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INITIAL GROWTH AND PHYSIOLOGICAL PARAMETERS OF ROMANIAN SWEET CHERRY CULTIVARS ON IP – C7 ROMANIAN DWARFING ROOTSTOCKS

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ABSTRACT

Grafting is widely used in horticulture to improve fruit crop production. The selection of rootstocks in the grafting process depends on soil conditions, local climatic and environmental resources. The objective of this research was to assess the growth and physiological behavior of different national sweet cherry varieties. The cherry cultivars i.e. Radu, Maria, Bucium, and Daria were grafted on IP-C7 dwarf rootstocks. It is demonstrated that the IP-C7 Romanian rootstock is compatible with Romanian sweet cherry varieties and can be used successfully for the establishment of intensive cherry plantations. The evaluation of the rootstock - scion interactions showed graft compatibility between the studied sweet cherry cultivars and dwarfing rootstocks. Plant vigor, number of buds and photosynthetic capacity were influenced by the interaction between rootstock and scion. The lowest trunk cross sectional area (TCSA) determined by IP-C7 was recorded in Radu cultivars. The Maria sweet cherry cultivar was the most vigorous in terms of trunk cross sectional area and trunk circumference. Rootstock - scion interactions revealed different photosynthetic capacity. Assimilatory pigments were differently influenced in different rootstock - scion combinations. The rootstock - scion combination evaluated in this study may be useful to develop high-density orchards.

Key words: dwarf rootstocks, photosynthesis, *Prunusavium* L., trunk cross-sectional area.

INTRODUCTION

Romania's annual production of cherries is around 81,800 tones. Romania, with 6,853 ha of sweet cherries, is the eighteenth largest producer in the world and occupies the third place in the world as yield efficiency with 11.9 tha^{-1} (FAOSTAT 2011). Dwarfing rootstocks are used to develop high density orchards, increase disease resistance, precocity, and yield and reduce tree height. They are an important part of the competitive technologies used in modern fruit growing (Facteau *et al*., 1996; Lang *et al.*, 1997; Webster, 1998; Atkinson and Else, 2001; Whiting *et al*., 2005; Seleznyova *et al*., 2008; Prassinos *et al.*, 2009). Milošević *et al.* (2014) investigated the impact of Mazzard seedlings and Colt rootstocks on tree growth and other features of seven sweet cherry cultivars which were grown in a high- density planting system. Results showed that most of the evaluated traits significantly varied between rootstocks and among cultivars. Twelve rootstocks of sweet cherry grafted with the cv. Lapins were tested to identify the growth and productivity performance in order to create high-density planting systems (Lanauskas *et al.*, 2012).

Rootstocks are also used to improve the resistance of trees to biotic and abiotic stress (Larsen *et al*., 1987; Webster, 1995). Freezes during early spring can affect the viability of flower buds of cherry tree and in this context, it is a serious problem for growers. Identification of the critical temperatures of cherries buds at different development stages was investigated for Bing, Chelan and Sweetheart cultivars (Salazar-Gutiérrez *et al.*, 2014). The identification of the morphological and anatomical characteristics of rootstocks is an important tool in understanding their influence on the growth of the scion (Zoric *et al*., 2012). The rootstock may influence the photosynthesis parameters in diverse groups of horticultural species (De Jong and Doyle, 1985; Flore and Lakso, 1989; Layne and Flore 1992; Layne and Flore, 1993; Pérez and Monge, 1997; Flore and Layne 1999; Lichev and Berova, 2004; Malcolm *et al*., 2008; Cantín *et al.*, 2010). It is found that rootstocks may affect physiological parameters of grafted sweet cherry trees expressed by gas exchange and chlorophyll a fluorescence, chlorophyll a and b, and carotenoids (Gonçalves *et al.,* 2005). The rootstock - scion combination may determine the training system for intensive sweet cherry orchards. It is a cultivation measure expressed by plantation density and canopy size, which can influence fruit quality, yield and labor cost (Radunić *et al.,* 2011). Dwarfing rootstocks may induce increases in the number and size of flowering spurs on older wood, increase precocity, yield per tree size and in the meantime, may reduce the amount of scion dry weight, excessive shoot growth and scion leaf area (Atkinson and Else, 2001). Thus, it is unlikely for a single rootstock to have all the desired properties. The selection of grafted sweet cherry trees depends on the conditions of the growing areas and the objectives of the producers (Cantín *et al.*, 2010). Bujdosó and Hrotkó (2014) tested ten dwarfing rootstocks grafted with sweet cherry cultivars in non-irrigated conditions.

Thus, the identification of the most suitable rootstocks and planting of grafted trees on the specified rootstock could be of significant economic importance for increasing production as well as fruit quality. Therefore, it is important to select an appropriate rootstock - scion combination to provide a tool for managing high density orchards in Romanian growing conditions. The aim of this study was to assess the effect of the rootstock on the vegetative growth and physiological parameters for some Romanian sweet cherry cultivars. Comparative analysis of trees of Romanian sweet cherry cultivars grafted on Romanian dwarf rootstock was conducted for photosynthetic activity, chlorophyll (chl) levels (chlorophyll a, chlorophyll b, total chlorophyll, chl a/b ratio) and carotenoids (car). Vegetative growth parameters such as trunk cross-sectional area (TCSA), vegetative and flower buds, and length of shoot in *Prunusavium* L. cultivars grown in intensive orchards were also investigated to assess the influence of the selected scion - rootstock combination.

MATERIALS AND METHODS

Plant material and culture conditions: The studies were carried out at the Research Institute for Fruit Growing Pitesti - Maracineni. This research institute is one of the most important institutions in Romania in the field of fruit growing technologies and fruit tree breeding. In the spring of 2009 a high-density sweet cherry orchard was established. The intensive cherry orchard is situated in one of the most important horticultural areas of Romania. The planting system chosen for the experimental plot was 4 m between rows and 2 m between trees within row, an intensive orchard with 1,250 trees/ha. Trees canopy is trained to a spindle for intensive orchards with permanent basal branches. The orchard has a trellis system and an individual support for each tree. The space between the tree rows in the orchard is maintained by permanent grassing.

The dwarfing sweet cherry rootstock that was tested and evaluated is IP- C7 [(*P. avium*×*P. nipponica*var. Kurilensis) × (*P.avium* 77-33-26 ×*P. pseudocerasus*)]. The Romanian cultivars investigated were Daria, Bucium, Maria and Radu. They were grafted with the IP - C7 sweet cherry rootstock.

Growth measurements: The influence of the rootstock on the vigor of the cultivar was assessed by the total number of shoots per tree, mean shoot length (cm), Trunk Cross Section Area – TCSA (cm^2) and trunk circumference – TC (cm). Growth measurements for shoot were taken from 10 trees per rootstock - scion combination in 2011. The number of shoots was determined by counting the number of shoots per graft combination. Trunk cross-section area (TCSA) is an important tool to characterize the influence of the rootstock on the scion variety. Trunk cross-section area (TCSA) was calculated using trunk diameter (d) and π (π is equal 3.14) function. The calculation formula for TCSA was $\pi\ (d^2/4)$. For each sweet cherry tree the grafted trunk diameter was measured at 15 cm above the graft union. The data on trunk cross section area(TCSA) of the sweet cherry trees for the specified rootstock were recorded during the third year after planting. The trunk circumference was calculated using trunk diameter with the formula $\pi \times d$. Annual growing capacity and productivity potential were analyzed by determining the number of leaf buds and flower buds.

Photosynthesis rate measurement: Photosynthetic capacity is an important parameter which explains the physiological activity of plants and the potential for vegetative development and productivity in cherry trees. Physiological studies were carried out in 2011 when the trees were in their phenological growth and flowering stages.

Leaf gas exchange was measured with a portable plant CO_2 analysis package. Photosynthesis was measured in attached leaves maintained in an assimilation chamber. The CO2 concentration was measured with an infrared gas analyzer (IRGA). The difference between the initial CO2 concentration in air and the air in the leaf chamber was used to measure the rate of photosynthesis.

During testing, the light level (PPFD) was 1800 $\mu mol\ m^{-2}\ s^{-1}$, the air temperature was 24 ± 2°C and the ambient relative humidity was between 60 and 65%.

The effects of rootstock - scion interactions on the net photosynthesis rate were evaluated in the leaves of the middle part of the east-oriented annual shoots. Leaf gas exchange was expressed as $\mu mol\ CO_2\ m^{-2}\ s^{-1}$.

Leaf chlorophyll and carotenoids measurements: Leaf chlorophyll and carotenoids measurements were estimated and presented as chlorophyll a (mg chlorophyllper g fresh weight), chlorophyll b (mg g^{-1}), total chlorophyll (mg g^{-1}), chl a/b ratio and carotenoids.

For determination of assimilatory pigments, the leaves were collected in early morning, and transported in an ice box to the laboratory. Photosynthetic pigments were extracted in 80% acetone. The absorbance values at 662, 646 and 440.5 were determined using a BOECO S-20VIS spectrophotometer. The amount of chlorophyll and carotenoid pigments was calculated using Holm's formula (Holm, 1954):

$$Chl\ a = 9.78\ A_{662} – 0.99\ A_{644}$$

$$Chl\ b = 21.4\ A_{644} – 4.65\ A_{662}$$

$$Car = 4.69\ A_{440.5} – 0.267\ (Chl\ a + Chl\ b).$$

Total chlorophyll content was calculated as the sum of chlorophyll a and chlorophyll b.

Statistical analysis: The experiment was designed according to a randomized complete block design with four replications of five trees per plot of each scion – stock combination (n = 20). The statistical analysis was performed using analysis of variance in the SPSS 16.0 software and means were compared using Duncan's multiple range tests at a level of 5 %. The results of this study are expressed as mean ± standard error (SE).

RESULTS

Trunk Cross Section Area (TCSA) and Trunk Circumference: The data regarding the trunk cross section area (TCSA) and trunk circumference are presented in Table 1. The influence of the IP - C7 Romanian rootstock on the Romanian varieties Daria, Bucium, Maria and Radu recorded values between17.65cm^2 (Radu) and 22.23cm^2 (Maria) TCSA. Trunk circumference was lower for the Radu cultivar as compared to Bucium and Maria cultivars. The trunk cross section area(TCSA) of sweet cherry trees grafted onto IP - C7 Romanian rootstocksdemonstrated that the Romanian varieties grafted ontoIP-C7 were within the limits established for dwarf rootstocks.

Number of Shoots and Shoots Lengths: The data recorded for the total number of shoots and shoots lengths are presented in Table 2. The number of shoots and the average annual increase in length represent the tree vigor. Daria had the maximum number of branches on the tree, but the lowest total annual growth (1390.88 cm); the differences are significant compared toother Romanian sweet cherry varieties ($P < 0.05$). Radu had the smallest number of shoots. The annual increases in lengths were higher in the Radu and Bucium varieties with the maximum annual growth (cm) in Bucium (1772.01 cm).

Reproductive and Vegetative Growth Potential: The reproductive and vegetative growth potential was evaluated by determining the total number of leaf buds and flower buds in sweet cherry trees. In the growth stage, the leaf buds, flower buds and total number of buds of the Daria cherry cultivar grafted onto IP – C7 rootstocks were not significantly different from the Maria cherry cultivar grafted onto IP – C7 rootstocks (Table 3). However, after three years after planting, the vegetative growth potentials were evident from the large number of leaf buds. The number of vegetative buds ranged from 185 (Daria) to 283 (Radu),while the number of flower buds ranged from12 (Daria) to19 (Maria). In terms of vegetative and productivity potential expressed by number of buds, the Bucium cultivar grafted onto IP – C7 rootstocks showed significant differences when compared to the Radu cultivar.

Chlorophyll Content (mg g^{-1}): The data recorded for the total chlorophyll content (mg g^{-1}), chlorophyll a content (mg g^{-1}), chlorophyll b content (mg g^{-1}), and Chl a / Chl b ratio in the leaves of the Romanian cherry cultivars grafted onto IP-C7 rootstock are presented in Table 4, while the data for carotenoids (mg g^{-1}), Chla+b / Car ratio and photosynthesis rate [µ mol (CO_2) m^{-2} s^{-1}] in the leaves are presented in Table 5. The total chlorophyll content (mg g^{-1}) was expressed by the amount of chlorophyll a and b (mg g^{-1}). The chlorophyll a and b concentrations were higher in Daria while the lowest content of chlorophyll a was observed for Radu grafted onto IP – C7. The statistical analysis conducted using the analysis of variance in the SPSS 16.0 software showed no significant differences of total chlorophyll content between Radu and Bucium grafted onto IP – C7 and significant differences between the Maria, Daria and Radu cultivars. In rootstocks – scion interactions, the highest Chl a / Chl b ratio was observed for Bucium grafted onto the IP – C7 Romanian rootstock (2.96). The ratio between Chl and Chl b seems to be constant in all trees, but total chlorophyll was higher in Daria and lowest in Radu and Bucium. Chlorophyll parameters were differently influenced by the rootstock - scion combination.

Carotenoids content, Chla+b / Car ratio and Chl/Car ratio: The carotenoids content was higher in Maria (2.33 mg g^{-1}) grafted onto IP – C7 rootstocks than in Bucium (2.08 mg g^{-1}) and Radu (2.11 mg g^{-1}). For the Maria and Daria cultivars, the content of carotenoids was not influenced by the rootstock-scion combination. The Chl/Car ratio varied from 6.10 mg g^{-1} (Maria) to 6.77 mg g^{-1} (Daria). Regarding the influence of IP – C7 on the Chla+b / Car ratio in the cultivars under study, there were no significant differences between Daria and Bucium; on the other hand, significant differences were observed between Maria and Bucium.

The photosynthesis rate [µ mol (CO_2) m^{-2} s^{-1}] varied from 23.77 µ mol (CO_2) m^{-2} s^{-1} in the Radu sweet cherry variety to 24.73 µ mol (CO_2) m^{-2} s^{-1} in the Daria sweet cherry variety (Table 5). The influence of the rootstock on the photosynthesis processes of the scion was significant in Radu grafted onto IP – C7 compared with the results obtained for Daria. However, the difference in the photosynthesis rate of the Bucium and Maria cultivars was not significant.

Table 1.Effect of rootstock - scion combination on Trunk Cross Section Area – TCSA and Trunk Circumference – TC.

Rootstock	Cultivar	Trunk Cross Section Area - TCSA (cm^2)	Trunk Circumference - TC (mm)
IP – C7	Daria	18.95 ± 0.18 b	15.43 ± 0.07 b
	Bucium	21.15 ± 0.28 a	16.30 ± 0.11 a
	Radu	17.65 ± 0.70 b	14.88 ± 0.29 b
	Maria	22.23 ± 0.67 a	16.71 ± 0.25 a

Data presented as mean ± standard error of mean (SE). Values within a group followed by different letters are significantly different at P < 0.05 (Duncan's test). Values followed by the same letter are not significantly different according to Duncan's multiple range test (P < 0.05).

Table 2. Mean values of total number of shoots and shoots lengths.

Rootstock	Cultivar	Total Number of Shoots	Mean Shoots Lengths (cm)
IP – C7	Daria	30.67 ± 0.88 a	45.35 ± 0.16 d
	Bucium	27.00 ± 0.58 b	65.63 ± 0.40 b
	Radu	23.67 ± 0.88 c	69.44 ± 0.40 a
	Maria	26.33 ± 0.88 b	59.07 ± 0.43 c

Data presented as mean ± standard error of mean (SE). Values within a group followed by different letters are significantly different at P < 0.05 (Duncan's test). Values followed by the same letter are not significantly different according to Duncan's multiple range test (P < 0.05).

Table 3. Mean values of leaf buds, flower buds and total buds registered in the tested rootstock - scion combination.

Rootstock	Cultivar	Leaf Buds	Flower Buds	Total Buds
IP – C7	Radu	185 ± 4.67 c	12 ± 0.33 c	197 ± 5.77 c
	Maria	280 ± 1.88 a	16 ± 0.33 b	296 ± 2.31 a
	Daria	283 ± 1.45 a	17 ± 0.57 b	300 ± 1.15 a
	Bucium	209 ± 1.73 b	19 ± 0.33 a	228 ± 1.15 b

Data presented as mean ± standard error of mean (SE). Values within a group followed by different letters are significantly different at P < 0.05 (Duncan's test). Values followed by the same letter are not significantly different according to Duncan's multiple range test (P < 0.05).

Table 4. Total chlorophyll content ($mg\ g^{-1}$), Chlorophyll a ($mg\ g^{-1}$), Chlorophyll b ($mg\ g^{-1}$), and Chl a / Chl b ratio in the leaves under the influence of rootstock - scion combination.

Rootstock	Cultivar	Chlorophyll a ($mg\ g^{-1}$)	Chlorophyll b ($mg\ g^{-1}$)	Chl a / Chl b ratio	Total Chlorophyll content ($mg\ g^{-1}$)
IP – C7	Radu	10.20 ± 0.17 c	3.57 ± 0.52 b	2.85 ± 0.47 ab	13.77 ± 0.35 c
	Maria	10.46 ± 0.61 b	3.79 ± 0.14 a	2.75 ± 0.25 b	14.25 ± 0.51 b
	Daria	10.95 ± 0.73 a	3.87 ± 0.16 a	2.82 ± 0.13 ab	14.83 ± 0.86 a
	Bucium	10.28 ± 0.56 bc	3.47 ± 0.56 b	2.96 ± 0.63 a	13.75 ± 0.19 c

Data presented as mean ± standard error of mean (SE). Values within a group followed by different letters are significantly different at P < 0.05 (Duncan's test). Values followed by the same letter are not significantly different according to Duncan's multiple range test (P < 0.05).

Table 5.Carotenoids (mg g^{-1}), Chl / Car Ratio and Photosynthesis rate [µ mol (CO_2) m^{-2} s^{-1}] in the leaves under the effect of rootstock - scion combination.

Rootstock	Cultivar	Carotenoids (mg g^{-1})	Chla+b / Car Ratio	Photosynthesis rate [µmol (CO_2) m^{-2} s^{-1}]
IP – C7	Radu	2.11 ± 0.63 b	6.53 ± 0.20 ab	23.77 ± 2.66 b
	Maria	2.33 ± 0.34 a	6.10 ± 0.06 b	24.25 ± 0.65 ab
	Daria	2.18 ± 0.42 ab	6.77 ± 0.12 a	24.73 ± 1.40 a
	Bucium	2.08 ± 0.41 b	6.60 ± 0.13 a	24.23 ± 0.75 ab

Data presented as mean ± standard error of mean (SE). Values within a group followed by different letters are significantly different at $P < 0.05$ (Duncan's test). Values followed by the same letter are not significantly different according to Duncan's multiple range test ($P < 0.05$).

DISCUSSION

According to Gregory *et al*. (2013), a sustainable production system requires proper understanding of the relation between rootstock, scion and specific climatic and soil conditions to increase the economic and technique efficiency of intensive plantation. In graft combinations, both rootstock and scion, by mutual influences, have acrucial role in the performance of the grafted plantation. Generally, good compatibility between the rootstock and scion cultivars is essential for success in grafting and subsequent growth (Prassinos *et al.,* 2009). Prassinos *et al.* (2009) demonstrated that when 'Bing' cherry scions are grafted onto Gisela 5 and Gisela 6 rootstocks the dwarfing influence of the tree is determined by differential cessation of the activities of the shoot apical meristem and this phenomenon is influenced by rootstock-specific gene regulation. This aspect was mainly explained by the following growth measurements: final node number, final shoot length (cm), mean metamer length (mm) TCSA increment, and shoot growth cessation (days). A similar study by Cantín*et al.* (2010) analyzed the influence of several rootstocks on the vegetative growth of Van and Stark Hardy Giant sweet cherry cultivars and reported that Gisela 5 rootstocks induced the lowest vigor as determined mainly by TCSA for both cultivars.

The rootstock exerts a significant influence on the physiological parameters of different scions cultivars in different horticultural crop species (Roper and Kennedy, 1986; Yadava and Doud, 1989; Layne, 1994; Caruso *et al*., 1996; Lichev and Berova, 2004; Gonçalves *et al.,* 2005; Malcolm *et al.,* 2006; Malcolm *et al*., 2008; Cantín *et al.,* 2010).

Thus, cherry rootstocks are evaluated for their compatibility and influence on the scion variety. Koç and Bilgener (2013) described 88 sweet cherry, 16 sour cherry, and 9 mahaleb types by morphological characterization. This potential of cherry germplasm for the rootstock breeding program was selected from the wild cherry populations in Turkey. These selected genotypes were compared with the standard clone rootstocks PHL-A, MaxMa 14, Montmorency, Weiroot158, Gisela 5, Gisela 6, and SL 64 and the authors demonstrated that the results can be useful for the cherry rootstock breeding program (Koç and Bilgener, 2013).

Studies on rootstocks have also demonstrated that the net photosynthetic rate varied from 7.3 µ mol (CO_2) m^{-2} s^{-1} to 11.3 µ mol (CO_2) m^{-2} s^{-1}in the growth stage and from 5.8 µ mol (CO_2) m^{-2} s^{-1} to 9.4 µ mol (CO_2) m^{-2} s^{-1} in the flower formation stage. Lichev and Berova (2004) used ten different rootstocks; one of them was Gisela 5, for which the recorded values were 10.7 µ mol (CO_2) m^{-2} s^{-1} in the growth stage and 7.1 µ mol (CO_2) m^{-2} s^{-1} in the flower formation stage. Flower bud differentiation in sweet cherry trees, good floral development and a correct fruit crop load are important aspects for a good productivity in intensive production. In this paper the grafted trees had a good bud differentiation, most of them being leaf buds three years after grafting. Engin and Unal (2007) examined the timing of floral developmental stages using scanning electron microscopy in order to apply correct cultural measures such as fruit crop load or plant hormones to improve the productivity of sweet cherry orchards. As regards the scion leaf area in dwarfing rootstocks, Atkinson and Else (2001) registered a lower leaf area than in vigorous rootstocks and in consequence a reduced total amount of photo assimilates.

Pilarski *et al.* (2007) described the content of photosynthetic pigments and their proportions in the stems and leaves of a sweet cherry tree and found that the total chlorophyll content in leaves was 4.5 mg dm^{-2} and the chlorophyll a/b ratio was 3.8. In comparison with the stems, the content of chlorophyll a in the leaves was higher, but the content of chlorophyll b was smaller than in 3-year-old stems and similar to its content in the younger stems (Pilarski *et al.,* 2009).

The photosynthetic capacity of the same sweet cherry cultivar can be different when grafted onto three different cherry rootstocks (Pérez and Monge, 1997). The authors attributed such variations to the chlorophyll a concentration that varied from 36.66 (mg g^{-1}) to 24.65 (mg g^{-1}) and to chlorophyll b concentration that varied from 11 (mg g^{-1}) to 7.28 (mg g^{-1}) despite similar values for Chl a / Chl b ratio in the leaves. Thus, as regards the

Chl a / Chl b ratio, the results of this study are in keeping with those presented by Pérez and Monge (1997).

In conclusion, the results reported here are in agreement with the scientific literature and could be useful for producers to understand the advantages of using appropriate scion – rootstock combinations. This will offer higher efficiency gains when utilizing the local environmental resources for the establishment of high – density sweet cherry orchards.

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REFERENCES

Atkinson,C. and M. Else (2001).Understanding how rootstocks dwarf fruit trees. Compact Fruit Tree64:46-49.

Bujdosó, G. and K. Hrotkó (2014). Preliminary results on growth, yield and fruit size of some new precocious sweet cherry cultivars on Hungarian bred mahaleb rootstocks. Acta Hort. (ISHS) 1058: 559-564.

Cantín, C.M., J. Pinochet, Y. Gogorcena and M.Á. Moreno (2010). Growth, yield and fruit quality of ‘Van’ and ‘Stark Hardy Giant’ sweet cherry cultivars as influenced by grafting on different rootstocks. Scientia.Hort. 123: 329–335.

Caruso, T., D. Giovannini and A. Liverani (1996). Rootstock influences the fruit mineral, sugar and organic acid content of a very early ripening peach cultivar. J. Hort. Sci. 72: 931–937.

De Jong, T.M. and J.F. Doyle (1985). Seasonal relationships between leaf nitrogen content (photosynthetic capacity) and leaf canopy light exposure in peach (Prunuspersica). Plant Cell Environ 8: 701–706.

Engin, H. and A. Ali Ünal (2007).Examination of Flower Bud Initiation and Differentiation in Sweet Cherry and Peach by Scanning Electron Micros. Turk J Agric For 31: 373-379.

Facteau, T.J., N.E. Chestnut and K.E. Rowe (1996). Tree, fruit size and yield of ‘Bing’ sweet cherry as influenced by rootstock, replant area, and training system. SciHortic 67: 13–26.

FAOSTAT (2011). Statistical database. http://www.faostat.fao.org.

Flore, J.A. and A.N. Lakso (1989).Environmental and physiological regulation of photosynthesis in fruit crops. Hort Rev 11: 111–157.

Flore, J.A. and D.R. Layne (1999).Photoassimilate Production and Distribution in Cherry.HortScience 34: 1015–1019.

Gonçalves, B. J. Moutinho-Pereira, A. Santos, A.P. Silva, E. Bacelar, C. Correia and E. Rosa (2005). Scion–rootstock interaction affects the physiology and fruit quality of sweet cherry. Tree Physiol 26: 93–104.

Gregory, P.J., C.J. Atkinson, A.G. Bengough, M.A. Else, F. Fernandez-Fernandez, R.J. Harrison and S. Schmidt (2013). Contributions of roots and rootstocks to sustainable intensified crop production. J Exp Bot 64: 1209–1222.

Holm, G. (1954).Chlorophyll mutations in barley. Acta Agr Scand 4: 457-471.

Koç, A. and Ş. Bilgener (2013). Morphological characterization of cherry rootstock candidates selected from Samsun Province in Turkey. Turk J Agric For 37: 575-584.

Lanauskas, J., N. Uselis, D. Kviklys, N. Kvikliené and L. Buskiené (2012). Rootstock effect on the performance of sweet cherry cv. Lapins. Horticultural Science39(2): 55-60.

Lang,G., W. Howell, D. Ophardt and G. Mink (1997). Biotic and abiotic stress responses of inter specific hybrid cherry rootstocks. ActaHort (ISHS) 451: 217-224.

Lang, G. (2008). Sweet cherry orchard management: from shifting paradigms tocomputer modeling. Acta.Hort. (ISHS) 795: 597–604.

Larsen, F.E., S.S. Higgins and Jr.R. Fritts (1987). Scion/interstock/rootstock effect on sweet cherry yield, tree size and yield efficiency. Sci. Hortic. 33: 237–247.

Layne, D.R. and J.A. Flore (1992).Photosynthetic compensation to partial leaf area reduction in sour cherry. J. Amer. Soc. Hort. Sci. 117: 279–286.

Layne, D.R. and J.A. Flore (1993). Physiological responses of Prunuscerasus to whole-plant source manipulation. Leaf gas exchange, chlorophyll fluo-rescence, water relations and carbohydrate concentrations. Physiol Plant 88: 45–51.

Layne, R.E.C. (1994). Prunus rootstocks affect long-term orchard performance of Redhaven peach on Brookston clay loam. Hort Science 29: 167–171.

Lichev, V. and M. Berova (2004). Effects of rootstock on photosynthetic activity and productivity in the sweet cherry cultivar ‘Stella’.J. FruitOrnam. Plant Res Special ed. 12:287-293.

Malcolm, P.J., P. Holford, B. McGlasson and J. Conroy (2006). Root zone temperature influences growth, partitioning, leaf morphology and physiology of the peach rootstock, Green Leaf Nemaguard. Aust. J. Exp. Agric. 46: 689–696.

Malcolm, P.J., P. Holford, B. McGlasson and I. Barchia (2008).Leaf development, net assimilation and leaf nitrogen concentrations of five Prunus rootstocks in response to root temperature. SciHortic 115: 285–291.

Milošević, T., N. Milošević, J. Milivojević, I. Glišić and R. Nikolić (2014).Experiences with Mazzard and Colt sweet cherry rootstocks in Serbia which are used for high density planting system under heavy and acidic soil conditions. Sci Hort., 176: 261-272.

Pérez, C., J. Val and E. Monge (1997). Photosynthetic changes of "*Prunusavium* L." grafted on different rootstocks in relation to mineral deficiencies. ActaHort (ISHS) 448: 81-85.

Pilarski, J., K. Tokarz and M. Kocurek (2007). Comparison of photosynthetic pigment contents in stems and leaves of fruit trees: cherry, sweet cherry, common plum, and walnut tree. Folia Horticulturae 19: 53-65.

Prassinos, C, J.H. Ko, G. Lang, A.F. Iezzoni and K.H. Han (2009).Rootstock-induced dwarfing in cherries is caused by differential cessation of terminal meristem growth and is triggered by rootstock-specific gene regulation. Tree Physiol 29: 927-936.

Radunić, M., A. Jazbec, M. Pecina, T. Čosić and N. Pavičić (2011).Growth and yield of the sweet cherry (*Prunusavium*L.) as affected by training system. Afr. J. Biotechnol 10: 4901-4906.

Roper, T.R. and R.A. Kennedy (1986). Photosynthetic characteristics during leaf development in ''Bing'' sweet cherry. J. Am. Soc. Hortic. Sci., 111: 938–941.

Salazar-Gutiérrez, M. R., B. Chaves, J. Anothai, M. Whiting and G. Hoogenboom (2014). Variation in cold hardiness of sweet cherry flower buds through different phenological stages. Sci. Hort., 172: 161-167.

Seleznyova, A.N., D.S. Tustin and T.G. Thorp (2008). Apple dwarfing rootstocks and interstocks affect the type of growth units produced during the annual growth cycle: precocious transition to flowering affects the composition and vigor of annual shoots. Ann Bot 101: 679–687.

Webster, A.D. (1995). Rootstock and interstock effects on deciduous fruit tree vigour, precocity, and yield productivity. New Zealand J. Crop Horti Sci., 23: 373–382.

Webster,A.D. (1998). Strategies for controlling the size of sweet cherry trees. Acta Hort (ISHS) 468*:* 229-239*.*

Whiting, M.D., G.A. Lang and D. Ophardt (2005). Rootstock and training system effects sweet cherry growth, yield and fruit quality. Hort. Science 40: 582–586.

Yadava, U.L. and S.L. Doud (1989). Rootstock and scion influence growth, productivity, survival and short-life related performance of peach trees. J Am SocHorticSci 114: 875–880.

Zorić, L., M. Ljubojević, L. Merkulov, J. Luković and V. Ognjanov (2012). Anatomical characteristics of cherry rootstocks as possible preselecting tools for prediction of tree vigor. J. Plant Growth Regul 31: 320–331.