*Bulgarian Journal of Agricultural Science, 24 (No 6) 2018, 1065–1070*

# Comparative investigations of Oblachinska sour cherry on own root and grafted on mahaleb

**Marjan Kiprijanovski[1], Toso Arsov[1], Viktor Gjamovski[2], Nikola Saraginovski[1*]**

[1]*Cyril and Methodius University, Faculty of Agricultural Sciences and Food, Skopje 1000, Republic of Macedonia*
[2]*Cyril and Methodius University, Institute of Agriculture, Skopje 1000, Republic of Macedonia*
[*]*Corresponding author:* nikola_saraginovski@yahoo.com

## Abstract

Kiprijanovski, M., Arsov, T., Gjamovski, V., & Saraginovski, N. (2018). Comparative investigations of Oblachinska sour cherry on own root and grafted on mahaleb. *Bulgarian Journal of Agricultural Science*, *24*(6), 1065–1070

Oblachinska sour cherry originates from the population of sour cherry from the Balkan Peninsula. This variety has high economic value for the Balkan region. In the Republic of Macedonia Oblachinska sour cherry is a unique cultivar which is cultivated in commercial orchards. These orchards are mainly established by own rooted trees. Despite numerous advantages, own rooted plants have a lot of disadvantages such as: poor development of root system, drought sensitivity, suckering, uniformity of the trees, mechanical harvest unsuitability, and root borer suffering in dry conditions. In order to eliminate these negative characteristics, we carried out a comparative investigation of this variety planted on own roots and grafted on *Prunus mahaleb*. The research was conducted in productive orchard in Tikves region (central part of Macedonia). The orchard was established in 2002 and the research was conducted in 4 consecutive years (2005-2008). Two variants of grafted trees on mahaleb were evaluated, grafted on height of 10 and 80 cm. Own rooted trees were used as a control. The vegetative growth of the trees, the yield and the fruit quality were followed during the investigation. An excellent compatibility on Oblachinska sour cherry with mahaleb rootstock was noticed from the recorded dates. The trees are medium vigorous, they are more tolerant to drought and attacks of root borer. The high grafted trees have better growth, and the yield and the fruit quality are better compared to other variants.

*Keywords: Prunus cerasus*; grafting; rootstock; yield; productivity; fruit quality

## Introduction

Oblachinska sour cherry originates from the population of sour cherry from the Balkan region where it has high economic value. On the territory of the R. Macedonia the Oblachinska is a unique sour cherry variety which is cultivated in commercial orchards. These orchards are mainly established by own rooted trees. The population of Oblachinska is heterogeneous, with diverse biological properties, which creates problems in productive orchards (Miletic et al., 2008).

Different rootstock can be used for every fruit variety, depending on the ecological conditions and the planned cultivation technology. Some rootstocks have deep root system and they are resistant of drought, some are tolerant of wet soils, and others are tolerant of carbonates and soil salinity.

The resistance of illnesses, tired soils, nematodes and other soil pests is also different. Rootstocks vigorousness is different. The vigorous rootstocks are more resistant of drought and poor soils, they bear later, the trees are higher and the agro technical measurements are harder done. The less vigorous rootstocks give smaller fruit trees which bear earlier, give more qualitative fruits, higher efficiency per unit area, the fruit trees are low and they can be pruned and harvested from the ground.

Oblachinska sour cherry has shallow, weak root system, it is sensitive to drought and flat-headed woodborer, give a lot of suckers and because of the shallow root system it is unsuitable for mechanical harvest by shaking (Ristevski et al., 2002). The yield and the success in fruit production are affected by the choice of cultivars, rootstocks, improvement of the production technology and intensification of production objects performed through increased density of planting (Grzyb and Gronek, 1991; Mika et al., 2000).

The growth and bearing of the sour cherry are related to the variety, rootstocks and the soil fertility (Wociór, 2008). It is commonly known that the growing and the yield of sour cherry trees are affected by the genetic factors of the variety and the rootstock (Anderson et al., 1993; Hrotkó et al., 1993). The yield, fruit weight, stone weight and sugar content of the fruit from Oblachinska sour cherry depend on rootstocks, with better results on *P. mahaleb* compared to own root (Milutinovic et al., 2005). The root system type plays an important role in the growth and productivity of sour cherry trees. Own rooted trees are promising to be smaller and more productive than trees grafted on *Prunus avium* seedlings (Jadczuk et al., 1997). Oblachinska sour cherry has excellent affinity with *P. mahaleb* (Kolekevski et al., 2004). Klaas et al. (2005) observed that the trees from sour cherry originated in vitro are more vigorous than trees grafted on *P. mahaleb* seedlings. In the first year of cropping, the own rooted trees had higher yield compared to grafted trees. Also, damages from winter frost were more serious on grafted trees than on own rooted trees.

*P. mahaleb* seedling is semi vigorous rootstock with deep root system, very resistant to drought, calcareous soil and low and height temperatures and has excellent affinity with Oblachinska sour cherry. It can be grafted at the height of 10 cm (low grafting) and at the height of 80 cm (high grafting). The trunk of *P. mahaleb* is very healthy, tolerant to big temperature amplitudes, diseases and mechanicals injuries (Ristevski et al., 2002). The mahaleb seedlings used as rootstocks for cherry give good results on saline and calcareous soil (Ribakov, 1973). According to Anderson et al. (1993), smaller sour cherry trees have greater yield efficiency compared with trees which have greater trunk diameter. The Oblachinska sour cherry trunk is more sensitive to winter frosts, bark cracking, cytospora canker, monilinia, occurrence of resin, flat-headed woodborer e.g., comparing to trunk of *P. mahaleb* seedlings.

Davarynejad et al. (2009) reported that Oblachinska sour cherry has dwarf growth and can be used as interstock for reducing vigorousness of the grafted trees of sour cherry cultivars. Rootstocks affect productivity, precocities, tree growth, tree architecture, suckering capacity, yield, fruit size, fruit quality and adaptability to different soil and climate conditions (Dimov, 1990; Hrotkó, 1993; Koleva, 1994).

Production features of sour cherry cultivars can be improved by using an appropriate rootstock which, to various degrees, can affect the growth and the yield of the trees (Kopytowski, 2010).

High budding on F 12/1 is not recommended for sour cherry since it creates a greater risk of winter damage to the rootstock and produces excessively vigorous trees.

So far researches have shown that the rootstock and the root type of the sour cherry have important influence on the entire development, fruitfulness and fruit quality. However, the obtained results are often different, some authors give preference on the vegetative roots, while in other researches grafted trees give better results.

The aim of this research was to evaluate the influence of the rootstock and the height of grafting on vegetative growth of the trees, productivity and fruit quality at Oblachinska sour cherry grown in adequate ecological conditions and growing technology.

## Materials and Methods

The investigations were carried out in experimental orchard located in Negotino – central part of the Republic of Macedonia. One-year old Oblachinska sour cherry trees were used for establishment of the experimental orchard.

The experiment was conducted in tree variants:

1. Own rooted trees propagated by suckers;
2. Trees grafted (at height above soil surface of 10 cm) on mahaleb seedlings;
3. Trees grafted (at height above soil surface of 80 cm) on mahaleb seedlings.

The trial orchard was established in autumn of 2002 year. The distance between the trees was 4 x 2.5 m (1000 trees per hectare) at the grafted trees, and 4 x 2 m (1250 trees per hectare) at the own rooted trees. The experimental plot has been arranged in randomized block design with 3 replications using ten trees per variant in replication.

The orchard was cultivated with standard technology. The soil surface was maintained with clean cultivation. The fertilization was performed with 10 t/ha poultry manure on every second year, combined with NPK and nitrogen fertilisers. In the summer months the orchard was irrigated with a sprinkling, but the irrigation was not adequate to the needs of the plants. The crown trees were trained as open vase with 4-5 scaffold branches.

The dynamics of growth of the trunk diameter was carried out since the planting of the orchard, till the end of 2010. Each year the trunk diameter was measured on 30 cm above ground. Dimensions of the crown were measured at the end of the season in 2009. Trunk cross section area (TCSA) and tree canopy volume (TCV) were calculated from those measurements. Yield per tree was determinate on harvest time in 2006, 2007, 2008, 2009 and 2010. The fruit quality parameters were evaluated in laboratory with standard methods. Cumulative yield for the whole period was computed. The yield efficiency was calculated as cumulative yield for 2006–2010 to TCSA and TCV at the end of the season in 2010.

Statistical analysis was performed using SPSS 14.0 software. 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 fruit production. The trial orchard was spaced on altitude of 220 m. In the investigation period the average yearly temperature was 13.5°C, average temperature in period of vegetation 20.2°C, average temperature in summer period 24.3°C, average yearly rainfalls were 450 mm, average rainfalls in period of vegetation 210 mm, and average rainfalls in summer were 80 mm.

Consequently, it could be emphasized that the conditions for sour cherry trees growing were not the most adequate in the investigated period, taking into consideration the climate conditions and the possibilities for irrigation.

The soil in the experimental orchard was clay loam, with pH 7.0 (KCl), very high content of phosphorous (38.8 mg/100 g) and a high content of potassium (32.5 mg/100 g).

**Trunk cross section area (TCSA) and tree canopy volume (TCV)**

The trunk diameter is an integral indicator of the whole vegetative potential of the trees. Higher absorption of the root system helps the organic matter production to increase in the crown, that contributes to the forming of more elements of xylem and phloem, which, at the end, is registered through the increase of the trunk diameter.

If the tree develops in better conditions, for which the rootstock has a great influence, the trunk will have a stronger cambial activity, making it growth higher.

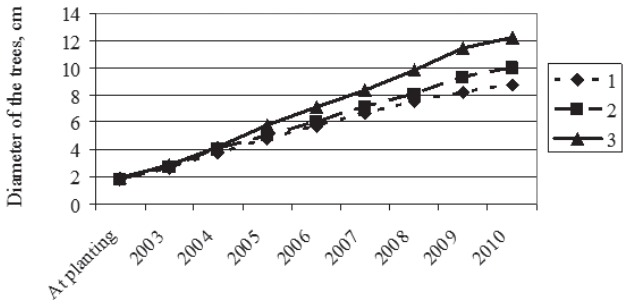


**Fig. 1. Growth dynamic of the trunk diameter**

As shown in Fig. 1, throughout the studied years, the own rooted trees of Oblachinska sour cherry showed lower vigorousness, compared with trees on rootstocks of mahaleb. It was manifested by a reduced number and total length of shoots per tree in the first year after planting. Also, statistically significant lower values for the trunk cross section area in successive periods were manifested as shown in Table 1. After seven years of study, the trees grafted on rootstock mahaleb on height of 80 cm had a bigger size by 95.2% expressed as trunk cross section area, and by 31.2% expressed as tree crown volume, compared with own rooted trees (Table 2). The high grafted trees are the most vigorous, with statistically significant differences compared to the other variants. The low grafted trees on mahaleb had higher trunk growth than own rooted trees, as seen on Table 1.

**Table 1. Trunk cross section area (TCSA), cm²**

| Variant | TCSA, cm² | | | | | | | | | Index |
|---|---|---|---|---|---|---|---|---|---|---|
| | At planting | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | |
| 1 | $2.45^{b}$ | $5.49^{a}$ | $10.97^{b}$ | $17.79^{b}$ | $25.52^{b}$ | $34.65^{b}$ | $44.18^{b}$ | $53.15^{c}$ | $60.20^{c}$ | **100.0** |
| 2 | $2.58^{b}$ | $5.75^{a}$ | $12.63^{ab}$ | $20.18^{b}$ | $28.90^{b}$ | $40.21^{ab}$ | $51.49^{b}$ | $67.83^{b}$ | $77.65^{b}$ | 128.9 |
| 3 | $3.05^{a}$ | $6.37^{a}$ | $13.77^{a}$ | $26.73^{a}$ | $39.73^{a}$ | $54.59^{a}$ | $76.57^{a}$ | $103.80^{a}$ | $117.50^{a}$ | 195.2 |

Values followed by the same letter in a column were not statistically different ($P < 0.05$)

**Table 2. Crown parameters to end of 2010 year**

| Variant | Width of the crown, m | Height of the trees, m | Volume of the crown (TCV), m³ | Index |
|---|---|---|---|---|
| 1 | $2.31^{b}$ | $2.29^{b}$ | $4.20^{c}$ | 100.0 |
| 2 | $2.46^{a}$ | $2.43^{a}$ | $5.16^{b}$ | 122.9 |
| 3 | $2.62^{a}$ | $2.46^{a}$ | $5.71^{a}$ | 131.2 |

Values followed by the same letter in a column were not statistically different ($P < 0.05$)

Davarynejad et al. (2009) concluded that Oblachinska sour cherry used as interstock, reduced TCSA of the trees for three times compared with the trees grafted directly on rootstock mahaleb. Wociór (2008) reported that growth of the sour cherry trees depends on rootstocks and soil fertility. He concluded that the trunk and crown size on fertile soil grafted on mahaleb grew worse, forming 12% thinner trunk and over 20% smaller crowns compared with trees grafted on mazzard. Contrary, on poor sandy-loam soil the crowns of trees grafted on mahaleb have been significantly, more than 40% bigger than those on mazzard. Świerczyński and Stachowiak (2004) presented that the growth of sour cherry trees depends on the cultivar and the rootstock. The trees grafted on vegetative rootstock F12/1 grows much stronger compared to trees on mazzard seedling. Own rooted trees of Schattenmorelle showed lower vigorousness, compared with trees on rootstocks. It was manifested by a reduced number and total length of shoots per tree in the first year after planting. Also, a significant decrease of the trunk cross section area in successive periods was manifested. Crown dimensions depend on lots of factors, and one of the most significant is the rootstock vigorousness. In the productive orchard, crown dimensions are determined by the planting distance, and the correction is made with crown forming and pruning.

As shown in Table 2, among the tested variants, the trees grafted on mahaleb on height of 80 cm, have the greatest TCV, followed by trees grafted on mahaleb on height of 10 cm and own rooted trees of Oblachinska sour cherry. Statistically significant difference of the crown parameters has been observed among the researched variants. These results agree with the findings on Davarynejad et al. (2009), who found out that sour cherry trees of all investigated cultivars with interstock of Oblachinska have smaller canopy compared with trees grafted directly on mahaleb.

Sotirov (2005) presented that own rooted trees have smaller crown volume from 1/3 to 1/2 compared with trees grafted on mahaleb rootstock depending on the investigated sour cherry cultivars. High budding resulted in more vigorous growth of Schattenmorelle scion in the nursery and orchard (Sadowski et al., 1993).

**Yield per unit area and yield efficiency**

The cumulative yield per unit area is also the greatest at high grafted trees, and lowest at the own rooted trees. As shown in Table 3, the cumulative yield per unit area, for all investigated periods, at high grafted trees is greater to 23,1% compared to own rooted trees.

Different investigations reported that rootstocks have significant effect on the yielding of sour cherries, but the soil type and the others ecological conditions play a great role in the soil behavior (Perry et al., 1993; Świerczyński and Stachowiak, 2004). Wocior (2009) presented that the trees of sour cherry cultivar Lutovka grafted on mazzard cherry on fertile soil give average yield by 10% higher than on mahaleb. Contrary, trees grafted on mahaleb give about 70% higher yield than trees grafted on mazzard cherry, on poorer soils.

A number of researches of different combinations of sour cherry cultivar/rootstock indicated that the increase of vigorousness of the tree increases cumulative yield for a long period. Bujdoso et al. (2004) reported that in intensive sour cherry orchards the moderate vigorous rootstocks give the best yield and fruit quality.

Milikan and Hibbard (1984) pointed that rootstock, interstock and scion may effect cherry tree yield and yield efficiency. Rootstocks significantly influenced yield at Oblachinska sour cherry with the best results on mahaleb (Milutinovic et al., 2005). The yield of high-budded trees of Schattenmorelle sour cherry on rootstock F12/1 is higher, due to the increased tree size (Sadowski et al., 1993). According to Anderson et al. (1993), there is a wide range in yield among trees on different rootstocks at Montmorency sour cherry, with yielding of 34.6 kg at the trees on mahaleb.

The yield efficiency is a complex index which includes the vegetative growth of the tree and its productivity. In our experiment the best yield efficiency (yield /TCSA and yield/TCV) was found at low grafted trees (var. 2) as shown in Table 4. Previous publications indicated that, besides the rootstock, genetic factors also affect the growth, productivity and yield efficiency at sour cherry trees (Anderson et al., 1993; Hrotkó et al., 1993; Klaas et al., 2005; Kopytowski et al., 2010). Wocior (2008) reported that yield efficiency at sour cherry trees depends on rootstock, cultivar and soil fer-

**Table 3. Yield per unit area**

| Variant | Yield per unit area, t/ha | | | | | | Index |
|---|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | 2009 | 2010 | Cumulative | |
| 1 | 9.37[a] | 16.10[a] | 20.66[b] | 18.96[b] | 17.78[c] | 82.87[b] | 100.0 |
| 2 | 6.95[ab] | 13.63[ab] | 23.92[ab] | 25.00[a] | 24.75[b] | 94.25[a] | 113.7 |
| 3 | 6.03[b] | 14.93[b] | 26.33[a] | 26.17[a] | 28.55[a] | 99.01[a] | 123.1 |

Values followed by the same letter in a column were not statistically different ($P < 0.05$)

tility. These parameters are different depending on the rootstocks, age of the trees, ecological conditions etc. Jadczuk et al. (1997) found out that smaller sour cherry trees, caused by rootstocks, have higher cropping efficiency compared with more vigorously trees.

Our results corresponded with the previous investigations.

**Table 4. Yield efficiency**

| Variant | Yield per TCSA kg/cm$^2$ (average 2006–2010) | Yield per crown volume kg/m$^3$, (average 2006–2010) |
|---|---|---|
| 1 | 0.371$^a$ | 3.467$^b$ |
| 2 | 0.384$^a$ | 3.653$^a$ |
| 3 | 0.270$^b$ | 3.158$^c$ |

Values followed by the same letter in a column were not statistically different ($P < 0.05$)

**Yield 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, rootstock, age of the trees, ecological conditions, development of the tree, applied agro and pomotechnical measures, etc. As shown in Table 5, in the investigated period, the highest cumulative yield was registered on high grafted trees on rootstock mahaleb (99.01 kg). The lowest cumulative yield gave own rooted trees (66.31 kg). Because of the greater vigorousness of the trees grafted on mahaleb, the productivity is smaller, but later in the attainment of the projected size of the canopy, it increases. Cumulative yield for five years at high grafted trees is 49.3 % greater compared to own rooted sour cherry trees. There was statistically significant difference in cumulative yield among grafted trees and own rooted trees, but there was not significant difference among high and low grafted trees. There is a positive correlation between the vigorousness and cumulative yield of the trees.

**Fruit quality**

Population of Oblachinska sour cherry is very heterogeneous, having a high number of selections with diverse biological properties. The fruits are small to medium size, from 2.5-4 g (Milatović et al., 2015). From previous experiences and in contemporary orchards, when intensive agro technique is used, it is possible that the fruits have average weight of 4.0-4.5 g.

Rootstocks significantly influenced fruit weight, stone weight and sugar content of fruit, but the best results give the trees grafted on mahaleb (Milutinovic et al., 2005).

The sour cherry fruit quality expressed by the weight of the fruit and fruit parameters depend on the cultivar and the rootstock (Kopytowski et al., 2010).

The results of our investigations show that rootstock influences the fruit quality of Oblachinska sour cherry, but the differences are not statistically significant, except at fruit weight (Table 6).

## Conclusions

The root system has an influence on growth and productivity of the sour cherry trees. The results from the conducted research show that the own rooted trees have small dimensions suitable for hand harvest, but they are very sensitive to drought and are easily attacked by flat-headed root borer. The trees give many suckers whose removal absorbs many labor and costs. Because of shallow root system, own rooted trees are not suitable for mechanical harvest. The seedlings of mahaleb have moderate vigorousness, with a strong root system, very resistant to drought, winter frost, pests, carbonates and have a great affinity with Oblachinska sour cherry.

**Table 5. Yield per tree, kg**

| Variant | Yield per tree, kg | | | | | | Index |
|---|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | 2009 | 2010 | Cumulative | |
| 1 | 7.50$^a$ | 12.88$^b$ | 16.53$^b$ | 15.17$^b$ | 14.23$^c$ | 66.31$^b$ | 100.0 |
| 2 | 6.95$^{ab}$ | 13.63$^{ab}$ | 23.92$^a$ | 25.00$^a$ | 24.75$^b$ | 94.25$^a$ | 142.1 |
| 3 | 6.03$^b$ | 14.93$^a$ | 26.33$^a$ | 26.17$^a$ | 25.55$^a$ | 99.01$^a$ | 149.3 |

Values followed by the same letter in a column were not statistically different ($P < 0.05$)

**Table 6. Fruit quality**

| Variant | Soluble solid matter, % | Total acids, mg/% | Fruit weight, g | Stone weight, g | Randman, % |
|---|---|---|---|---|---|
| 1 | 18.8$^a$ | 1.74$^a$ | 2.64$^a$ | 0.25$^a$ | 90.53$^a$ |
| 2 | 18.6$^a$ | 1.80$^a$ | 2.88$^b$ | 0.28$^a$ | 90.28$^a$ |
| 3 | 18.5$^a$ | 1.75$^a$ | 2.96$^b$ | 0.29$^a$ | 90.20$^a$ |

Values followed by the same letter in a column were not statistically different ($P < 0.05$)

The seedling of mahaleb can be grafted with Oblachinska sour cherry low on 10 cm and high on 80 cm. High grafting, where mahaleb is, the root system and the trunk has many advantages and can be recommended for use in practice.

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*Received:* January 24; *Accepted:* March 29; *Published:* December 31