of micropropagation. Therefore, three nutrient media were examined for the multiplication phase of a step sour cherry shoot (*Prunus fruticosa*, Pall). They varied in mineral contents (MS – Murashige and Skoog, 1962: DKW – Driver and Kuniyuki, 1984 and WP – Lloyd and McCown, 1980). The following was added to nutrient media: saccharose (3%), agar (0.8%) and in mg l^{-1} – B_1 (0.5): B_6 (0.5): inositol (100): Ca-pantothenate(10): IBA (0.1): BAP (1.5) and GA_3 (0.1). Six nutrient media were tested for shoot rooting. In MS and DKW mineral solutions, salt concentration was reduced by half, while WP mineral solution was used according to the recipe. Beside that, root media contained saccharose (1%) and in mg l^{-1} –B_6 (4.0): inositol (200): biotin (0.2) and IBA (1.5 or 2.0). The best multiplication of step sour cherry shoots of genotype SV11 was accomplished on MS3-nutrient medium, about 5 shoots per culture, while the best multiplication of genotype SV 2 was accomplished on the medium DKW3. The nutrient medium for rooting with WP-mineral solution was the best for both examined genotypes. All shoots (100%) rooted on these media. The results of the research indicate the importance of the choice of a nutrient medium and show that it is possible to produce vegetative dwarfing rootstocks for a cherry and sour cherry by *in vitro* vegetative propagation of a step sour cherry.
Key words: step sour cherry (*Prunus fruticosa*, Pall), nutrient medium, *in vitro* vegetative propagation.

Introduction

A step sour cherry (*Prunus fruticosa*, Pall.) can be found in our region as shrubbery and hedges in abandoned vineyards and on rocky ground. So far it has been used for creating new rootstocks as one of the parents. Due to its extremely low vigor, it could replace vigorous rootstocks used up to now, which would facilitate all agrotechnical measures and reduce cherry and sour cherry production costs.

The selection program of the Department of fruit growing, viticulture, horticulture and landscape architecture undertakes the study and selection of dwarfing rootstocks for cherries and sour cherries. It has been selected several varieties of a step sour cherry (*Prunus fruticosa*, Pall.) which should be multiplied, and therefore, it has been studied the process of micropropagation of two genotypes.

Material and methods

Plant material: Shoot tips of two step sour cherry genotypes (SV2, SV11) were isolated from a natural population within the habitat on Fruska gora and put into *in vitro* culture.

Methods: Shoot tips of 5-7 mm in length were isolated in May from a natural population. After sterilization in accordance with the procedure presented in the paper by Gološin and Radojević (1985), the shoot tips of a step sour cherry were cultured on different nutrient media, depending on the phase of *in vitro* culture.

The basic nutrient medium contained a mineral solution (MS-Murashige and Skoog, 1962; DKW-Driver and Kuniyuki, 1984 or WP-Lloyd and McCown, 1980), saccharose (3%), agar (0.8%), and in mg l^{-1}: B_1 (0.5), B_6 (0.5), inositol (100) and Ca-pantothenate (10). Depending on the phase of growth and development, growth regulators were added to the basic nutrient medium in different concentrations. In the phase of shoot multiplication, the following was added to the basic nutrient medium: (in mg l^{-1}): BAP (1.5), IBA (0.1) and GA_3 (0.1). The media were marked according to the used mineral solutions as MS3, DKW3 and WP3. Six nutrient media were tested for shoot rooting. In the basic nutrient medium, the concentration of mineral salts was reduced by half (in MS and DKW) and saccharose to 1%, while the content of the following compounds was increased: (in mg l^{-1}) inositol (200), vitamin B_6 (4.0) and biotin (0.2) which was added to the medium for the first time. Two concentrations of indole butyric acid (IBA) in the medium were examined (1.5 mg l^{-1} IBA - MSO3, DKWO3 and WPO3; and 2.0 mg l^{-1} IBA - MSO4, DKWO4 and WPO4). Cultures were grown under controlled conditions at a temperature of 26±2 °C, with a photoperiod of 16h light/day. Rooted shoots were transplanted to plastic containers and acclimated in the laboratory, after which they were planted to a nursery.

Results and discussion

Formed leaf rosettes of the examined genotypes of a step sour cherry were subcultivated on different nutrient media for multiplication. Multiplication was conducted by formation of axillary buds (table 1). Shoot multiplication of a step sour cherry was more or less successful depending on the genotype and nutrient medium. On the examined media, a good multiplication was achieved for both genotypes (SV2 and SV11). The medium MS3 was the best for the multiplication of SV11 (4.87 shoots per culture), while DKW3 was the best for the genotype SV2 (3.75 shoots per culture). Dai Han Ping et al. (2001) argue that the best multiplication of a step sour cherry was accomplished on MS mineral solution, while Saponari et al. (1999) achieved the best multiplication of *P. mahaleb* on a medium with DKW mineral solution containing 1.0 mg l^{-1} of BA.

Table 1. Shoot multiplication of different genotypes of a step sour cherry (SV2, SV11)

Genotype of a step sour cherry	Nutrient medium	Total number of cultures	Newly formed buds	
			total number	average number
SV2	MS3	189	613	3.24
	DKW3	175	656	3.75
	WP3	139	331	2.38
SV11	MS3	373	1815	4.87
	DKW3	205	858	4.19
	WP3	145	318	2.19

Shoots which grew by 1 cm or more in the phase of multiplication were subcultivated on a medium for rooting. Depending on the mineral solution, the concentration of IBA in the medium and the genotype, it was achieved different rooting of tested genotypes of a step sour cherry in *in vitro* culture (table 2).

Table 2. Shoot rooting of different genotypes of a step sour cherry (SV2 i SV11)

Genotype of a step sour cherry	Nutrient medium	Number of shoots in a culture	Average number of roots per shoot	Average length of root (mm)	Rooted shoots	
					number	%
SV2	MSO3	18	3.50	50.86	4	22.22
	MSO4	19	0.00	0.00	0	0.00
	DKWO3	16	2.60	41.00	10	62.50
	DKWO4	14	2.33	29.14	6	42.86
	WPO3	16	3.56	36.45	16	100.00
	WPO4	16	4.50	50.29	16	100.00
SV11	MSO3	48	5.23	48.47	39	81.25
	MSO4	39	4.70	16.99	23	58.97
	DKWO3	30	5.17	56.16	24	80.00
	DKWO4	24	5.83	62.20	24	100.00
	WPO3	24	3.83	63.80	24	100.00
	WPO4	32	4.00	56.75	32	100.00

Rooting of the total number of shoots of the genotype SV11 was conducted on the three examined media: DKWO4, WPO3 and WPO4, while two media were used for the genotype SV2: WPO3 (fig. 2) and WPO4. The media with diluted (½) DKW mineral solution containing IBA proved to be satisfactory for *in vitro* rooting of *Prunus mahaleba* (Saponari et al., 1999). Besides achieving very good shoot rooting of the genotype SV11, on the basis of examining the formed root system, it could be said that the increasing concentration of IBA led to the appearance of callus, although a sour cherry does not have that tendency (Riffaud and Cornu, 1981), but this has not significantly influenced the acclimatization of the rooted shoots of a step sour cherry.

Rooted plants were planted in plastic containers with a mixture of peat:perlite (3:1) and acclimated under laboratory conditions. After 5-6 weeks, plants were acclimated forming new leaves. Different acclimatization was achieved (table 3), depending on the genotypes of a step sour cherry. 63 plants (53.39%) were acclimated out of 118 SV11 plants produced *in vitro*, while the shoots of the genotype SV2 were acclimated worse (13.63%) (Bijelić et al., 2003; Bijelić, 2004).

Table 3. Acclimatization of *in vitro* produced shoots of different genotypes of a step sour cherry (SV2 i SV11)

Medium for cherry and sour cherry	Number of plants for rooting	Number of rooted plants	Number of successfully acclimated plants	%
SV2	52	22	3	13.6
SV11	166	118	63	53.3

Acclimated plants of a step sour cherry were planted to a nursery within the experimental field of the Faculty of Agriculture in Rimski Sancevi, where their further growth and development is monitored under field conditions.

Conclusions

Based on the studying of *in vitro* propagation of a step sour cherry and different physiological response in *invitro* culture, it could be concluded that there are very clear genetic differences between the examined genotypes.

Efficient multiplication of a step sour cherry in *in vitro* culture is possible. It depended on the genotype and the content of a nutrient medium. Different mineral solutions and concentrations of growth regulators had a great influence on the rate of multiplication and shoot rooting. The best *in vitro* multiplication of shoots as well as adaptation of *in vitro* plants to environmental conditions showed the genotype SV11.

References

Bijelić, S., Gološin, B., Cerović, S., Ognjanov, V. (2003). Uticaj mineralnih rastvora na *in vitro* razmnožavanje *Prunus fruticosa*. Letopis naučnih radova Poljoprivrednog fakulteta, Novi Sad, 1:198-203.

Bijelić, S. (2004). Mikropropagacija slabo bujnih podloga za trešnju i višnju. Magistarski rad. Poljoprivredni fakultet, Novi Sad.

Bijelić Sandra, Gološin Branislava, Cerović, S., Ognjanov, V. (2005). Uticaj mineralnih rastvora na *in vitro* ožiljavanje stepske višnje. X Savetovanje o biotehnologiji, Zbornik radova, vol. 10, br. 10, str. 226 - 232, Čačak.

Dai HanPing, Li Baojiang, Lin Lihua, Liu FengJun. Techniques of tip tissue culture for Prairie sour cherry. China Fruits, No. 6, pp. 19 – 21, 2001.

Driver, J. A., Kuniyuki, A. H. (1984). *In vitro* propagation of Paradox walnut rootstock. HortScience, 19: 507 - 509.

Gološin Branislava, Radojević Ljiljana (1985). Uticaj floroglucinola na razmnožavanje *in vitro* podloge jabuke M27. Jugoslovensko voćarstvo, 19, br. 73 – 74, str. 371 – 378.

Lloyd, G., McCown, B. (1980). Comercially-feasible micropropagation of mountain laurel, *Kalmia latifolia*, by use of shoot tip culture. In: Proc. Int. Plant. Prop. Soc., 30: 421 - 427.

Murashige, T., Skoog, F. (1962). A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol. Plant., 15: 437 - 497.

Riffaud, J., Cornu, D. (1981). Utilization de la culture *in vitro* pour multiplization de merisiers adultes (*P. avium* L.) selectionnes en foret. Agronomie, 1: 633 - 640.

Saponari, M., Bottalico, G., Savino, V. (1999). *In vitro* propagation of *Prunus mahaleb* and its sanitation from prune dwarf virus. Advances in Horticultural Science, 13, 2, 56- 60.

ИЗБОР НА ХРАНЛИВА ПОДЛОГА ЗА IN VITRO ВЕГЕТАТИВНО РАЗМНОЖУВАЊЕ НА ВИШНА (*PRUNUS FRUTICOSA*, PALL)

Бијелић Сандра, Голошин Бранислава, Церовић Слободан, Богдановић Боривое

Апстракт

Процесот на in vitro вегетативно размножување зависи од ралични фактори: овошниот вид, староста на експлантот, големината и типот на изолираните експланти, сезоната на прибирање на експлантите. Хранливата подлога е еден од најзначајните за успешна микропропагација. Затоа, три хранливи подлоги беа испитани во фазата на размножување на изданок од степска вишна (*Prunus fruticosa*, Pall). Тие варираа во содржината на минерални материи (MS – Murashige and Skoog, 1962: DKW – Driver and Kuniyuki, 1984 and WP – Lloyd and McCown, 1980). Во хранливата подлога беше додадено следново: сахароза (3%), агар (0.8 %) и во милиграми l^{-1} – B_1 (0.5): B_6 (0.5): inositol (100): Ca-pantothenate(10): IBA (0.1): BAP (1.5) и GA_3 (0.1). Шест хранливи подлоги беа тестирани за проценка на вкоренувањето на изданоците. Во MS и MKW минералните раствори, концентрацијата на соли беше редуцирана за половина, додека WP минералниот раствор беше употребен според рецептот. Покрај тоа подлогата за ожилување содржеше сахароза (1%) и во mg l^{-1} –B_6 (4.0): inositol (200): biotin (0.2) и IBA (1.5 or 2.0). Најдобро размножување на изданоците од киселата цреша, генотип SV11 беше постигнато на хранливата подлога MS3 околу 5 изданоци по култура, додека најдобро размножување на генотипот SV 2 беше постигнато на хранливата подлога DKW3. Додека хранливата подлога за ожилување со WP минерален раствор беше најдобра за двата испитувани генотипови. Сите изданоци (100%) се ожилија во оваа хранлива подлога. Резултатите добиени од ова истражување, укажуваат на значењето на изборот на хранлива подлога и на можноста за производство на слабобујни вегетативни подлоги за цреша и кисела цреша со *in vitro* вегетативно размножување на киселата цреша.

Клучни зборови: степска вишна (*Prunus fruticosa*, Pall), хранлива подлога, *in vitro* вегетативно размножување.

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EFFECT OF BUMBLEBEES (BOMBUS TERRESTRIS L.) POLLINATION ON FRUIT SET OF SOME APPLE CULTIVARS

H. Kiprijanovska[1*], S. Bandzo[2], V. Gjamovski[2], M. Kiprijanovski[1], A. Uzunov[1]

[1]Faculty of Agricultural Sciences and Food–Skopje, Republic of Macedonia
[2]Institute of Agriculture–Skopje, Republic of Macedonia
[*]e-mail: hrisulak@yahoo.com

Abstract
In this paper the results of the two years investigation of influence of bumblebees pollination to fruit set of some apple cultivars in Prespa region are carried out. In the apple orchard two TRIPOL-hives (TRIPOL-hive = three colonies of *Bombus terrestris* in corrugated plastic box with temperature insulation) per 1 ha were placed during blooming period. The investigation included the following: the percentage of initial fruits set and final fruit set after June dropping on the experimental fruit trees. The results showed that on the fruit trees which were on the smallest distance from bumblebee hives the percentage of initial fruit were the highest. Also, the final fruit set was the highest on the fruit tress which were on the smallest distance from bumblebees hives.
Key words: apples, bumblebees, pollination, fruit set.

Introduction

The pollination is crucial part of successful fruit production. The fruit-set of most apple cultivars depends on cross pollination, and thus on the synchronization of their bloom with that of a compatible cultivar and on pollinating insects (McGregor, 1976; Free, 1993; Delaplane and Mayer, 2000). Although honey bee (*Apis mellifera* L.) colonies are often used for pollination in apple orchards, several other species have been studied as alternative pollinators throughout the world.

Since the beginning of the nineties of 20th century the use of bumblebees as pollinators is well established. Several commercial companies throughout the world are rearing colonies of bumblebees. The commercial most used species is *Bombus terestris* L. On the beginning in practice bumblebees were mainly used for pollination in glasshouses and plastic tunnels, especially to pollinate tomatoes. Lately, the global trade in commercial bumblebee (*Bombus* spp.) colonies provides pollination services for both glasshouse and open-field crops (Velthuis H.H. and Van Doorn A., 2006). In our country up to now the bumblebees are use for pollination of tomatoes and strawberries in glasshouses and plastic tunnels. In the orchards mainly honey bees are used as pollinators. However, when climate conditions are unfavorable for honey bee flight activity (cold, cloudy, rainy, windy weather) during the blooming period of fruit plants, the pollination is insufficiently successful. Having in mind this condition, the fruit yields are reduced. Therefore in practice alternatives to honey bee as pollinators, especially for apples pollination, are seek. The aim of this research was to investigate the possibilities for usage of bumblebees' colonies for pollination of apple trees. Bumblebees are flying under excessive and severe weather conditions, when honeybees (*Apis mellifera*) stop their flight activities. They are also flying at lower temperatures

(8^0C), on cloudy days and under stronger wind. In comparison with honey bee, bumblebee mainly visit flowers to forage pollen, and transfer more pollen to the stamen with each flower visit, which increase the chance for successful fruit set (Goulson D. 2009).

Material and methods

The effect of bumblebee pollination was investigated on two apple cultivars, Mutsu and Granny Smith grafted on M9 rootstock. Two apple cultivars, Red chief and Idared grafted on MM 106 were used as pollinators. The orchard was established in spring 2004 with a planting distance of 3.5 x1.5 m (1905 trees/ha). In the orchard two TRIPOL-hives (Tripol hive = three colonies of *B. terrestris* L. in corrugated plastic box with temperature insulation) per 1 ha were placed at the beginning of the blooming period. The investigation was performed in 2009 and 2010 year. Regarding the hives' distance from the trees there were 3 variants: 1 variant -Trees on distance of 0-30 meter to bumblebee hives; 2 variant -Trees on distance of 30-50 meter to bumblebee hives; 3 variant -Trees on distance more than 50 meter to bumblebee hives. Ten trees of each cultivar per variant were selected randomly. The number of total flowers at experimental trees was counted during the beginning of blooming. The initial percent of fruit set was calculated 2 weeks after end of blooming. The final fruit set was calculated after the June dropping of the fruits. We have analyzed effects of the factors such as year, variety and variant (DO) on the percentage of initial and final fruit set by using common Generalized linear model (GLM).

Results and discussion

The results for the analyzed effects of the factors such as year, variety and variant (DO) on the percentage of initial and final fruit set are presented in table 1 and table 2.

The data show that all three factors had significant effect on initial fruit set and only variety and DO had effect on the final fruit set. The effect of the year on pollination, according to many authors, come from different weather conditions during the flowering and post-flowering time. Weather have a direct effect on pollinators' activity, but can also influence fruit set in other ways. Low temperatures during early spring can result in reduced pollen production and pollen viability (Faust, 1989), as well as ovule sterility (Williams, 1969). Insufficient sunlight hours in the 10-day-period immediately after flowering significantly reduces fruit set, even after an optimal pollination period (Williams, 1991).

Table 1. Analysis of the effect of year, variety and variant (DO) on the percentage of initial fruit set

Source	df	Mean Square	F
Model	5	13613,597	384,767**
Year	1	433,200	12,244**
Variety	1	10193,633	288,107**
DO	2	2762,175	78,069**
Error	115	35,381	
Total	120		

R Squared = 0,944

Table 2. Analysis of the effect of year, variety and variant (DO) on the percentage of final fruit set

Source	df	Mean Square	F
Model	5	6647,942	582,348**
Year	1	33,075	2,897**
Variety	1	5161,408	452,130**
DO	2	687,108	60,189**
Error	115	11,416	
Total	120		

R Squared = 0,962

The differences of percentage of fruit set between cultivars are coming from the different number of flowers per tree. According to many authors, cited by Misic (1994), the number of flowers is in negative correlation with the percentage of fruit set. Some cultivars have 3 to 4 times more flowers than others and because of that cultivars can provide satisfactory yields despite the lower percentage of fruit set.

The bumblebees' hives distance from the fruit trees had significant effect of initial and final fruit set. The differences of percentage of fruit set between variants came from different distance of the bumblebees' hives from the experimental trees. In table 3 and table 4 are presented LS means values of the percentage of initial and final fruit set of experimental trees from our study. The highest fruit set (initial and final) was determined in the first variant (the trees that were closest to the bumblebees' hives) and the lowest in the third variant (the trees that were farthest to the bumblebees' hives). Previously, many authors cited that the influence of the distance of the bumblebees' hives from the experimental trees have significant effect on the fruit trees pollination. According to them bumblebees have short foraging distance, comparing to the honey bees, and they are not flying far for foraging (Goulson D. 2009, Kevan *et al*.1993, Moritz and Wolf, 2007). Wolf and Moritz (2008) reported that mean foraging distance of *B. terrestris* was 267,2 ± 180,3 m. However, according to the same authors 40% of the workers foraged within 100 m of the nest.

Table 3. Adjusted means values and standard errors of the percentage of initial fruit set of experimental trees

DO	LS Mean ± Std. Error
1,00	28,475±0,940
2,00	21,950±0,940
3,00	11,975±0,940

Table 4. Adjusted means values and standard errors of the percentage of final set of experimental trees

DO	LS Mean ± Std. Error
1,00	18,450±0,534
2,00	15,925±0,534
3,00	10,350±0,534

The data show that the differences between all variants are significant. It means that the effect of bumblebee's pollination is reduced with their distance to the fruit trees.

Conclusions

1. The organized pollination with bumblebees indicated significant influence on the percentage of fruit set on both investigated cultivars and years.
2. The highest percentage of fruit set was determined in the first variant (the trees that are closest to the bumblebees' hives). The effect of bumblebees' pollination is reduced with their distance to the fruit trees. Significant reduction of fruit set on the trees of triploid cultivar Mutsu, which were more than 50 meters away from bumblebees' hives, was estimated.
3. In areas with unstable weather conditions, during the apple blooming period, the pollination with bumblebees can be an alternative to traditional pollination by honey bees or other insects. For organized bumblebee pollination we are recommending introduction of 2 to 3 Tripol -bumblebees' hives per 1 ha, but their position to the fruit trees should not be further than 50 meters.

References

Delaplane K.S and Mayer D.F. (2000). Crop pollination by Bees. CABI Publishing, Cambridge.
Free J.B. (1993). Insect Pollination of Crops, Academic Press, London.
Goulson D. (2009). Bumblebees: Behaviour, Ecology and Conservation. OUP Oxford.
Mc Gregor S.E. (1976). Insect Pollination of Cultivated Crop Plants. Agricultural Handbook No 495, USDA-ARS, U.S. Gov. Print Office, Washington.
Mišić, P. (1994). Jabuka. Nolit, Subotica.
Moritz R. and Wolf S. (2007). Foragin distance in Bombus terrestris L. Apidologie, Volume 39/4.
Velthius H.H.W and Van Doorn A. (2006). A century of advances in bumblebee domestication and the economic and envirnmental aspects of its commercialization for pollination. Apidologie,37, pp.421-451.
Wolf S and Moritz R.F.A (2008). Foraging distance in *Bombus terrestris* L. (Hymenoptera: Apidae), Apidologie, 39, pp. 419-427.

ЕФЕКТ ОД ОПРАШУВАЊЕТО СО БУМБАРИ (*BOMBUS TERESTRIS* L.) ВРЗ ЗАВРЗУВАЊЕТО НА ПЛОДОВИ КАЈ НЕКОИ СОРТИ ЈАБОЛКА

Х. Кипријановска, С. Банџо, В. Ѓамовски, М. Кипријановски, А. Узунов

Апстракт

Во трудот се дадени резиултатите од двегодишните испитувања на влијанието на опрашувањето со бумбари кај некои сорти јаболка во регионот на Преспа. Во насад од јаболка за време на цветањето беа населени 2 TRIPOL-кошници (TRIPOL-кошница е импрегнирана пластична кутија во која се населени три семејства од *Bombus terrestris*) на 1 хектар. Истражувањата вклучуваат: процент на почетно заврзување на плодови и финално заврзување на плодови по јунското опаѓање на плодовите кај експерименталните стебла. Резултатите покажуваат дека кај стеблата кои се на најмало растојание од кошниците со бумбари утврден е највисок процент на почетно заврзување на плодови. Исто така, кај овие стебла е утврден и највисок процент на финално заврзување на плодови.

Клучни зборови: јаболка, бумбари, опрашување, заврзување на плодови.

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DEEP PLANTING OF THE TREES - ALTERNATIVE WAY FOR CULTIVATION OF APPLE ON DWARFING ROOTSTOCKS IN CHANGED CLIMATE CONDITIONS

Kiprijanovski Marjan[1*], Gjamovski Viktor[2], Arsov Tosho[1]

[1]Faculty of Agricultural Sciences and Food, Skopje, Republic of Macedonia
[2]Institute of Agriculture, Skopje, Republic of Macedonia
[*]e-mail: mkiprijanovski@yahoo.com

Abstract
Intensive apple orchards are planted mostly on dwarfing rootstocks. These rootstocks have some disadvantages such as shallow and poor developed root system, sensitivity to drought, weakness anchorage, need of supporting system, e.t.c. Usually in practice, the trees are planted on depth to root necks. In some cases with a porpoise to reduce vigour, the trees are planted shallower, but there are cases when aimed improving of anchorage, the trees are planted deeper. In Macedonia, climate change expressed through reduced precipitation, are increasingly feel that deteriorating conditions for growing many traditional fruit crops. This situation highlights the need to introduce new practices in production technology in apple orchards. In this paper results of research of the influence on deeper planting of apple trees grafted on dwarfing rootstocks are presented. The orchard is being growing with standard technology. For investigation were used trees on the rootstocks M9 T337, M9 T984 and Mark 9) grafted with cv. 'Granny Smith'. At the establishment of the trail orchard were used: nursery trees with standard height of grafting and depth of planting and nursery trees grafted on height of 30 cm and planted on depth of 50 cm. The trial orchard was established in 2004 in Prespa region, and research is carried out from period of planting to 2012. During this period vegetative characteristics of the trees, yield and quality of the trees are followed. Also distribution of root system was investigated. It was found that deeper planted trees at all rootstocks are more vigorous and developed and can be managed without supporting system. Also these trees are more productive with better fruit quality.
Key words: apple, rootstocks, depth of planting, climate changes.

Introduction

Modern orchards of apples are grown on dwarfing rootstocks that provide low vigorous trees. The cheapest way to control vigour of the apple trees is by using adequate rootstock (Webster, 1993). Currently, the greatest interest in tree size control is the use of rootstock that produced trees near of M9 (Crassweller et.al., 2001). The clonal dwarfing apple rootstocks are popular in commercial orchards because they offer both small size and earlier production. Beside a lot of positive characteristics, dwarfing apple rootstocks have some disadvantages such as: shallow root system, poor anchorage in the soil, need of supporting system, sensitive to drought e.t.c. (Kiprijanovski et. al., 1997). In fruit growing practice, usually rootstocks in the nursery are grafted at the height of 10 to 15 cm above soil level and trees are planted at the level of the root neck (Kolecevski et. al., 2004). The dimensions of the apple trees are smaller when the dwarfing rootstocks are grafted

higher (Baart et. al., 1991). The apple trees which are grafted higher and are deeper planted have more vigorous growth. The higher grafted and deeper planted apple trees in arid regions, on alluvium soil and deficiency of water for irrigation, have higher growth, higher yield and better fruit quality (Kiprijanovski, Kolecevski, 1997). Aimed better anchorage of the trees and managing without support system Rom et. al. (1987) recommend deeper planting of apple trees on dwarfing rootstocks. Deep planting increased the vigor and yield of trees on M. 26 (Parry, 1974). Trilot et. al. (1989) reported that higher grafted and deeper planted apple trees grown less. This was resulted by poorly uptake of nutrients from the plough layer of the soil. Detail evaluation of each combination variety/rootstock/soil type/ecological conditions are necessary to determinate the optimal depth of planting of the fruit trees (Lyons et. al., 1983). Czynczyk et. al., (1989) conclude that deeper planted apple trees are more resistant to winter frosts. The cost of establishment of high-density orchards is still a major constraint on their profitability. Deep planting on rootstocks is being used as a technique to improve anchorage and remove or reduce the need for staking (Jackson and Harrison-Murray, 1986). Dwarf apple trees often need stakes as support to keep the trees upright. The cost of stakes is very significant in the total establishment costs of an orchard. Therefore growers are interested in growing the trees without stakes (Callesen, 1986).

Modern orchards are established on dwarf and semi-dwarf rootstocks. Rootstock M.9 has become most dominant for apples because of its suitability for high-density plantings (Wertheim, 1997). It is clear that intensive apple orchard should be established on the dwarfing rootstocks. But, in the regions with arid climate, with insufficient of rains especially in the summer months, and with deficit of water for irrigation, disadvantages of the dwarfing rootstock are more expressed. On the other hand, dwarfing rootstocks have poor anchorage and orchard should have supporting system. These disadvantages were the main reason to conduct researches of apple fruit growing on dwarfing rootstock with a higher grafting and deep planting of the trees. The aim of this research was to study the influence of depth planting of the trees under the agro-ecological conditions in Prespa region, the biggest apple production region in R. of Macedonia. Study was carried out trough the analyses of the vegetative growth, productivity, root development and possibility of removing or reducing the need of supporting system. On other hand, the climate change, expressed through reduced rainfalls and long lasting droughts, impose the needs for finding new measures aimed at adaptation to these conditions.

Material and methods

The research was performed in orchard placed in Prespa region. This region is located in the south-western part of R. Macedonia, on the banks of Lake Prespa, at altitude of 860 meters.

For establishment of the trial orchard trees, grafted on height of 10 and 30 cm above ground were used. The trees grafted on 10 cm were planted with grafted union 5 cm above ground (variant 1), and the higher grafted trees were planted 30 cm deeper (variant 2). The trees on rootstock M9T337, M9T984 and Mark 9 grafted with cultivar Granny Smith were investigated. The trial orchard have been established in spring of 2004 at spacing 3.5x1.5 m (1905 trees/ha). The trees were trained according to the slender spindle system and drip irrigated. The soil surface was maintained by grassing and mulching. The experiment has been arranged in randomized block design with four replications, 5 trees per repetition.

The dynamics of diameter growth of the trunk was carried out since planting of the orchard until 2011 (end of 8th leafs). Each year the trunk diameter was measured on 20 cm above ground, Dimensions of the crown (spread into and along the tree row) were measured at end of vegetation. Trunk cross section area (TCSA), tree canopy volume (TCV) and crown area (CA) were calculated from those measurements. Yield per tree was determinate on harvest time in period 2008-2012. Cumulative yield per tree and unit area was computed. Yield efficiency was calculated as kg/cm^2 TCSA, kg/m^3 TCV and kg/m^2 CA. The investigation of root system was carried out on the end of 2010 by digging up using free monolith method (Kolesnikov 1974).
Statistical analysis was performed using SPSS software. Independent samples t-test were used to analyse all the experimental data. Results were expressed at the $P<0.05$ level of significance.

Results and discussion

Agro ecological conditions in the area

The ecological conditions in certain region have an essential role in cost-effective and competitive apple production. Despite the fact that apples have a great ability to adapt nevertheless development of trees, bearing and fruit quality are in direct dependence of appropriate environmental conditions. In accordance with the existing conditions and achievements of science in practice are choice cultivars, rootstocks, and cultivation technology (Kiprijanovski 2011). Most apple cultivars give good results in a moderate continental climate with average annual temperature from 8 to 12^0C, vegetation temperature from 15 to 21^0C and with equally distributed rainfalls during the vegetation should be more than 600 mm (Misic 1994).
Some climatically and soil conditions registered in the area during research period and in the period 1950-1990 are shown in table 1 and 2.
Comparing the data for climatic conditions of the region can be found a significantly increase of temperature and reducing in annual rainfalls and relative humidity of the air in investigational period (2004-2011) relative to the previous period (1950-1990). The increased air temperature and diminished relative air humidity, especially in vegetation and summer, causing an increased water loss through evaporation and transpiration from plants. In order to maintain the required soil moisture in orchards in terms of increased losses there is a greater need for precipitation. Because the annual rainfalls are reduced water shortage in the soil must be replenish by irrigation. This lack of rainfalls and water deficit in shallow soil layers negatively reflects on development of the root system of trees especially when irrigation opportunities are limited. Hence, it could to emphasize that in the last period deteriorating conditions for growing apple orchards and imposes a need for finding new alternative ways of planting and cultivation of fruit trees.

Table 1. Agro climatic conditions in area along the period 2004-2011 and 1960-1990

Period	Parameter					
	Air temperature,^{0}C		Rainfalls, mm		Air humidity,%	
	2004-2011	1950-1990	2004-2011	1950-1990	2004-2011	1950-1990
Yearly	11.3	9.6	656.2	717.0	66	74
Vegetation	16.4	14.5	349.1	329.3	64	70
Summer	20.4	18.1	106.2	89.0	60	67

Accordingly the WRB classification the soil is Dystric Flufisol. According to Scheffer's and Schachtschabel's classifications the soil is a texture class clay loamy soil, which characterized with a very suitable texture which suits of the needs to the root system of apples.

Table 2. Texture and fertility of the soil in the trial orchard

Depth cm	$CaCO_3$ %	Humus %	Sand %	Silt %	Clay %	pH (KCl)	N %	P_2O_5 mg/100 g	K_2O mg/100 g
0-20	1.43	2.74	47.8	34.5	17.7	6.8	0.14	47.5	59.1
21-40	0	2.12	44.4	35.6	20.0	6.5	0.12	36.6	49.4
41-60	0	1.56	44.3	35.8	19.9	5.6	0.09	302	41.7

Tree growth

The diameter of the trunk is an integral indicator of the whole vegetative potential of the trees. The higher absorption of the root system helps increase the production of organic matter in the crown, and all these products together contribute to the forming of more elements of xylem and phloem, which at the end is being registered through the increase of the stem diameter. If the roots of the trees develop in better soil moisture conditions, the stem will have a stronger cambial activity, making the trunk growth higher.

Table 3. Trunk cross section area (TCSA), cm^2

Root-stock	Var.	At planting	Year after planting								Index
			1st	2nd	3rd	4th	5th	6th	7th	8th	
M9 T337	1	2.25	3.47	5.96	8.96	13.14	15.85	21.94	25.41	36.53	100
	2	1.63	3.66	8.86	12.64	16.61	26.04	35.66	41.60	54.22	148.5
	M	1.94	3.57	7.41	10.80	14.88	20.95	28.80	33.51	45.38	
	P-value	*.112*	*.719*	*.764*	*.944*	*.067*	*.001*	*.003*	*.004*	*0.012*	
M9 T984	1	2.48	3.1	5.97	9.92	12.12	16.22	21.86	25.09	33.65	100
	2	1.77	3.40	9.18	12.95	16.32	24.62	39.80	46.06	55.12	164.0
	M	2.13	3.25	7.58	11.44	14.22	20.42	30.83	35.58	44.39	
	P-value	*.036*	*.342*	*0.565*	*0.927*	*.041*	*.004*	*.000*	*.000*	*0.019*	
Mark 9	1	2.24	3.48	6.11	11.31	14.78	17.80	23.13	26.95	39.71	100
	2	1.70	3.28	8.62	11.42	15.87	18.52	27.19	32.01	45.63	114.9
	M	1.97	3.38	7.36	11.36	15.32	18.16	25.16	29.48	42.67	
	P-value	*.100*	*.504*	*.047*	*.025*	*.342*	*.644*	*.227*	*.174*	*0.256*	
Avrg	1	2.32	3.35	6.01	10.06	13.35	16.62	22.31	25.82	36.63	100
	2	1.70	3.45	8.89	12.34	16.27	23.06	34.22	39.89	51.66	141.0
	M	2.01	3.40	7.45	11.20	14.81	19.84	28.26	32.86	44.15	

Data for growth dynamic of TCSA for period from planting until 8th growing season are shown in table 3. At planting, the trees of all rootstocks and variants, had similar TCSA, but because deeper planted trees are measured higher the data have smaller values. At the end of the eighth vegetation largest TCSA had trees on rootstock M9 T984 who were deeper planted. The lowest mean values for TCSA were observed at trees on rootstock M9 T337 which were planted with standard

technology. At all rootstocks bigger TCSA was observed at deeper planted trees by an average of 41.0 %. The values for this parameter differ statistically among all tested rootstocks (table 3). Costante (1983) found approximately 20% less developed trees that have been planted according to the standard technology in comparison with deeper planted trees.
At the end of the eighth vegetation the trees from second variant had a larger crown (crown area and canopy volume). In terms of researched rootstocks, average for both variants, the least developed crowns had fruit trees grafted on Mark 9 (table 4). There are differences among the tested variants in crown volume due to the greater height of the leaders. The width of the crowns which determines the horizontal projection is limited through pruning of the trees because of there is no major differences between the tested variants. Kiprijanovski (1997) during examining the depth of planting at the variety Jonagold on rootstock M9 in an extremely arid conditions and insufficiently irrigation found 48.3% greater crown area and 76.8% greater crown canopy at trees that were highly grafted and planted 30 cm deeper than standard planted trees. Ugolik (1990) points out that trees grafted on vigorous rootstocks and deeply planted are many vigorously resulting in poor yield. Deep planting of spur' Red Delicious'/MM 111 resulted in greater tree height with fewer blooms and greater depth to first root (Jackson and Harrison-Murray, 1986)

Table 4. Crown parameters of the trees at the end of 8th vegetation

Rootstock	Var.	Crown area (CA), m^2	Tree canopy volume (TCV), m^3	Index
M9 T337	1	2.19	1.95	100
	2	2.45	2.44	125.1
	M	2.32	2.20	
	P-value	*0.48*	*0.484*	
M9 T984	1	2.08	1.82	100
	2	2.27	2.33	128.0
	M	2.18	2.08	
	P-value	*0.21*	*0.384*	
Mark 9	1	1.85	1.78	100
	2	2.03	2.15	120.8
	M	1.94	1.97	
	P-value	*0.702*	*0.230*	
Average	1	2.04	1.85	100
	2	2.25	2.31	124.9
	M	2.15	2.08	

Productivity of the trees
Productivity of the trees is the most important factor for successful cultivation of fruit plantations. The productivity depends on several factors such as genetic potential of the cultivar, ecological conditions, development of the tree, applied agro and pomotechnical measures, rootstock etc.
In investigational period the highest cumulative yield was registered on deep planted trees grafted on M9 T984 (104.2 kg). The lowest cumulative yield have trees grafted on M9 T984 and planted according standard technology. The average cumulative yield for researched period, in bouth

variants, has trees grafted on the rootstock M9 T984. (tab.5). Concerning depth of planting, trees for second variant have up to 27,8% higher yield compared to those planted with standard technology. Analyzing the data (table 5 and figure 1) it can be seen that at shallow planted trees there are large variations in yield per year. In all evaluated rootstock alternative bearing was notice, while at deeper planted trees this negativity has not been observed. Statistically significant differences between the variants in terms of the cumulative yield was notice at all evaluated rootstocks.

Table 5. Yield per tree and unit area

Root-stock	Var.	Yield, kg/tree					Yield, t/ha					Index
		2008	2009	2010	2011	Cumu-lative	2008	2009	2010	2011	Cumu-lative	
M9 T337	1	19.5	24.2	15.0	21.3	80.0	37.1	46.1	28.6	40.6	152.4	100
	2	17.4	24.8	24.9	26.3	93.4	33.1	47.2	47.4	50.1	177.8	116.7
	M	*18.5*	*24.5*	*20.0*	23.8	86.8	*35.1*	*46.7*	*38.0*	45.3	165.1	
	P-value	*0.59*	*0.83*	*0.00*	1.16	*2.58*	*1.12*	*1.59*	*0.12*	1.29	*4.1*	
M9 T984	1	17.5	22.5	13.0	18.8	71.8	33.3	42.9	24.8	35.8	136.8	100
	2	18.9	28.0	29.6	27.7	104.2	36.0	53.3	56.3	52.8	198.4	145.0
	M	*18.2*	*25.3*	*21.3*	23.3	88.1	*34.7*	*48.1*	*40.6*	44.4	167.8	
	P-value	*0.44*	*0.04*	*0.00*	0.78	*1.26*	*0.84*	*0.74*	*1.60*	1.86	*5.0*	
Mark 9	1	20.0	22.2	14.9	20.8	77.9	38.1	42.3	28.4	39.6	148.4	100
	2	18.6	21.8	26.1	29.4	95.9	35.4	41.5	49.7	56.0	182.6	123.0
	M	*19.3*	*22.0*	*20.5*	25.1	86.9	*36.8*	*41.9*	*39.1*	47.8	165.6	
	P-value	*0.465*	*0.89*	*0.00*	0.87	*2.22*	*0.88*	*1.17*	*0.25*	1.90	*4.2*	
Ave-rage	1	19.0	23.0	14.3	20.3	76.6	36.2	43.8	27.2	38.7	145.9	100
	2	18.3	24.9	26.9	27.8	97.9	34.8	47.4	51.2	53.0	186.4	127.8
	M	18.7	23.9	20.6	24.1	87.3	35.5	45.6	39.2	45.9	166.2	

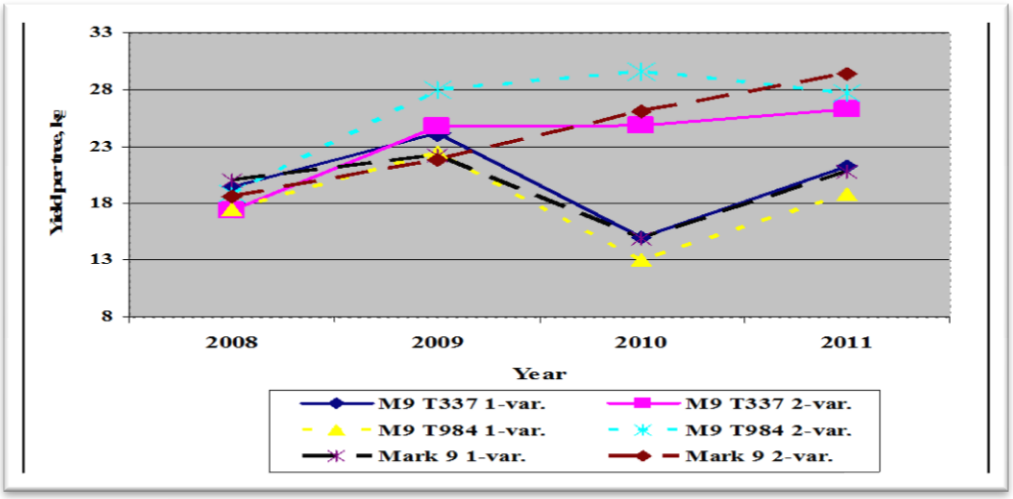


Figure 1. Dynamics of the fruiting at the trees

There is a positive correlation between the vigorousness and cumulative yield of the trees (Figure 2). Czynczyk et al., (2001) and Autio et al., (2001) testing new dwarfing apple rootstocks pointed that the trees on the rootstock Mark 9 have high yield efficiency. Barrit et al., (1997) reported that cumulative yield efficiency showed a linear decline as tree size increased for more apple rootstocks. Our researches showed that the increase of the vigorousness of the trees decreases the yield efficiency, expressed through yield per cm^2 /TCSA, but the trees with greater canopy have greater yield efficiency expressed through kg/m^2 crown area and kg/m^3 crown volume (Table 6). There are significant differences in yield efficiency between variants except yield efficiency expressed through kg/m^3 crown volume.

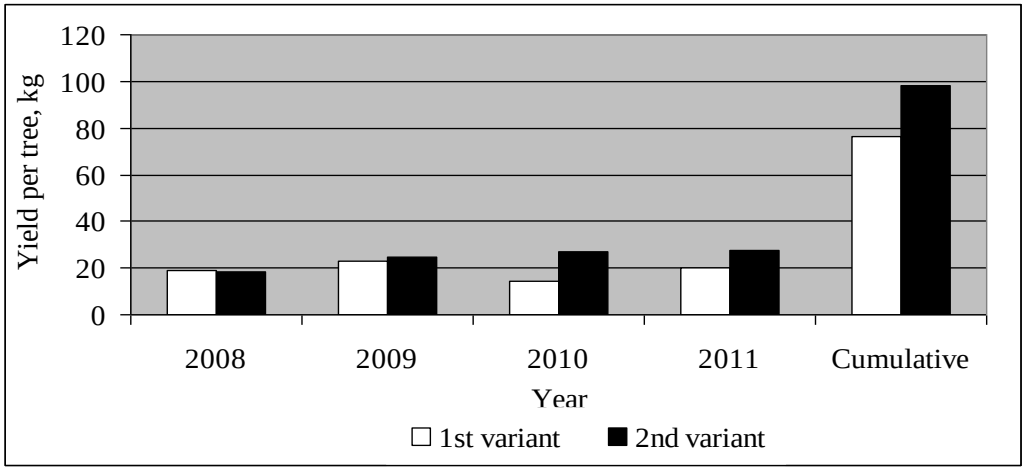


Figure 2. Average yield per tree for all rootstocks

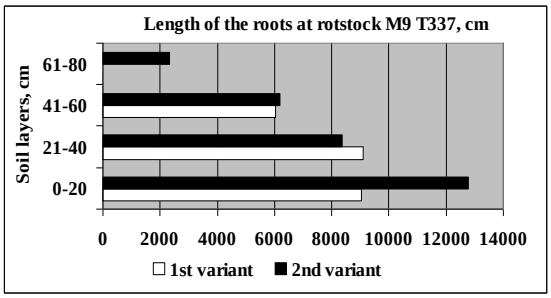
Table 6. Yield efficiency (average 2008-2011)

Rootstock	Var.	Yield/TCSA, kg/cm^2	Yield/CA, kg/m^2	Yield/TCV, kg/m^3
M9 T337	1	0.88	12.12	14.68
	2	0.61	13.69	14.11
	M	0.71	12.91	14.40
	P-value	*0.006*	*0.125*	*0.705*
M9 T984	1	0.80	11.80	14.15
	2	0.65	15.35	16.11
	M	0.71	13.61	12.78
	P-value	*0.120*	*0.226*	*2.120*
Mark 9	1	0.79	13.14	15.53
	2	0.82	15.25	16.27
	M	0.81	14.20	13.83
	P-value	*0.092*	*0.128*	*1.150*
Average	1	0.82	12.33	14.72
	2	0.69	14.73	15.47
	M	*0.76*	13.54	15.15

Root system attaches trees in the soil, provides them with the necessary nutrients and water, in the primary assimilation processes creates specific substances important for metabolism, growth and the generative activities of the trees. Distribution, structure and development of the root system of the fruit trees depends on the genetic nature of species, properties of the rootstock and the variety, soil type, manner of soil preparation before establishing of the trees, agrotechnical measures in the orchards and other factors.

Table 7. Distribution of the roots through soil layers, cm

Root stock	Var.	Length of the roots, cm					Mass of the roots, g				
		Depth of the soil, cm					Depth of the soil, cm				
		0-20	21-40	41-60	61-80	Cum.	0-20	21-40	41-60	61-80	Cum.
M9 T337	1	9051.2	9096.0	6044.7		24191.9	845.5	479.3	132.8		1457.4
	2	12778.3	8377.7	6198.8	2340.5	29275.3	766.7	492.9	211.8	72.5	1543.8
	M	10914.8	8736.8	6121.7	1170.3	26733.6	806.1	486.1	172.3	36.2	1500.6
M9 T984	1	6465.6	11691.2	5184.0		23340.8	637.6	482.3	176.5		1296.4
	2	8681.0	10370.0	5636.0	3291.2	28056.2	917.7	629.2	199.8	48.8	1795.5
	M	7573.3	11030.6	5410.0	1645.6	25698.5	777.7	555.8	188.1	24.4	1545.9
Average	1	7758.4	10393.6	5614.4		23766.4	741.6	480.8	154.7	.	1376.9
	2	10729.7	9373.8	5917.4	2815.9	28665.8	842.2	561.1	205.8	60.6	1669.7
	M	9244.1	9883.7	5765.9	1407.9	26216.1	791.9	520.9	180.2	30.3	1523.3



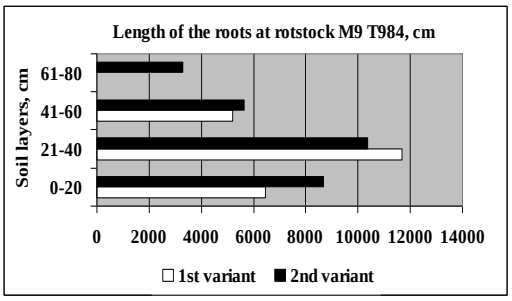
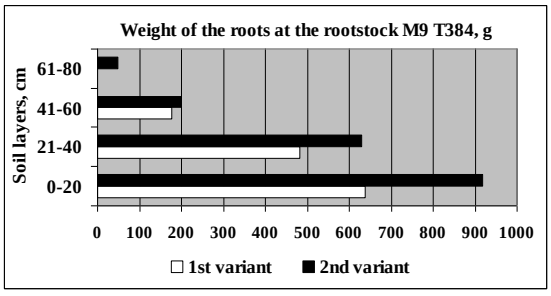


Figure 3 and 4. Distribution of the root length through soil layers



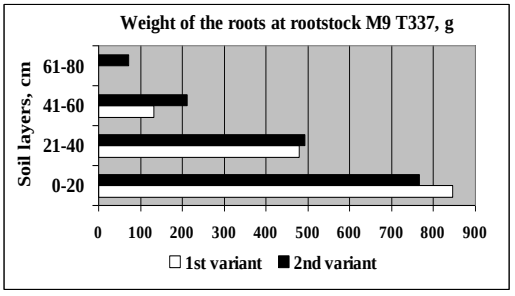


Figure 5 and 6. Distribution of the root weight through soil layers

Productivity of fruit trees largely depends on the development and architecture of the root system (Kolesnikov, 1974, Ristevski, 1995). The length of the roots at the apples directly depends on the distance of the planting and the type of rootstock (Atkinson, 1980). The study of the root system at the trees with different planting depth is conducted at the trees grafted on rootstocks M9T337 and M9 T984. From results (table 7 and Figures 3 and 4) it can be concluded that there is no big difference in the root system of the trees between rootstocks, but the differences are evident at planted trees of varying depth. Greater development of the roots system at deeper planted trees can be explained by the fact that through the underground stem of rootstocks after planting emerging new adventives roots, and these roots influence in much of the total mass and length of the roots system. At deeper planted trees root system, even at the planting, is placed in the soil layer where there is more moisture, and thus better conditions for the development and functioning of roots. The better developed roots have greater possibilities for the supply of trees with water and nutrients from the soil, which contributes to the development of the above-ground part of the trees. Mihailov (1973) found that deeper planted apple trees have 17% more developed roots. Kolecevski and Ristevski (1988) noted that the root system of apples on dwarfing rootstocks on heavy soils penetrates to a depth of ploughing (75 cm). Angelov (1976) found that 60% of the apple roots are in the 20-40 cm layer, and in the layer of 0-20 cm found 19-21% of the total roots. Our data are similar with results from previous studies.

Conclusions

The results got from conducted research show that the rootstocks, have a direct influence on vegetative behaviour and generative parameters of the apple trees. The deeper planting of the trees on dwarfing rootstocks in adequate ecological conditions has positive influence to growth of the apple trees in orchard. The yield affected of the growth of the trees. High growth trees are more productivity and the fruits have better quality. The root system at deeper planted trees is more developed and penetrates in deeper soil levels. Anchorage in soil of apple trees on dwarfing rootstocks is better at deeper planting. High grafted and deeper planted trees can cultivate in orchard without support system. At the establishing of apple orchards on dwarfing rootstocks (group M9) in drought climatically conditions, with deficit of water for irrigation, it can be recommend higher grafting and 20-30 cm deeper planting of the nursery trees.

References

Angelov T. (1986). Distribution of root system at bearing apple trees and way of irrigation. Fruit growing 7. Sofia.

Atkinson D. (1980). The distribution and effectiveness of the roots of the tree crops. Horticulture Reveiw 2, 424-490.

Autio, W.R. (2001). Rootstock and scion interact to affect apple tree performance: Results from the 1990 NC-140 Cultivar/Rootstock Trail. Acta Hortic. (ISHS) 557, 41-46.

Barrit, B.H., Konishi, B. S., Dilley, M.A. (1997). Tree size, yield and biennial bearing relationships with 40 apple rootstocks and tree scion cultivars. Acta Hort. 451, 105-112.

Callesen, O. (1986). Spindle trees without stakes. Acta Hort. (ISHS) 160, 405-412.

Costante J.F., Lord W.J., Howard D., Connington L. (1983). Influences of planting depth on growth, root suckering and yield on interstem apple trees. Hort science 18, 6, 913-915.

Crassweller, R.M., Smith, D.E., Tukey, L.D. (2001). Performance of 'Golden Delicious' and 'Delicious' apples on dwarfing rootstocks. Acta Hortic. (ISHS) 557, 47-54.
Czynczyk A., Omeicinska B. (1989). Effect of new rootstocks of Polish, Russian and Czekoslovakian breeds and two depth of planting of the trees with interstem on growth and cropping of 3 apple cultivars Acta Hort. (ISHS) 243, 71-78.
Kiprijanovski M., Kolecevski P. (1997). Results of depth planting of apple trees. Anniversary annually proceeding of papers on Faculty of Agriculture, Skopje, 42, 133-138.
Kosina, J. (2002). Evaluation of some dwarf apple rootstocks. Hort. Sci. 29, 23-25.
Jackson, J.E., Harrison-Murray, R.S. (1986). Reducing the cost of anchoring trees. Acta Hort. (ISHS) 160, 399-404
Lyons C.G. Jr., Byers R.E., Yoder K.S. (1983). Influence of Planting Depth on growth and Anchorage of Young 'Delicious' Apple Trees. Hortscience 18, 923- 924.
Lyons C.G. Jr., R.E. Byers, K.S. Yoder. (1987). Influence of Planting Depth on Growth of Young Apple Trees. J. Environ. Hort. 5, 163-164.
Kolechevski P., Ristevski B. (1988). Structure and schedule of root system of apple on the rootstocks M9 and MM106. Jug. voc. 84-85.
Kolesnikov V.A. (1974). The root system at fruit trees and berry plants. Kolos, Moscow.
Mihailov C., Topcijski S. (1973). Depth of planting at fruit trees. Fruit growing, 10 Sofia.
Parry, M.S. (1974). Deeper planting as an alternative to staking. East Malling Res. Sta. Report 1973. p. 175.
Parry M. S. (1974). Depth of planting and anchorage of apple trees. J.Hor.Sci.49, 349-354.
Ristevski B. (1995). Establish and cultivation of the orchards. University book, BIGGOS, Skopje.
Rogers, W.S., M.S. Pa r ry. (1968). Effect of deep planting on anchorage and performance of apple trees. J . Hor t . Soc. 43, 103-106.
Tworkoski, T., Miller, S. (2007). Rootstock effect on growth of apple scion with different growth habits. Sci. Hortic. 111, 335-343.
Webster, A.D. (1993). New dwarfing rootstocks for apple, pear, plum and sweet cherry – A brief review. Acta Hortic. 349, 145–154.
Wertheim, S.J., Morini, S., Loreti, F. (1989). Effect of M.27 and M.9 used as rootstock and interstem on apple tree behaviour in two different growing conditions. Acta Hortic. (ISHS) 243, 37-50.
Wertheim, S.J. (1997). Useful differences in growth vigour between subclones of the apple rootstock M.9. Acta Hortic. (ISHS) 451, 121-128.

ДЛАБОКО САДЕЊЕ НА ОВОШКИТЕ-АЛТЕРНАТИВЕН НАЧИН НА ОДГЛЕДУВАЊЕ НА НАСАДИ ОД ЈАБОЛКА НА СЛАБО БУЈНИ ПОДЛОГИ ВО ИЗМЕНЕТИ КЛИМАТСКИ УСЛОВИ

Киприjановски Марјан, Ѓамовски Виктор, Арсов Тошо

Апстракт

Интензивни насади од јаболка се подигаат главно на слабо бујни подлоги. Овие подлоги имаат некои недостатоци како што се: плиток и слабо развиен коренов систем, осетливост на суша, слабо вкоренување, потреба од потпорна констукција и др. Во практиката обично садниците се садат на длабочина до кореновиот врат. Во некои случаи, со цел намалување на бујноста, садниците се садат поплитко, но има и случаи кога со цел подобрување на вкоренувањето садниците се садат подлабоко.

Во Македонија климатските промени изразени преку намалени врнежи се повеќе се чувствуваат, со што се влошуваат условите за одгледување на традиционалните овошни култури. Ваквата состојба ја нагласува потребата од воведување на нови практики при подигањето и одгледувањето на насадите од јаболка. Во трудот се презентирани резултати од истражувањето на влијанието на подлабокото садење на садниците врз однесувањето на овошките во насадот. Насадот е одгледуван според стандардна технологија. За истражување се користени подлогите М9 Т337, М9 Т984 и Марк 9 калемени со сортата Грени Смит. При подигањето на опитниот насад се користени две варијанти: садници кои се калемени на стандардна висина и истите се садени на длабочина до кореновиот врат и садници кои се калемени на висина од 30 cm и истите се садени на длабочина од 50 cm. Опитниот насад е подигнат во Преспанскиот регион, во 2004 година, а истражувањето е изведено во период од садењето до 2012 година. Во овој период се следени вегетативните карактеристики на овошките, приносот и квалитетот на плодовите и дистрибуција на кореновиот систем на овошките. Од истражувањето е констатирано дека подлабоко посадените овошки се побујни, поразвиени и може да се одгледуваат без потпорна констукција. Исто така подлабоко посадените овошки се попродуктивни и даваат плодови со подобар квалитет.

Клучни зборови: јаболка, подлоги, длабочина на садење, климатски промени.

UDC:634.13-152.61"323"(497.712)"2008/2010"
Original scientific paper

RESEARCH OF QUALITY CHARACTERISTICS OF SOME AUTUMN PEAR VARIETIES

Kiprijanovski Marjan[1*], Arsov Tosho[1], Gjamovski Viktor[2]

[1]Faculty of Agricultural Sciences and Food - Skopje, Republic of Macedonia
[2]Institute of Agriculture, Skopje, Republic of Macedonia
[*]e-mail: mkiprijanovski@yahoo.com

Abstract
The pear is quality, fine fruit which is appreciated and requested by the consumers. With the permanent increase of the standard and increased purchasing power, the demand of quality pear fruits becomes larger. In Macedonia there is not enough production of pears and because of that a big part of the needs are supplied by import. In the plantation are cultivated a big number of pear varieties with different quality characteristics and ripening time. In this paper the results from investigation of some quality characteristics of 10 pear varieties with autumn ripening time are presented. The researchers are carried out at the follow varieties: Harrow Sweet, Honey Sweet, Abate Fetel, Packhams Triumph, Conference, Magness, Starking Delicious, Highland and Kaiser. Bartlet was used as control variety. The research was carried out in the pear orchard located in the Skopje area. Investigation was conducted during tree consecutive years (2008-2010). The researches comprise: time of harvesting, weight and dimensions of the fruits, dimensions of the stalk, content of soluble solid matters, total sugars and total acids. Organoleptics evaluations of the fruits were done on two occasions: beginning of October and beginning of December. Based on investigations it was concluded that beside standard variety Bartlet the best quality have the variety Harrow sweet, Abate Fetel and Packhams Triumph.
Key words: pear, variety, quality, evaluation.

Introduction

The pear is fine, delicious fruit, widely grown in temperate zones in the world. Worldwide area under orchards of pears and production is increasing steadily (Segre, 2002). The assortment which cultivated in different regions varied related size of the fruits, their shape, texture and flavors (Janick, 2002). The varieties mainly suited to the environmental conditions in adequate area and demand by consumers. The existing pear assortment worldwide, is becoming too conservative and therefore, the market conditions and the sensibility of certain varieties towards some pests and diseases, request not only complementing of the existing assortments but also a replacement of varieties with more quality characteristics of the fruits and less sensitive to the unfavorable biotic and abiotic factors (Gliha, 1997). Pear breeding objectives are complex, but most pear breeders share a number of common purposes such as fruit quality, storage ability, consistent production, diseases and pests resistance (Bell et al., 1996). The adaptation to the ecological conditions including the pest and disease resistance, are the main goals of selection of new pear varieties (Belini, 2002). During the classification of the varieties by their resistance towards certain pests and

diseases, Belini (1997), puts the varieties Harrow Delight, Harvest Queen, Harrow Sweet, Honey Sweet and Magness, in the group of Fire Blight resistant varieties. The pear production is facing a line of problems mainly concerning the sensitivity of the varieties towards diseases which largely endangers the pear productivity. In many ways, the pear remains a problem for producers and consumers. The producers have to content with hardiness like early blooming, sensitive of frosts, fire blight and psylla susceptibility, sunburns, difficulties with handling of the fruits that must be carefully picked and ripened to achieve maximum quality. To the consumers, appearance and taste related size, color and form of the fruits, perfect proportion of the texture, flavor, acidity and sweetness of the flesh have primary importance. There are many definitions of quality. The most widely used is perhaps fitness for use (Tijskeens et al., 1998). A more recent definition of quality is meeting the expectations (MacFie, 1997). Some consumers like pears juicy, buttery and melting texture with a good flavour. However there are consumers that prefer pears with a crispy and juicy texture to a buttery and melting one (Hoehn et al. 1996). Pears must ripen before they are ready to eat. Eating quality depends on ripeness stage and ripening progress proceeded more rapidly in fruits picked at later picking times (Zerbini, 2002). A major objective of breeding is to develop cultivars combining fire blight resistance and high fruit quality. Pear sensory attributes suited to satisfy consumer were studied by Kappel et.al. (1995). New cultivars to have changes to be successfully introduced in a pear producing area must be of eating quality comparable or superior to those already affirmed. Before the economic transformations in Macedonia pear production reached over 20.000 tones. Later, the area under orchards and pear production decreased rapidly. Nowadays, the pear production is not satisfied for domestic needs. Especially in the autumn and winter period the markets are supply with imported high prised pears nearly unaffordable for the consumers. The reasons for this situation lay mostly in the appearance of epiphitotonic measures of the psylla and Fire Blight, for which the producers have lack of information and knowledge (Ristevski, 2004). In the present years interest among the producers for establishing the pear orchards is increasing. One of the manners for advancement of the production is improvement of the assortment structure and increase of the participation of quality and productive varieties. Proper cultivar choice is a very important factor for the cost effective production of pear, especially in conditions where the technology of growing and consumers require reduced application of pesticides. Pear intended for fresh consumption quality of the fruits regards appearance, size and especially taste is very important. Pear fruits of different varieties vary in the range of morphological, anatomical-histological, physiological, physical and chemical properties that are manifested in the appearance (color, shape, size), taste, aroma, consistency, firmness, time of harvest, storage ability, transportability and others. The sum of these properties constitutes the quality of the fruits.

Material and methods

The field researches of the pear varieties, varieties have been carried out in the area Trubarevo near Skopje. The trial orchard has been established in the spring 1997 with the varieties Harrow Sweet, Honey Sweet, Abate Fetel, Packams Triumph, Conference, Magness, Starking Delicious, Highland, Kaiser and Bartlet as control variety. A quince BA29 has been used as a rootstock. For the incompatible varieties was used Cure as interstock. The distance between trees was 4x1.5 m. The research was conducted during period 2008-2010. The orchard has been established on a fertile loam soil. The area has been maintained with a clean cultivation until the seventh vegetation, and

after that with natural grassing. In the orchard drip irrigation system was installed. The fruit crowns have been formed by the spindle bush system. During the research, the following parameters have been observed: ripening time, productivity and fruit quality of the evaluated varieties. Yield per tree and yield per unit area was calculated, the pomological characteristics was determinate by measuring dimensions of the fruits and stalk using a caliper with a sensitivity of ± 0.1 mm. The weight of the fruits was measured on an electronic balance with a sensitivity of ± 0.01 g. The chemical characteristics were determined after harvesting. The content of soluble solids, total sugars (TS) and titratable acids (TA) were researched in laboratory by standard methodology. Sugar: acids ratio was estimated. Organoleptic characteristics of the fruits are evaluated troughs their appearance and taste. Evaluation was conducted by spontaneously selected 30 consumers. The evaluation was carried out in two occasions at 5 October and 5 December. After harvesting the fruit were placed and stored in a laboratory refrigerator at temperature of 0-2 ^{0}C. The statistic analyses have been performed by an analysis of the variance, and the testing of the differences by LSD-test.

Results and discussion

Ripening time and yield per tree

Time of ripening is an important characteristic of the variety in terms of determining the harvesting season, consumption and the potential ability to storage of the fruits. Ripening of the pears is associated with variety characteristics and environmental conditions in the respective region. The researched group includes varieties with late summer and autumn time of ripening. All tested varieties ripen after Bartlet and in period of one month. The earliest ripen fruits of variety Honey Sweet, and the latest fruits of the variety Packams Triumph (table 1). High yield, as well fruits with good quality is a major goal in fruit production. In the pear orchards the yield depends of many complex factors such as environmental conditions, variety, combination variety/rootstock, planting density, training system, growing technology etc. In the researching period the highest average yearly yield per tree and unit area gave the variety Harrow Sweet (21.4 kg/tree and 35.65 t/ha), followed by the variety Conference, Packams Triumph and Magness (table 1). The lowest yield was determined at variety Honey Sweet followed by Starking Delicious and Highland.

Table 1. Ripening time, yield per tree and per unit area (average 2008-2010)

Variety	Time of ripening	Yield per tree, kg	Yield per unit area, t/ha
Bartlet	28.8	17.8	29.59
Honey Sweet	30.8	12.1	20.13
Starking Delicious	4.9	14.4	24.05
Highland	13.9	15.4	25.71
Magness	13.9	18.7	31.15
Conference	20.9	20.3	33.81
Abate Fetel	23.9	18.6	31.01
Harrow Sweet	25.9	21.4	35.65
Kaiser	28.9	18.6	30.98
Packams Triumph	30.9	19.4	32.26
	$LSD_{0.05}$	1.73	2.88
	0.01	2.37	3.94

Pomological characteristic of the fruits

In modern fruit production dimensions and weight of individual fruit is a very important characteristic hence varieties with larger fruit in general have a higher price. The dimensions and weight of the fruits are dependent on a number of factors such as genetic potential, abundance, growing technology, environmental conditions, etc. Analyzing the data for the fruit weight we can concluded that the varieties Bartlet, Abate Fetel, Highland and Packams Triumf have large fruits. The fruits of varieties Starking Delicious, Kaiser and Conference are with good size. The variety Honey Sweet, Magness and Harrow Sweet have fruits with smaller but satisfactory size and weight (table 2). Gliha (1997) describing some pear varieties, stated that the variety Abate Fetel has large to very large fruits (180-320 g), varieties Bartlet, Highland, Kaiser and Packams Triumph have large fruits (180-280 g) Conference and Starking Delicious have medium large fruit (160-180 g) and Harrow Sweet and Magness have fruits with medium to small size (160-170 g).

Among other environmental conditions and winds can cause damage in the pear orchards pushing the fruits. Generally varieties with long and strong stalks of the fruits are more resistant to winds but here there are exceptions (Ristevski et.al., 2004). The varieties Starking Delicious, Abate Fetel have very short stalk and these varieties are very sensitive on winds. In contrast variety Pakams Triumph although there is a large fruit has a long and thick stalk and fruits are not susceptible to winds.

Table 2. Pomological characteristics of the fruits

Variety	Weight, g	Fruits, mm			Stalk, mm	
		Height (H)	Width (W)	Ratio: H/W	Length	Thickness
Bartlet	215	85.9	69.1	1.24	34.4	4.3
Honey Sweet	145	68.4	48.7	1.40	19.4	3.8
Starking Delicious	190	73.2	71.6	1.02	26.3	2.9
Magness	160	81.9	59.6	1.37	14.0	5.4
Conference	175	94.6	69.0	1.37	28.0	6.1
Abate Fetel	265	124.5	73.3	1.70	22.3	4.1
Highland	212	94.4	76.3	1.24	33.5	3.4
Harrow Sweet	165	83.9	67.5	1.24	28.2	3.8
Kaiser	194	102.2	76.2	1.34	39.2	3.4
Packams Triumph	235	90.4	79.3	1.14	38.3	5.2
$LSD_{0.05}$	11.5	10.1	8.6	0.10	2.5	0.2
0.01	15.5	13.6	11.6	0.13	3.4	0.3

Content of some chemical components in the fruits

The pear fruits can use as fresh and processed into various types of processing. Fruits have a high nutritional, energy and dietary value. Chemical composition varies in rather wide limits, depending on the variety. The content of some chemical matters in fruits determine the quality and technological value of the varieties. From this aspect of particular importance is content of soluble solids and titratable acids. Content of certain chemical substances in fruits is variety characteristic, but it also depends on many other factors such as environmental conditions, the method of cultivation, degree of maturity, the yield, etc. In practice, more appreciated is the fruit with higher

soluble solids content regardless of whether there are intended for fresh use or processing. Ratio sugar/acids content gave determinate the taste of the fruits. Pear generally contains little acids so dominates sweet taste. Analyzing the data on the fruit quality, it can be pointed out that the average content of soluble solids and total acids in the fruits are different at certain varieties (table 3). The fruits from the varieties Conference, Harrow Sweet, Kaiser and Honey Sweet highlight for their high content of soluble solids matters. The highest content of the titratable acid have fruits from varieties Bartlet and Packams Triumph, and very low acids have the fruits of the variety Kaiser and Abate Fetel. These varieties have and the highest total: total acids ratio.

Table 3. Content of some chemical components in the fruits

Variety	SSM , %	TS, %	TA, %	TS: TA ratio
Bartlet	14,3	9.2	0.36	25.6
Honey Sweet	15.3	9.6	0.25	38.4
Starking Delicious	13.6	8.7	0.24	36.3
Highland	13.9	8.9	0.25	35.6
Magness	15.1	7.9	0.20	39.5
Conference	18.6	11.5	0.21	54.8
Abate Fetel	13.6	7.8	0.13	60.0
Harrow Sweet	17.4	12.1	0.33	36.7
Kaiser	16.3	9.4	0.15	62.7
Packams Triumph	15.4	11.8	0.27	43.7
$LSD_{0.05}$	2.5	2.5	0.05	9.3
0.01	3.4	3.4	0.07	12.6

Sensory evaluation of the fruits

To assess the quality and value of various fruits decisive role have the final consumers. Evaluation of the quality, attractiveness and acceptability of fruits of pear varieties in a certain period of consumption season is done through tasting of fruits. Without continuously monitoring consumer needs and desires as well as their involvement in creating assortments can not harmonize production with consumption of fruits prosperity. Standard analytical measurements like soluble solids and titratable acidity have shown in apple poor correlation with sensory perception and the same is true for pear (Watada et.al., 1981). It is difficult to give an objective assessment for taste of the pears because it depends on the taste and habits of individuals, individual regions and even whole nations (Gliha, 1997). Sensory evaluation is increasing its importance in supporting breeding and introduction of new cultivars (Hampson et.al., 2000).

Table 4. Sensory evaluation of the fruits

Variety	October 5th			December 5th		
	Appearance (0-5)	Taste (0-5)	Total (0-10)	Appearance (0-5)	Taste (0-5)	Total (0-10)
Bartlet	4.04	4.32	8.36	3.75	4.05	7.85
Honey Sweet	3.18	4.34	7.52	3.05	3.40	6.45
Starking Delicious	3.65	4.11	7.76	3.45	3.64	7.09
Highland	3.77	3.68	7.45	3.98	3.75	7.73
Magness	3.46	4.46	7.92	3.40	3.55	6.95
Conference	3.07	4.11	7.18	3.28	4.20	7.58
Abate Fetel	4.15	3.00	7.15	4.30	3.45	7.75
Harrow Sweet	4.54	4.44	8.98	3.45	3.65	7.10
Kaiser	3.12	3.45	6.57	3.10	4.10	7.20
Packams Triumph	3.16	3.45	6.61	3.95	3.85	7.80
$LSD_{0.05}$	0.43	0.48	0.91	0.24	0. 32	0.56
0.01	0.59	0.65	1.24	0.33	0.44	0.77

Eating quality is very difficult to measure objectively. To determine how consumers accept the fruits of different pear varieties in terms of organoleptic properties sensory evaluation was made. Sensorial tests were performed on visual and eating traits. In first term of evaluation (October 5th) the best scores for appearance and taste derived fruits from variety Harrow Sweet and Bartlet followed by Magness and Starking Delicious (table 4, figure 1). Kapel and Quamme (1987) stated that the fruits of variety Harrow Sweet were given high preference rating by trained panelist, which rated the flavor as good as that have fruits of Bartlet. This is confirmed in our researches. The lowest scores got the fruits from varieties Kaiser and Packams Triumph. Probably the low scores on these varieties isare due to the late maturing and the fruits were not sufficient ready for consumption. In second term of evaluation (December 5th) the best grades received the fruits of the variety Bartlet and Packams Triumph, and the lowest grades got fruits from variety Honey Sweet and Magness (table 4, figure 2). Due to poor ability to store the fruits of the variety Harrow Sweet in second term of evaluation drastically reduced their quality.

According average values of two conducted sensory evaluations, fruits from Bartelet are characterized with the best organoleptic characteristics, followed by Harrow Sweet, Highland and Abate Fetel (figure 3). Based on the evaluation of the consumers, only fruits from Abate Fetel and Highland have better appearance that taste (figure 3).

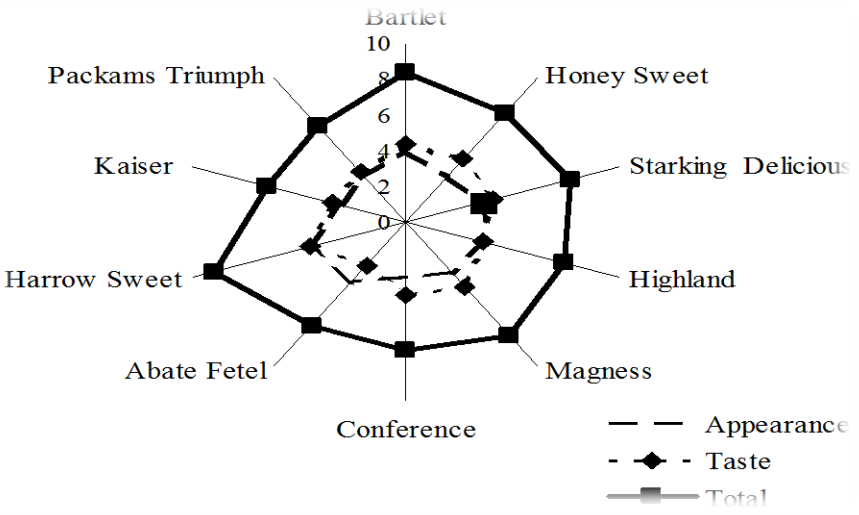


Figure 1. Sensorial profiles of the fruits from pear varieties on October 5th

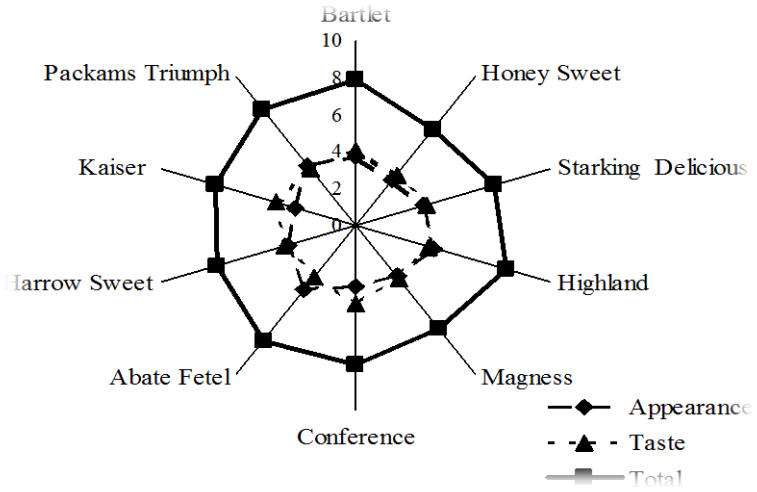


Figure 2. Sensorial profiles of the fruits from pear varieties on December 5th

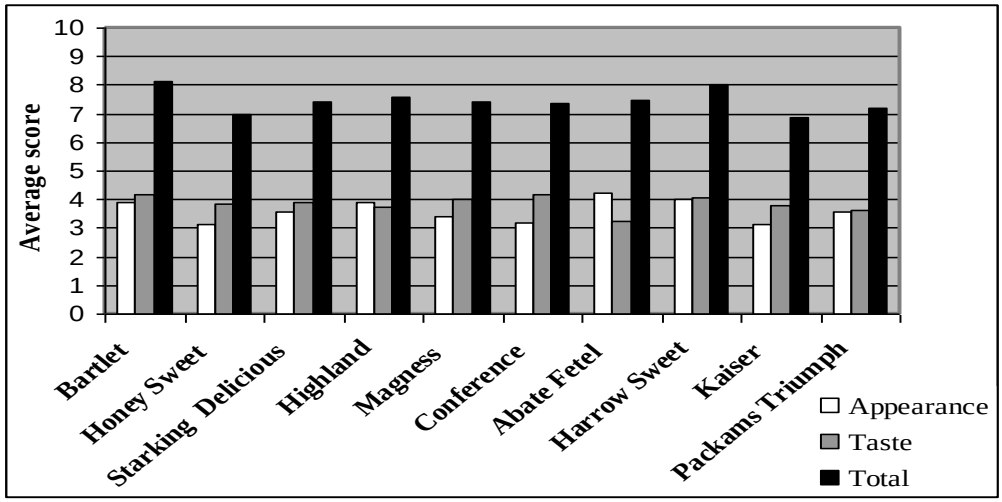


Figure 3. Average value of sensory evaluation of the fruits (October 5th and December 5th)

Conclusions

Based upon researches of the production and the quality characteristics of some autumn pear varieties a few conclusions can be made:

-The varieties resistant to Fire Blight (Harrow sweet, Honey Sweet and Magness) the best productive attributes and quality characteristics of the fruits has Harrow Sweet variety. Despite resistance to fire blight it is less sensitive to psylla, it has excellent productivity and good quality of the fruits. Due to this, this variety can be recommended for growing in the commercial orchards.

- From varieties which are belonged in assortment which is sensitive to the Fire Blight the best results despite variety Bartlet were obtained at Packams Triumph and Abate Fetel. These varieties can be recommended for growing in some typical agro ecological areas. The standard variety Conference is very sensitive to sunburn and the variety Kaiser is very susceptible to Fire Blight and to the psylla and these varieties are not recommend for growing in our production regions.

References

Bell R.L., Quamme H.A., Layne R.E.C., Scirvin R.M. (1996). Pears. In Fruit Breeding, volume I: Tree and Tropical fruits J. Janick and J.N. Moore eds., Wiley, pp 441-514.

Bellini E., Nin S. (1997). II miglioramento genetico del pero nel mondo. Rivista di Fruticoltura LIX, 3, 19-30

Bellini E. Nin S. (2002). Breeding for new traits in pear. Acta Hort. (ISHS) 596, 217-224.

Elkins R. B. DeJong T.M. (2002). Effect of training System and Rootstock on Growth and Productivity of Golden Russet Bosc Pear Trees. Acta Hort. (ISHS) 596, pp. 603-607.

Gliha R.(1997). Pear variety in modern production. Fragaria, Zagreb, pp. 1-278.

Hampson C.R., Qamme H.A., Hall J. W., MacDonald R.A., King M.C., Cliff M.A. (2000). Sensory evaluation as a selection tool in a apple breeding. Euphytica 111, pp. 79-90.

Hunter D.M., Pinsonneault P., Kappel F., Quamme H.A., Bonn W.G., Layne R.E.C. (1992). Harrow Sweer Pear. HortScience 27, pp.1331-1334.

Janick J. (2002). The pear in History, Literature, Popular Culture and Art. Acta Hort. (ISHS), No.596, pp. 41-52.

Kappel F., Quamme H.A. (1987). Processing quality of pear selection in the Harrow breeding program. Fruit variety Journal 41 (4), pp. 136-140.

Kappel F., Fisher-Fleming R., Hogue E.J., (1995). Ideal pear sensory attributes and fruit characteristics. HortScience 30, pp. 988-993.

Kiprijanovski M., Ristevski B., Popovski H. (2006). Necessity and possibilities for revitalization of pear production in R. Macedonia. Proceeding of Meeting Faculty-Farms 2006. 14, pp. 61-86.

Kiprijanovski M., Ristevski B. (2009). Biological and pomological characteristics of some pear varieties in Republic of Macedonia. Agriculturae Conspectus Scientificus, Vol. 74 No.2 . pp. 123-126.

MacFie H. (1997). Quality and acceptability. International conference an integrated view of fruit and vegetable quality. Postdam, Germany, pp. 11-15.

Rapparini F., Predieri S. (2002). Volatile Constituents of Harrow Sweet Pears by Dynamic Headscape. Acta Hort. (ISHS), No.596, pp. 811-816.

Ristevski B., Pejcinovski F., Kolecevski P., Lazarevska S., Kiprijanovski M. (2004). Integrated and organic pear production, GTZ, Skopje, pp. 1-85

Segre A. (2002). The World Pear Industry: Current trends and prospects. Acta Hort. (ISHS), No.596, pp. 55-59.

Zerbini E. (2002). The Quality of Pear Fruit. Acta Horticulture, No.596, pp. 805-810.

Watada A.E., Abbot J.A., Hardenburg R.E., Lusby W. (1981). Relationships of apple sensory attributes to headspace volatiles, soluble solids and titratable acids. J. Amer. Soc.Hort.Sci.106, pp. 130-132.

ПРОУЧУВАЊЕ НА КВАЛИТЕТНИ КАРАКТЕРИСТИКИ НА НЕКОИ ЕСЕНСКИ СОРТИ КРУШИ

Киприjановски Марjан, Арсов Тошо, Ѓамовски Виктор

Апстракт

Крушата е квалитетно, фино овошје кое е ценето и барано од страна на потрошувачите. Со постојаното зголемување на стандардот и куповната моќ на населението побарувачката на квалитетни плодови од круша станува се поголема. Во Македонија нема доволно производство на круша и поради тоа голем дел од потребите се обезбедуваат преку увоз. Во насадите се култивираат голем број сорти со различни квалитетни карактеристики и време на зреење. Во трудот се презентирани истражувањата на некои квалитетни карактеристики на плодовите од 10 сорти круши со есенско време на зреење. Во проучувањето се опфатени следните сорти: Harrow Sweet, Honey Sweet, Абате Фетел, Пакамс Триумф, Конференс, Магнес, Старкинг Делишес, Хајланд и Боскова Тиквичка. Сортата Виљамовка е употребена како контрола. Проучувањата се изведени во насад од круши лоциран во скопскиот регион во период од три последователни години (2008-2010). Во истражувањето беа вклучени следните параметри: време на зреење, маса и димензии на плодовите, димензии на дршката, содржина на растворливи суви материи и вкупни киселини. Органолептички оценувања на плодовите се правени во два термина и тоа на почетокот на октомври и почетокот на декември. Врз основа на истражувањето констатирано е дека покрај сортата Виљамовка добар квалитет на плодови имаат и сортите Harrow Sweet, Абате Фетел и Пакамс Триумф.

Клучни зборови: круша, сорти, квалитет, оценување.

UDC:634.11-152.61
Original scientific paper

EFFECT OF APPLE VARIETIES ON THE QUALITATIVE CHARACTERISTICS OF APPLE CHIPS PREPARED WITH OSMOTIC TREATMENT

Arjan Ganiji[1*], Kiprijanovski Marjan[2]

[1]Faculty of technology and metallurgy - Skopje, R. Macedonia
[2]Faculty of Agricultural Sciences and food - Skopje, R. Macedonia
[*]e-mail: pena_ag@yahoo.com

Abstract
The aim of this research is to examine the effect of apple varieties on the qualitative characteristics of the chips obtained by applying osmotic drying as pretreatment. For this aim apple chips is prepared from five apple varieties: Idared, Mutsu, Jonagold, Granny Smith and Red Delicious. Qualitative characteristics are examined using a sensoric analysis. Qualitative properties covered by sensoric analysis are: color, aroma, taste, texture and crispy. Samples were cut with a special knife with thickness 1 to 2 mm in the form of a disc diameter of 18 mm. Osmotic solutions were prepared from aqueous solution of sucrose with a concentration of 50%. After 60 min osmotic treatment, samples were dried in air-dryer at 100^{o}C, 120 min. In terms of color best results are obtained for the variety Mutsu, which by the panelists was evaluated with 3.72 while the weakest score is evaluated variety Granny Smith 2.97. Best scores in terms of taste and aroma are obtained from Idared variety, which for aroma is evaluated 3.41 and for taste 3.70, while in terms of aroma and taste again the weakest score was assessed with the variety Granny Smith 2.79 and 2.68. The highest scores in terms of mechanical properties are obtained for the Idared while the weakest of the variety Granny Smith. Best results for eligibility are obtained for Idared variety 3.93, then Jonagold 3.77, Mutsu 3.66, Red Delicious 3.18 while the lowest scores were obtained for the variety Granny Smith 2.77.
Key words: apple, osmotic treatment, chips, sensory analysis.

Introduction

Growth of the population and living standards impose the need for increased food production in quantity, and even more by its quality. Fruits as foods with a lower energy value are more demanding in human nutrition. Apple fruits with their high nutritional properties in human diet have a significant place.

Humans have long used apples as refreshments and food as medicine. Apple fruits are rich in a number of biologically active substances such as carbohydrates, organic acids, vitamins, minerals and anthocyanins. These fruits belong to the group of foodstuffs with high dietetic and prophylactic activity. Apple is the most grown continental fruit species. Apple production in the world is steadily increasing.Apple fruits have a certain period of harvest, and can be consumed during the whole year. This situation highlights the need to storage fruits for a longer period. As a result of microbiological and biochemical activity fruit quality during storage is constantly deteriorating. This imposes the need of development of various methods of preserving fruit quality and extending the period for their consumption. Using different methods of processing apple fruits become fit for

consumption for a long period of time. Dehydration is a classic method of food storage for a long period. Using this method of preservation provides keeping fruits for a long period, while providing less weight and requires less space for storage. Fruit drying commonly performed by applying heat under controlled conditions in order to remove part of the water. This prevents the development of microorganisms, reduces enzyme activity and chemical reactions. Due to the heat treatment in the process of drying comes to a deterioration of certain physical characteristics of fruits such as taste, color and texture. Deterioration of these characteristics makes fruits to become less attractive for the consumers. Besides physical appearance, classical dried fruit have less of certain nutritional components such as vitamins and antioxidants which again reduce the biological value of the product. This disadvantages leads for use of new methods by the food processing industry for improvement of the quality attributes of dried fruits. Need to introduce new methods for drying allows development of different dehydration methods such as: osmotic, microwave, infrared and ultrasonic dehydration various hybrid technologies etc. The application of the osmotic dehydration on food products offers energy efficient procedure with minimal processing and reaching high quality food. Osmotic dehydration has great potential market for the production of high quality food of various kinds. Osmotic dehydration can be defined as a process of simultaneous development of dehydration and absorption by immersion in osmotic solution. In this process, biological material carried out in two opposite processes of mass transfer. This is made possible by the osmotic pressure which occurs as a result of the difference in the concentration of osmotic solution and the solution in the tissues in biological material across the cell membrane tissues. Cell membrane is not selective so along with water to remove other components of biological material, such as: sugars, organic acids, minerals and vitamins.

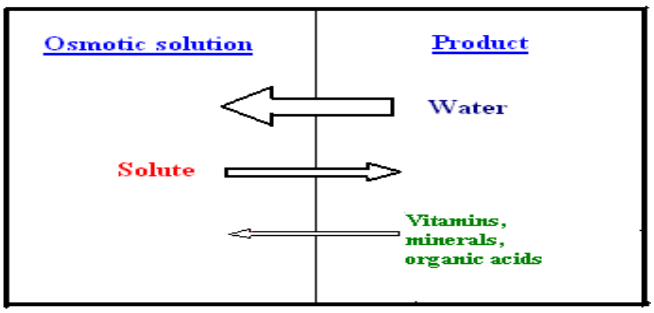


Figure 1. Mechanism of mass transfer with osmotic dehydration

Diffusion of those components is negligible with comparison to water loses and absorption of diluted particles from osmotic solution (Mastrantonio et.al.2005, Ramaswamy, 2003).

An apple chip is attractive product that greatly increases the value of often cheap raw material and expands the production in range of products of apples.

In apple production orchards large number of varieties with different biological and quality characteristics of fruits was used. The choice of variety depends on the environmental conditions in the region, the tradition of growing, the demands of consumers, the purpose of fruits etc. (Kiprijanovski, 2009). During osmotic dehydration among the most important variables affecting the mass transmission beside osmotic pressure, the structure of plant tissue has great influence (Mauro et.al. 2005). Chemical composition of the fruits and physical structure such as porosity, content of plant fiber and skin have also influence on osmotic dehydration (Wais et. al. 2004). Fruits

from the different apple variety differ in numerous parameters which determinate their quality, among them is certainly structure of mesocarp. The main aim of this paper is to determinate the influence of different apple varieties on quality of the chips obtained from osmotic dehydration.

Material and methods

Fruits from the 5 different apple varieties (Idared, Mutsu, Jonagold, Granny Smith and Red Delicious) were used as a material for this investigation. Fruits were collected from the production orchards in R. of Macedonia. Fruits were harvested in full maturity and till the moment of drying was kept in the cold storage at temperature of 4 ^{o}C. Osmotic solutions were prepared with concentration of sucrose. Before osmotic treatment fruits were slices in pieces with circle shape, thickness 1- 2 mm and diameter of 18 mm. Prepared samples were measured on analytical scale, accuracy ±0,0001 g. After the measurement samples are submerged in 50 % osmotic solution. Submerging time was 60 minutes. Relationship between fruit weight and solution was 1:15. Temperature during osmotic treatment was 23-25 ^{0}C. After the treatment fruit slices were dried in conventional drying oven in the duration of 120 minutes. After that was packaged in inter atmosphere of nitrogen in polypropylene. Color change is determined by usage of colorimeter Dr. Lange spectro-color. Color was determinate at fresh, osmotic treated and conventional dried samples during different time intervals. Calibration of the colorimeter was conducted by the manual of the producer. Tree color parameters were measured: L* (light), a*(greenish) and b*(yellowish). Index of darkening was determinate using following equilibrium:

$$I_{pot} = \frac{100}{0,17}\left(\frac{a^{*} + 1,75L^{*}}{5,645L^{*} + a^{*} - 3,012b^{*}} - 0,31\right)$$

Texture of the samples was determinate with TA-XT2 Texture analyzer, Stable Micro System Ltd. For evaluation of the acceptance of the products by consumers, sensory analyzes of the organoleptic attributes of the apple chips was conducted. Evaluation was performed by the 42 panelist between 21-64 years of age. Four of them were male and 38 were female. In the questionnaire, panelists used descriptive and hedonistic test and product evaluation scale intensity.

Results and discussion

For determination of the quality value of each food product final consumers have key role. Evaluation of quality attractiveness and acceptance of the apple chips was preformed trought sensory analyzes of the color, aroma, taste, texture, crispiness and final acceptance. Samples were rated on a scale of 0 to 5. Data of sensory analysis are shown in Table 1 and Figure 1. Concerning the color, the best score from the panelist are given to the apple chips from the Mutsu variety (3.72), while the lowest score was given to the apple chips from Granny smith variety (2.97). The percentage of moisture loss and absorption of soluble substances in the conditions under which it is prepared chips from apples (50% concentration of osmotic solution during osmotic dehydration of 60 minutes) affect the color of the resulting chips. Slices from Mutsu variety has a high percentage of moisture loss (34.41%) and absorption of sucrose (65.87%) while the pieces of the variety Granny Smith has small values of these variables, 13.05% for water loss and 9.98% for the absorption of sucrose. Large values of the water loss and absorption soluble solids contribute to reducing the intensity of the enzyme and unenzyme bolding.

Table 1. Intensity of sensorial characteristics of the cips of different apple cultivars

Cultivar	Color	Aroma	Taste	Texture	Crispness	Acceptability
Idared	3.54	3.42	3.71	4.06	4.35	3.94
Mutsu	3.73	3.27	3.48	3.65	3.88	3.67
Jonagold	3.67	3.27	3.52	3.85	3.98	3.77
Granny Smith	2.98	2.79	2.69	2.81	2.83	2.77
Red Delicious	3.13	3.06	3.00	3.42	3.75	3.19
M	3.41	3.16	3.28	3.56	3.76	3.47

The percentage of moisture loss and absorption of sucrose was also affected the taste and aroma of apple chips. Best grades in terms of flavor and aroma are achieved at variety Idared which aroma is evaluated with 3.41 and taste 3.70. The lowest score for this attributes, again has chips from Granny Smith variety with 2.79 and 2.68 (Fig. 1). Losses of water in the chips from Idared was 37.50%, while absorption of sucrose 67.42%. We presume that high absorbed quantity of sucrose in chips from Idared variety was neutralized by the present acids.

Concerning mechanical attributes highest values were obtained from the chips of Idared while lowest from chips of Granny Smith. It can be concluded that higher quantity of removed water and absorption of the sucrose leads to the texture keeping and increase of crispiness on the chips.

Chips from Idared were high ranked concerning acceptance, followed by Jonagold, Mutsu and Red delicious. The lowest was ranked chips from Granny smith (Figure 1). These results are in accordance to the values of percentage of water losses and sucrose absorption. Taking into account average value of the sensory analyzes by the panelist about acceptance of the apple chips from all variety (3.47) it can be concluded that chips obtained from osmotic treatment is acceptable by the consumers.

Table 2. Instrumental data for color of the apple cultivars

Sample	Color of the apple cultivars (BI)				
	Idared	Mutsu	Jonagold	Granny Smith	Red Delicious
Fresh	8,33	15,00	17,75	17,56	16,29
Osmotically treated	11,30	19,24	23,90	22,81	29,07
Chips	52,31	44,40	31,70	46,56	54,09

Table 3. Instrumental data for crispness of the apple cultivars

Sample	Crispness of the apple cultivar				
	Idared	Mutsu	Jonagold	Granny Smith	Red Delicious
Fresh	1,01	1,10	0,91	1,40	1,01
Osmotically treated	1,35	0,92	1,76	2,64	0,75
Chips	0,25	0,70	0,27	0,58	0,82

Color and crispness of the fresh samples, osmotic treated and apple chips are give in Table 2 and Table 3. Results are presented trough index of bolding (BI). The best results were obtained at chips from Jonagold, while lowest value for this parameter has chips from Red Delicious. Chips from Idared have highest crispness while chips from Red Delicious have the lowest (Table 3).

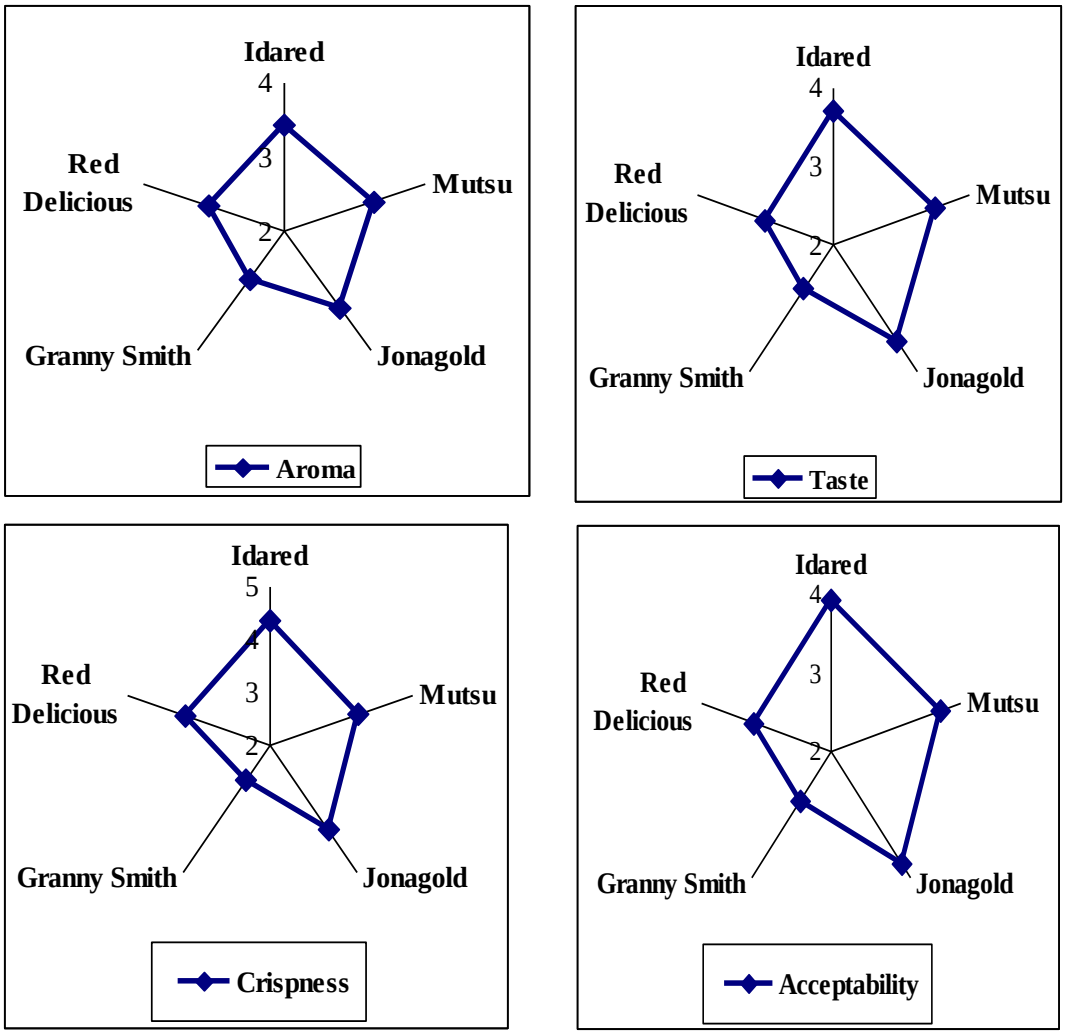


Figure 2. Sensorial profiles of the of apple cips by different assessed parameters

Conclusions

The results got from conducted research show that:

-A chip obtained by osmotic treatment of the five varieties of apples has been accepted by the panelists.

-From sensory analysis best apple chips with osmotic treatment are obtained from a variety Idared while the worst from the variety Granny Smith.

-Sensor properties of apple chips produced by osmotic treatment depend on the percentage of removed water and sucrose absorption during osmotic pretreatment.
-In practice it can be recommended that fruits from Idared variety can be used for producing apple chips by drying through osmotic way.

References

Ali H. S., Moharram H. A., Ramadan M. T., Ragab G. H., (2010).Osmotic dehydration of banana rings and tomato halves, J Amer Sci., 6 (9):383-390.
Gobbi S., (2009). Osmo-air-drying to obtain dried crispy fruits: optimization and modeling of processing and product shelf life, 14th Workshop on the Developments in the Italian PhD Research on Food Science Technology and Biotechnology, Oristano (Italy) 16-1.8.
Konopacka D., Jesionkowska K., Mieszszakowska M., Plocharski W. (2008).The usefulness of natural concentrated fruit juices as osmotic agents for osmo-dehydrated dried fruit production, J Fruit Ornam Plant Res 16: 275-284.
Konopacka D., Jesionkowska K., Klewicki D., Bonazzi C. (2009). The effect of different osmotic agents on the sensory perception of osmo-treated dried fruit, J Hort Sci Biotech 80-84.
Manstrantonio S.D.S., Pereira L.M., hubinger M.D. (2005). Osmotic dehidratation kinetics of guavas in maltose solutions with calcium salt. Alim Nutr Arar.a, 16:309-314.
Mauro M., Monnerat S., Rodrigues A. (2004). Vacuum drying of osmotic dehydrated apple slices. Proceeding of the 14th International Drying Symposium, August 22-25.
Quiles A., Hernado I., peres-Munuera I., Larrea V., Llorka E., Lluch A. (2005). Polyphenoloxidase (PPO) activity and osmotic dehidratation in Granny Smith apple. J. Sci food Agric., 1017-1020.
Lewicky P.P., Porzecka –Pawlak R. (2005). Effect of osmotic dewatering on apple tissue structure. J. Food Eng., 66, 1, 43-50.
Kiprijanovski M., Arsov T., Gjamovski V., Damovski K. (2009). Study of certain introduced apple cultivars in the Prespa region. Acta Horticulturae 825, 125-132.
Janowicz M., Lenart A. (2010). Some physical properties of apples after low –pressure osmotic dehidratation and convective drying. Chem. and process engineering 31, 237-252.
Wais N., Santos V., Marany M., Agneli E., Mascheroni H. (2004). Osmotic dehidratation and combined osmotic dehidratation-hot air drying of banana and apple slices. Sao Paolo, Brasil 22-25 August.

ВЛИЈАНИЕ НА СОРТАТА ВРЗ КВАЛИТАТИВНИТЕ СВОЈСТВА НА ЧИПС ОД ЈАБОЛКА ПРИПРЕМЕНИ СО ОСМОТСКО ТРЕТИРАЊЕ

Арјан Ганији, Кипријановски Марјан

Апстракт

Целта на ова истражување е да се испита ефектот на јаболковите сорти врз квалитативните својства на чипси од јаболка подложени на осмотско сушење. За оваа цел се подготвени чипси од јаболка од пет сорти на јаболка: Ајдаред, Муцу, Јонаголд, Грени Смит и Црвен Делишец. Квалитативните својства се испитувани со употреба на сензорна анализа. Квалитативните својства кои се опфатени со сензорната анализа се: боја, арома, вкус, текстура и крцкавост. Примероците беа сечени со специјален нож во форма на диск со дијаметар од 18 mm и дебелина од 1 до 2 mm. Осмотскиот раствор беше подготвен од воден раствор на сахароза со концентрација од 50 %. После 50 минутно осмотско третирање, примероците беа сушени во сушална на 100 °C, во времетраење од 120 минути. Во однос на бојата најдобри резултати се добиени кај сортата Муцу, која од страна на оценувачите беше оценета со оценка 3.72, додека најниски резултати се добиени кај сортата Грени Смит. Најдобри резултати во однос на вкусот и аромата се добиени кај сортата Ајдаред, чија што арома беше оценета со 3.41 а за вкус 3.70, додека во однос на вкусот и аромата повторно најнизок резултат беше постигнат кај сортата Грени Смит 2.79 и 2.68. Највисоките резултати по однос на механичките карактеристики се дебиени кај Ајдаред додека најниските резултати се добиени кај сортата Грени Смит. Најдобри резултати во однос на подобноста се добиени кај сортата Грени Смит 2.77.

Клучни зборови: јаболко, осмотско третирање, чипси, сензорна анализа.

UDC:634.13
Original scientific paper

MATHEMATICAL MODELS OF A PEAR, VARIABILITY AND APPLICATIONS

Snežana Matić-Kekić[1*], Nebojša Dedović[1]

[1] Faculty of Agriculture, University of Novi Sad, Serbia
[*]e-mail address: snmk@polj.uns.ac.rs

Abstract
Various factors have influence on growth and development of bio-materials. Therefore, shape variability is very important and should be examined. In many processes of heat exchange, as well as in other processes in bio-material handling, very important role play the physical properties of a fruit such as dimensions, shape, surface area and volume. The objective of this work is to find a function which approximates a pear border line as precisely as possible. Previously described estimation of an average pear border line is relying on the sixth order polynomial and proposed algorithm. Also, two different ways of calculating the Williams pear border line are earlier shown. The first one includes spline functions as an estimation of a pear border line, while the second way uses regression function obtained by the nonlinear regression method. The regression function has two independent variables, length and total length of a pear. Border lines of all pears in the sample are fitted with one regression function with large precision (R2=97.48). Surface area and volume of a pear is now calculated based on the regression function and total pear length. In this paper, it is compared different ways of pear border line calculation. Presented surveying methods should be a non-destructive one.
Key words: shape variability, integral calculus, cubic spline, nonlinear regression.

Introduction

Physical properties of fruit (dimensions, shape, surface area and volume) have very important role in many processes of heat exchange and other processes of biomaterial handling (Mohsenin, 1980).Various factors influence the growth and development of bio-materials. Therefore, shape variability is very important and should be examined. It is well known that fruits, including pears, are dominantly irregular in shape. Certain number of measurements must be made for full characterization of fruit shape. Analysis of three mutually perpendicular axes usually contains enough information for volume or surface area modeling. The finite element method was used to discretize the governing differential equations over the actual 3D pear geometry (Wang *et al*., 2006). Pear dimensions were evaluated during the drying process and those data were used to calculate the pear surface area and volume (Guine *et al*., 2006). Cut pears were photographed horizontally and vertically against a millimeter-scaled paper. The shape of the whole pear was replaced with two regular bodies, half of a sphere and a cone. The dimensions and volume were also investigated for cherries (Ochoa *et al.*, 2007), almond cultivars (Altuntas *et al*., 2010) and mango (Spreer and Müller, 2010). If color is an important factor, then the use of digital images is essential (Quevedo *et al*., 2009; Purlis and Salvadori, 2009; Altuntas *et al.*, 2010;). Xiao-bu *et al.* (2010) also used digital images to detect the apple defects. Optimization of digital images was widely studied

(Acketa and Matić-Kekić, 2000; Matić-Kekić *et al.*, 1996). An image processing-based method is appropriate for measuring the volume and surface area of ellipsoidal agricultural products such as lemons, peaches, limes and eggs (Sabliov *et al*., 2002). Now, let us make a short introduction to the approximation one of three methods, that will be presented here. For various kinds of approximation problems, it is frequently advantageous to use piecewise polynomials instead of polynomials. Reason for this lies in the fact that using low-degree polynomials locally is usually more accurate and more efficient than using a high-degree polynomial globally (Ascher *et al*., 1995). The main idea of cubic spline function is that it remains twice continuously differentiable over the observed interval. Program package Mathematica 6 (Wolfram, 1991) was employed for testing the cubic spline approximation of pear border line and for all necessary numerical integrations. This software is very applicable in many other problems related to agriculture (Bodroža-Pantić *et al.*, 2008) and to optimization (Matić-Kekić and Acketa, 1997; Acketa *et al.*, 2000).

The aim of this study was to compare various mathematical expressions for Williams pear border line. Those expressions allow easy estimation of both pear surface area and volume. The presented surveying method should be a non destructive one. Confirmation of precision of mathematical model for pear border line approximation was performed in Dedović *et al.* (2011), as follows: firstly, volumes of the pears were measured by Archimedes' method; secondly, volumes were calculated using numerical integral calculus with assumption that pear could be observed as a rotation body; thirdly, relative errors for calculated volumes were given.

Material and methods

Thirty fruits of Williams pear (*Pyrus communis*) were randomly selected and then halved through the longitudinal axis. Each half was split along the same axis to generate two pear quarters. The core and seeds were removed and half of a pear was placed in a two-axis system, such that the total length (*L*) of the pear was on *l*-axis, and width (*W*) was on the *w*-axis. Zero point was placed at the bulbous end of the pear (see Fig. 1).

The coordinates of the seven points, located on the pear border line $T_i(A_i,B_i)$, i=0,…,6, are presented in Babić *et al.* (2012) and Dedović *et al.* (2011).

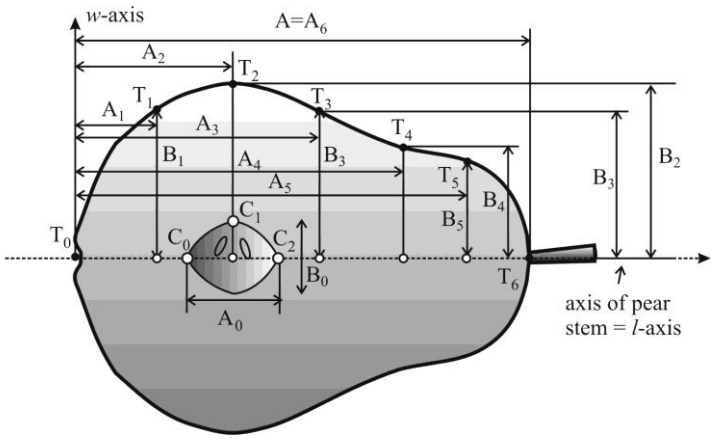


Figure 1. The pear outline and its measured points T_i (A_i,B_i), i=1,…,6, as well as dimensions of pear core A_0 and B_0. Point $T_0(0,0)$ is start point of Cartesian coordinate system with *l*-axis (length) and

w-axis (width); $A_1=0.5\cdot A_2$, $A_3=0.5\cdot(A_2+A_4)$, $A_5=0.5\cdot(A_4+A_6)$, $C_0=(0.5\cdot(A_2-A_0),0)$, $C_1=(A_2,B_0/2)$ and $C_2=(0.5\cdot(A_2+A_0),0)$. This figure is taken from Babić *et al*. (2012).

Among basic dimensions, thickness of a pear was not measured because it was assumed (www.rainierfruit.com/products/pears/img/pears.pdf) that pear could be represented as rotating body, where "stem axis" was, actually, the axis of rotation. Based on this assumption, pear thickness was equal to pear width, and surface area and volume of a pear could be calculated using formulas (1) and (2), respectively. However, pear border line function $f(x)$ must be defined first. Generally speaking, the formulas for the surface area S and volume V of the rotating body within the interval (a,b), where a is the starting point on the x-axis and b the last point on the same axis, for a non negative period of function $f(x)$ are:

$$S(f(x),a,b)=2\pi\int_a^b f(x)\cdot\sqrt{1+(f'(x))^2}\,dx \qquad \text{(surface area of rotating body)} \qquad (1)$$

and

$$V(f(x),a,b)=\pi\int_a^b (f(x))^2\,dx \qquad \text{(volume of rotating body)} \qquad (2)$$

Volumes of the pears from sample, were measured by Archimedes' method and calculated by formula (2), where $f(x)$ was border line function (polynomial function (4), spline function (5) or regression function (6)). Also, surface area of the pears from sample, were calculated by formula (1), where $f(x)$ was border line function.

The quarter of one pear is additionally bounded with two lateral flat surfaces. Flat surface area, denoted as *FS*, bounded by the x-axis and $f(x)$, is calculated as:

$$FS(f(x),a,b)=\int_a^b f(x)\,dx \qquad (3)$$

for $f(x)\geq 0$, $x\in(a,b)$. Surface area and volume of a seed core, can also be calculated by using (1) and (2) since seed core can be considered as a rotating body, too.

Results and discussion

1. Polynomial fitting

In Babić *et al*. (2012), function $f(x)$, which is approximation of pear border line, passes through all seven points T_i, i=0,1,2,…,6 on the average pear border line. Function $f(x)$ is actually sixth order polynomial $P(l)$,

$$P(l)=4.1135\cdot l-0.2531\cdot l^2+0.0093\cdot l^3-0.0002\cdot l^4+2.083\cdot 10^{-6}\cdot l^5-8.5968\cdot 10^{-9}\cdot l^6 \qquad (4)$$

where $l\in[0,\overline{L}]$ is an independent variable, i.e. l is pear length which takes values from 0 to $\overline{L}$, while the average total length of pears is marked as $\overline{L}$ =84.3 mm.

2. Spline functions

The next objective is to determine the polynomial function of lower order than sixth, with the same outline representation. High order of polynomial $P(l)$ produces very small coefficients multiplying l^5 and l^6, which causes less precision and greater errors during the numerical calculations of volumes and surfaces area. If cubic spline involves all seven characteristic points T_i, i=0,1,…,6, the interval of the average pear length [0,84.3] has to be split into four parts. The first subinterval [0,29] contains points T_0, T_1 and T_2, the second one [29,44.5] contains T_2 and T_3 points, the third

subinterval [44.5,60] contains points T_3 and T_4, and the fourth subinterval [60,84.3] contains points T_4, T_5 and T_6. Thus, cubic spline $s(l)$ in (5) is represented by four polynomial functions of third order (one polynomial for each subinterval).

In case when total length of a pear is L=84.3, the function describing pear border line is

$$s(l)=\begin{cases} 3.09764\cdot l-0.0984982\cdot l^2+0.00102846\cdot l^3,\ l\in[0,29], \\ 30.1456-0.011803\cdot l+0.00841199\cdot l^2-0.000196814\cdot l^3,\ l\in[29,44.5] \\ -75.7114+7.10387\cdot l-0.151026\cdot l^2+0.000994001\cdot l^3,\ l\in[44.5,60] \\ 628.3-27.9943\cdot l+0.432242\cdot l^2-0.00223695\cdot l^3,\ l\in[60,84.3] \end{cases} \quad (5)$$

Two previously described methods are based on the same idea. Firstly, functions which approximate average pear border line (polynomial or spline functions) pass through all seven points on the average pear outline. Secondly, those functions are used for stretching or compressing of pear border line for each pear, using the previously proposed algorithm. However, there is the following limitation: for each total pear length, new polynomial function or spline function must be created (this means that each pear from a sample has a shape which can be obtained by stretching or compressing a pear with average border line). In general, it cannot be correct because the shape of a pear from the same cultivar does not have to be equal to the shape of an average pear. These problems can be overcome by using the following approach.

3. Nonlinear regression

Our aim (Dedović *et al.* 2011) was to create only one function which could describe the variability of pear boarder line.

So, the surface (6) is accepted as the final model for pear border line variability:

$$Q(l,L)=-\frac{40.6437}{L^5}\cdot l^6+\frac{116.805}{L^4}\cdot l^5-\frac{130.088}{L^3}\cdot l^4+\frac{72.6492}{L^2}\cdot l^3-\frac{22.9904}{L}\cdot l^2+4.26753\cdot l \quad (6)$$

Very high coefficient of determination R^2=97.48% is obtained for the confidence level of 95%. The main advantage of this model is that there is no need for extra algorithm as in Babić *et al.* (2012). Another advantage is that this (third) method is more precise than the first two methods previously presented. Moreover, all experimental points were used in nonlinear regression method and not only the mean values of seven coordinates on the pear border line.

Conclusions

The Williams pear border line function is presented by: polynomial function, spline function and nonlinear regression function.

Cubic spline has similar properties as the polynomial function for average pear border line approximation. The only advantage of cubic spline is more acceptable polynomial coefficients.

Pear border line variability implies that priority must be given to the nonlinear regression function for the following reasons:

-it calculates pear border line for smaller and larger pears more precisely than other two proposed functions;

-volumes obtained by using regression function as pear border lines approximation are different from real volumes (measured by Archimedes' method) with relative error 6.97%. Removing the three smallest pears from the sample, relative error is 4.24% only (Dedović *et al.* 2011). Very high

precision in volume of the pears calculation implies that surface area of a pear can be calculated very precisely as well.
-it is clear that precise determination of the pear border line function, surface area and volume of a pear is more accurate;
-only one function is sufficient for pear border line formation, for arbitrary total pear length;
-this function does not require any additional algorithm.
These results are useful for packing, storage as well as in technology processes, biomaterial handling and drying processes.

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References
Acketa, D.M., Matić-Kekić, S. (2000). Asymptotics for the maximal number of edges of a digital convex arc. Indian J. Pure Appl. Math. 31, pp. 583-590.
Acketa, D. M., Mudrinski, V., Matić-Kekić, S. (2000). A large collection of 2-designs from a wreath product on 21 points. Ars Combinatoria 54, pp. 109-118.
Altuntas, E., Gercekcioglu, R., Kaya, C. (2010.) Selected mechanical and geometric properties of different almond cultivars. Int. J. Food Prop. 13, pp. 282-293.
Ascher, U.M., Mattheij, R.M.M., Russel, R.D. (1995). Numerical Solution of Boundary Value Problems for Ordinary Differential Equations. SIAM, Philadelphia.
Babić, Lj., Matić-Kekić, S., Dedović, N., Babić, M., Pavkov, I. (2012). Surface area and volume modeling of the Williams pear (*Pyrus communis*). Int. J. Food Prop. 15(4), pp. 880-890.
Bodroža-Pantić, O., Matić-Kekić, S., Jakovljev, B., Marković, Đ. (2008). On MTE-model of mathematics teaching: studying the problem related to a plane division using the MTE-model. Int. J. Math. Educ. Sci. Tech. 39(2), pp. 197-213.
Dedović N., Matić-Kekić S., Ponjican, O., Karadzic, B. (2011). New approach to border line evaluations for whole sample of Williams pear (*Pyrus communis*). Computers and Electronics in Agriculture 79(1), pp. 94-101.
Guine, R.P.F., Ramos, M.A., Figueiredo, M. (2006). Shrinkage characteristic of porosity of pears during drying. Drying Technol. 24, pp.1525-1530.
Matić-Kekić, S., Acketa, D. M. (1997). Non-greedy optimal digital convex polygons. Indian J. Pure Appl. Math. 28(4), pp. 455-470.
Matić-Kekić, S., Acketa, D. M., Žunić, J. (1996). An exact construction of digital convex polygons with minimal diameter. Discrete Math., 150, pp. 303-313.
Mohsenin, N.N. (1980). Physical Properties of Plant and Animal Materials. Gordon and Breach science publishing, New York.
Ochoa, M.R., Jesseler, A.G., Pirone, B.N., Marquez, C.A., De Michelis, A. (2007). Analysis of shrinkage phenomenon of whole sweet cherry fruits (Prunus avium) during convective dehydration with very simple models. J. Food Eng. 79, pp.657-661.
Purlis, E., Salvadori, V.O. (2009). Modeling the browning of bread during baking. Food Res. Int. 42, pp. 865-870.

Quevedo, R., Díaz, O., Ronceros, B., Pedreschi, F., Aguilera, J.M. (2009). Description of the kinetic enzymatic browning in banana (Musa cavendish) slices using non-uniform color information from digital images. Food Res. Int. 42, pp. 1309-1314.
Sabliov, C.M., Boldor, D., Keener, K.M., Farkas, B.E. (2002.) Image processing method to determine surface area and volume of axi-symmetric agricultural products. Int. J. Food Prop. 5, pp. 641-653.
Spreer, W., Müller, J. (2010). Estimating the mass of mango fruit (Mangifera indica, cv. Chok Anan) from its geometric dimensions by optical measurement. Comp. Electron. Agricul. doi:10.1016/j.compag.2010.10.007
StatSoft. Statistica: data analysis software system. Version 9. Available at: http://www.statsoft.com. Accessed on: 8 Nov. 2010.
Wang, J., Ying, T., Cheng, K. (2006). Finite element modelling and MRI validation of 3D transient water profiles in pears during postharvest storage. J. Sci. Food Ag. 86,.745-756.
Wolfram, S. (1991.) Mathematica: A System for Doing Mathematics by Computer. Addison-Wesley Publishing Company, California.
Xiao-bo, Z., Jie-wen, Z., Yanxiao, L., Holmes, M. (2010). In-line detection of apple defects using three color cameras system. Comp. Electron. Agricul. 70(1), pp.129-134.

МАТЕМАТИЧКИ МОДЕЛИ НА КРУША, ВАРИЈАБИЛНОСТ И АПЛИКАЦИИ

Снежана Матич-Кекич , Небошја Дедович

Апстракт
Различни фактори влијаат врз порастот и развојот на биолошките материјали. Затоа, разликите во обликот се многу значајни и треба да се испитуваат. При процесите на размена на топлина, како и кај други процеси при справувањето со биолошки материјал, многу значајна улога имаат и физичките карактеристики на овошјето како што се димензии, форма, површина и волумен. Целта на ова истражување е да се изнајде функција со која граничната линија кај крушата се пресметува што е можно попрецизно. Предходно опишаните пресметки за просечната гранична линија на круша се базираат на шестиот полиноминален ред и предложен алгоритам. Исто така, два различни начини за пресметување на Вилијамовата гранична линија на крушата се предходно прикажани. Првиот опфаќа долги функции за пресметка на граничната линија на крушата, додека при вториот начин се користи регресивна функција која е добиена со нелинеарен регресивниот метод. Регресивната функција има две независни променливи, должина и вкупна должина на круша. Граничните линии на сите примероци од круши се вклопени во една регресивна функција со голема прецизност (R^2=97.48). Површината и волуменот на крушата се пресметани врз основа на регресивната функција и вкупната должина на крушата. Во овај научен труд се споредени различни начини на пресметување на граничната линија на крушата.
Клучни зборови: различни облици, интегрална пресметка, cubic spline, нелинеарна регресија.