British Journal of Applied Science & Technology
9(5): 419-426, 2015, Article no.BJAST.2015.281
ISSN: 2231-0843

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Carbohydrate Concentration in ‘BRS Rubimel’ Peach Trees during the Annual Cycle

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Authors’ contributions

This work was conducted in collaboration between all authors. Authors BHLG, SL and MAT designed the study, performed the statistical analysis, wrote the first draft of the manuscript and managed literature searches. Authors RAF, JMAS and LLA, along with the author BHLG, held biweekly field analysis throughout the study period, tabulation of data in spreadsheets and sewing tables and graphs. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2015/17846
Editor(s):
(1) Soichiro Nakamura, Department of Bioscience and Biotechnology, Shinshu University, Japan.
Reviewers:
(1) Anonymous, Cadi Ayyad University, Morocco.
(2) Dimitra A. Loka, Crop, Soil and Environmental Sciences, University of Arkansas, USA.
(3) Anonymous, University of the Western Cape, South Africa.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=1140&id=5&aid=9484

Original Research Article

Received 27th March 2015
Accepted 19th May 2015
Published 29th May 2015

ABSTRACT

The carbohydrate storage is necessary to support the plant growth in periods of stress, during the dormancy, in the beginning of the vegetative development and during the fruiting time. In this context, this work intended to evaluate the carbohydrate concentrations of the peach (*Prunus persica* (L.) Batsch) tree ‘BRS Rubimel’, cultivated under subtropical conditions. The experiment was performed at the experimental farm Lageado, of the Faculty of Agricultural Sciences of UNESP at Botucatu/SP. The evaluated peach trees were two years old and were cultivated in the spacing of 6.0 x 4.0 m. The adopted experimental delineation was in randomized blocks, making use of four plants per parcel with four repetitions. The treatments corresponded to the period of the collection of leaves and branches, during the annual cycle, corresponding to January to May and July to December 2012. The sample collection of the roots was performed in January, April, August, November and December 2012. Four fruits per plant were collected. The

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concentration of starch in the roots of the peach tree were superior to the ones from the branches, from August to December. The carbohydrate with the higher storage level in the peach tree 'BRS Rubimel' was starch.

Keywords: Prunus persica L. Bastch; photo-assimilated compounds; sugars.

1. INTRODUCTION

The economic potential of peach *(Prunus persica* (L.) Batsch) crop, at State of São Paulo, presented as great advantage the early harvest of fruit, when compared with the major Brazilian producers regions and the countries located in the Southern Hemisphere like Chile, Argentina, Uruguay, additioned the possibility of cultivars diversification more adapted to subtropical climate, whose introduction by producers could increase income and the seasonality product offer [1].

The state of São Paulo, located in a warmer climatic zone, contributes with about 10% of the planted area and 23% of the national production, featuring an average productivity of 21.5 t/ha/ year, with economic potential to crop peach. Many peach-tree crops have been cultived in tropical and subtropical regions at State of São Paulo, with thermal rates between 40 and 80 hours (below 7ºC) or 600 and 800 hours (below 13ºC), in areas near, Campinas, Tietê, Botucatu and Bauru [2].

The evaluation of the phenological and the carbohydrate levels of cultivars is a key to establishing and maintaining a culture in particular region because it provides information about the adaptation of cultivars, helping to determine the time and intensity of management techniques such as thinning, pruning, fertilizing and harvesting [1].

The physiological processes involved in the entry and the interruption of the dormancy of the fruit may be related to many intrinsic and extrinsic factors connected to the plants, such as the carbohydrate flow and the translocation of the reserve in short distances. In the *Rosaceae* family, most part of the carbon fixed during the photosynthesis is stored as starch in the chloroplast or is transferred to the cytosol and converted in the soluble carbohydrates sucrose and sorbitol [3].

The competition for photo-assimilated compounds can occur between the vegetative growth and the flower buds, since, in the case of the peach tree, the vegetative growth occurs simultaneously with the fruit formation [4].

Several strategies are being researched aiming the enhancing of the quality of the fruits, based, directly or indirectly, on the exploitation of the reserves and the relations among the demand of soluble solid contents and reserve tissues and/or carbohydrate producers [4].

The carbohydrate translocation of the organs of the peach tree, during different phases of the plant, needs more studying, mainly in subtropical conditions, in which the cycle among the phenological stages of the plant is different, just as well, there's the need of the use of subsidiary handling techniques, like the replenishment pruning and the defoliation, that are different in temperate regions where the cultivation is traditionally implemented. In Brazil, the study of the carbohydrate mobilization is being utilized to comprehend the problems arising from the lack of cold winters, in temperate climate fruit trees [1].

The knowing of the reserves concentration in different organs of the plant, according to the months of the year can be a subsidy for the adaptation of the handling techniques and cultivation practices, at the most appropriate times, taking into account the plant physiology.

In view of it, this work had, as objective, the determination of the carbohydrates concentration during the annual cycle of the peach tree 'BRS Rubimel' cultivated in subtropical conditions, in the city of Botucatu, SP.

2. MATERIALS AND METHODS

The study was conducted in Lageado Experimental Farm of UNESP, São Paulo State University of Botucatu/SP, situated at 22º51' 55" S and 48º26' 22" W, and 810 meters altitude. The region has a mesothermal climate, Cwa, in other words, humid subtropical with droughts during the winter and with rains from November to April, being the average annual rainfall of 1.433 mm. The climatic data of the experimental area were collected by the Meteorological station of the Department of Natural Resources of the above-mentioned Faculty (Figs. 1-A and 1-B).

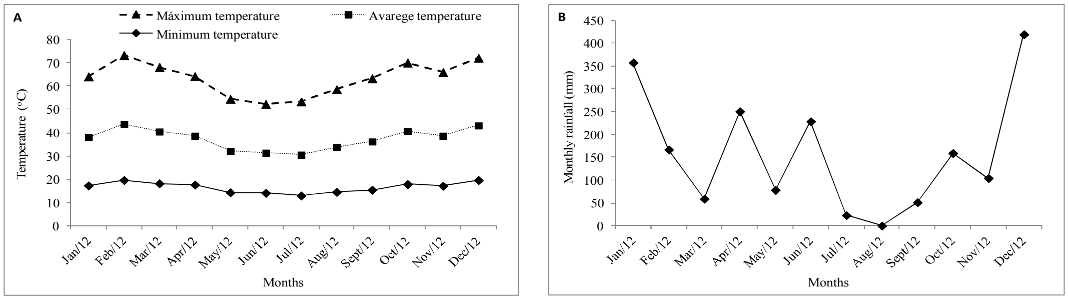

Fig. 1. Maximum, average and minimum temperatures (A); and monthly rainfall (B); of the experimental area. Botucatu, SP. 2012

Two-year-old plants from the BRS Rubimel cultivar, grafted on the Okinawa rootstock, were evaluated. The BRS Rubimel cultivated, launched in 2007 by Temperate Climate EMBRAPA, originated from the crossing effectuated in 1991 between 'Chimarrita' e 'FlordapriLnce'. It is a semi-adherent stone crop, with average or big-sized fruits, round or round-conic shape, yellow-colored pulp, average weight 100-120 g [4]. It has an attractive appearance and a sweet and pleasant flavor, due to its low acidity itis indicated for the *au naturel* consumption. It ripens in the beginning of November and, exceptionally, the ripening can occur until the end of the month. The low chilling requirements go from 200 to 300 hours [5].

The plants received the recommended cultural treatments [6]. The green or replenishment pruning was performed on January 15, 2012. The production pruning or fruiting was performed on July 20th, 2012. After this operation, on the same day, the pruned branches were brushed with Bordeaux mixture made from copper sulphate, lime and water, at the cut spots, to avoid the development of pathogenic microorganisms. It was not necessary to defoliate the plants since they were young and suffered a natural defoliation. The application of products to break the dormancy was performedin the swollen buds stage, always one day after the production pruning. A hydrogen cyanamide 0.6 % (Dormex®) + Mineral oil 1.0% (Assist®) was utilized and the plants were totally wet, a volume of 2.5% of spray solution was employed per plant.

The experimental delineation was made in randomized blocks, making use of four plants per parcel with four repetitions. The treatments corresponded to the period of the collection of leaves and branches, during the annual cycle, corresponding to January, February, March, April, May, July, August, September, October, November and December 2012. The sample collection of the roots was performed in January, April, August, November and December 2012 and the collection of the fruits was performed in the month of November/2012.

The samples of the aerial part were collected by cutting the segments of the branches (the woody ones) that were six months old, in the distance of 10 cm from the main limb and, subsequently, the leaves were harvested separately, from these branches. The size of the samples of the branches was approximately, from 10 to 15 cm, the branches were taken from all the limbs (four) of the plant.

The samples of the roots were taken from the soil from approximately 20 cm deep and 40 cm away from the base of the trunk of peach tree. After finding the root system, segments from approximately 10 to 20 cm were collected, with the same diameter of approximately 10 cm.

When the fruits reached the soluble solid content of 10º Brix, four fruits per plant were sampled. The samples of branches, leaves and fruits were taken to the laboratory, being subjected to the washing and drying in the greenhouse with forced air circulation, with the temperature of 65ºC. After drying and milling the samples the concentration of carbohydrates, reducing sugars (fructose + glucose), non-reducing (sucrose), total and starch was determined and the results were expressed in percentages (%) [7]. The results were subjected to an analysis of variance, being compared by using the Tukey test at 5% of significance level.

3. RESULTS AND DISCUSSION

There were variations in the carbohydrate concentrations in the different organs of the plant according to the months of evaluation (Figs. 2-A, 2-B, 3-A, 3-B, 4-A e 4-B). In the peach tree, the production potential of the fruits of a cycle is directly related to the reserves accumulated by the plant during the former cycle, what is more explicitly visible in the roots, compared to the branches [8].

From the month of January on, there was a decay in the concentration of starch, being April the month with the greatest reduction in the concentration of starch in the branches (Fig. 2-A), phase in which the plant was in full vegetative development of the aerial part. In this period, it was possible to infer that the low concentration of starch in the roots occurred. In the plants, broadly, during the vegetative growing, most of the carbohydrates are transported to the young roots and leaves whereas after the flowering the carbohydrates are mainly addressed to the fruits, tubers and reserve roots [9]. The biggest concentration of starch in the roots was observed in August, characterized by the end of the dormancy period and beginning of the sprouting (Fig. 2-A). This fact is related to the drop of the temperature observed since May (Fig. 1), in which the dormancy period of the peach tree started, with the gradual loss of the leaves, being this, one of the characteristics of the deciduous trees.

The starch accumulated in the chloroplasts is converted into sucrose for the translocation until the roots, where it is converted again into starch and is stored. Hence, the starch accumulation keeps the plant protection against the coldness and provides energy to the metabolic activities of the peach tree [4]. The insoluble carbohydrates are accumulate din the branches and roots of the peach tree, reaching a climax in the middle of the resting period [3].

During the dormancy, the buds present a low potential absorption and an increasing in the concentration of sucrose, due to the starch hydrolysis. This way, the soluble sugars are accumulated during the winter. Also in this period, the buds are able to absorb carbohydrates allowing the carbohydrate storage [10].

In the beginning of January, the replenishment pruning of the branches of the peach tree was performed and due to this, it was verified a low concentration of total reducing sugars in the roots because they were translocated to the aerial part, to supply the metabolic needs of the plant because of the pruning. At this time, the plant was in full vegetative development, with high carbohydrate production, with this, the total reducing sugars stored in the leaves, were transported to the non-photosynthetic reserve organs, in the case, the roots (Fig. 2-A). This is in accordance with Borba et al. [8], which considered two distinct moments in the carbohydrate flow in roots of subtropical climate crop peach tree, where the first flow was the accumulation of carbohydrates in the roots that happened after the harvest and until the fall of the leaves (dormancy). After the harvest of the fruits, in December/2012, there was a higher concentration of total reducing sugars in the roots because of the withdrawal of the fruits (drainage) that enhanced the storage, stimulating the root growth (Fig. 2-A).

In the month of December/2012, there was a higher concentration of sucrose in the roots (Fig. 2-B), probably due to the root growth spurts, followed by the branches growth. The growth of the root system depends on the aerial load and fruits load of the plant, taking into consideration that the initial growth, usually corresponds to the beginning of the aerial part growth and the second root growth spurt starts right after the aerial part ceases [1].

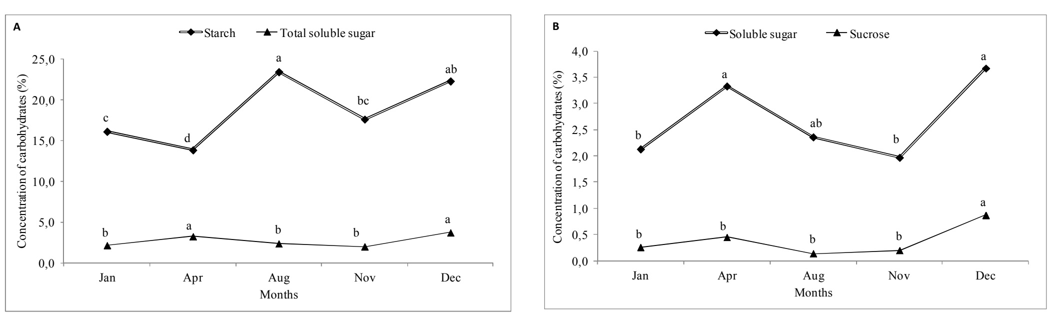

Fig. 2. Average concentrations of starch and total reducing sugar (A); reducing sugar and sucrose (B), in roots of the BRS Rubimel cultivar, in different sampling periods. Botucatu. SP, 2012. Averages followed by the same letter, for each carbohydrate, do not differ statistically by the Tukey test at 5%

In the branches, there was a variation in the concentrations of total reducing sugars, reducing sugars, sucrose and starch, in the evaluation months, throughout the cycle of the plant (Figs. 3-A e 3-B), The same ones presented lower concentrations, compared to the roots (Figs. 2-A e 2-B), not depending on the period of the sampling, It was also observed [4,8].

There were two distinct flows in the concentration of total reducing sugars (Fig. 3-A), considering that the first flow occurred in January. After this first flow, there was a gradual reduction in the concentration of reducing sugars, caused by the beginning of the dormancy period, in which the carbohydrates were translocated to the roots. Thus, there was a decrease of soluble sugars in the crown, and the lower concentrations were observed in the months of July and August, also caused by the execution of the fructification pruning on July 20, 2012. The second flow occurred in the month of September, when higher concentrations were verified, because the translocation of the total reducing sugars from the roots to the aerial part occurred. The starch is degraded by the action of phosphorylases and amylases. When high amounts of glucose are necessary, this degradation occurs essentially by the action of the amylases. Such degradation is important to the resistance against the coldness, considering that this process is highly controlled by the temperature. During the winter, with the decreasing of the temperatures, the activity of the amylase, sucrose-6-P-synthase and sucrose-synthase increase in the tissues of the wood and the bark, converting starch into glucose, fructose and sucrose [11]. These soluble carbohydrates have an important role in the protection against the coldness, and provide energy and substrate to the initial growth of the branches, during the spring.

In the month of July/2012, the concentrations of total reducing sugars, reducing sugars and sucrose in the branches (Fig. 3-A) presented lower values, due to the decreasing of the temperatures, taking into account that during these months the lowest averages of the minimum temperatures occurred (Table 1), being it the peak of the dormancy and the conversion into starch. The results indicated that the occurrence of coldness anticipated the accumulation of reserve carbohydrates while the coldness, during the endodormancy, promoted the accumulation of carbohydrates of transport.

The fluctuations of temperature interfere in a very quick way in the metabolism of the carbohydrates of the plant [3]. This was verified at this work, because in the month of August, with the beginning of the sprouting there was an intensification in the concentration of soluble carbohydrates, what goes along with the quotation of, which reports that the starch is the main reserve carbohydrate of fruit plants, being initially consumed by conversion, into soluble sugars, which are used in the process of breathing for energy supplying for sprouting and flowering [12].

In the peach tree, the soluble carbohydrates, mainly glucose and fructose, decreased during the rest period whereas in the end of the dormancy phase, the mobilization of these sugars increased, possibly in order to obtain energy and provide carbon skeletons to the resumption of the active growth [13]. High levels of hexoses are necessary to the maintenance of the osmotic pressure of the cell during the cell elongation phase [14].

The low metabolic activity in the fruit tree buds during the dormancy allows important changes in the carbohydrate content from the internal tissues to the bud, or in its adjacencies whose dynamic can inhibit or facilitate the growth of a new organ in the plant. Apple *(Pyrus malus L.)* tree buds feature higher percentages of soluble carbohydrates in the entry into endodormancy and the coldness promoted the accumulation of these carbohydrates both in the buds and in the branches adjacent to it [15]. In pear (*Pyrus communis* L.) trees, the higher accumulation of carbohydrates in buds, in the dates close to the flowering can indicate the end of the endodormancy.

It was verified that from the month of April on, there was reduction in the concentrations of starch and soluble sugars in the branches (Fig. 3-B). Caused mainly by the beginning of the decrease of the temperatures and rainfall (Fig. 1), being June the month with the month with the lower observed concentrations. In the month of August, with the plant in the beginning of the fructification there was total reducing sugars translocation stored in the roots to the aerial part of the fruits. This translocation was necessary to supply the energy expenditure in the initial growth of the sprouts and fruits. During this initial phase, the new leaves do not produce total reducing sugars enough to supply the metabolic needs and the development of the fruit. The sucrose concentration in the branches followed the same pattern of the total reducing sugars (Fig. 3-B), and in the months of July and

October it was detected the lowest concentrations, due to the mobilization for the buds in the month of July and the fruits in the month of October.

Sucrose plays the role of transporting the photo-assimilated compounds over the phloem to all the organs of the plant, including the buds. In peach tree, the specific transporters can transport specific molecules in a direction and transport it in contrary directions.

The time interval elapsed between the sprouting and the falling of the leaves, is basically divided in two periods in the state of São Paulo, varying the concentrations of the carbohydrates in the leaves of the tree (Figs. 4-A and 4-B). The first phase happens after the break of the dormancy in mid-July, when the development of the vegetative growth starts. The sprouting is directly compromised with the accumulated carbohydrate concentration during the dormancy period, and this provided energy to start the development of the first leaf primordia, because in this period the peach tree does not have leaves for the production of the energy demand, so it needs the accumulated concentrations. The second period comprises the phase of translocation of the carbohydrates produced by the photosynthesis, which are transported from the leaves to the roots, as soluble sugars, mainly sucrose. This phase begins in mid-November (Figs. 4-A and 4-B), ending in May, when the plants starts the dormancy again and the leaves fall.

In warmer climate regions, under subtropical conditions, the foliar dehiscence is slow and many times not very effective, demanding the employment of chemical products that promote the most uniform defoliation. However, there is no certainty or a precise recommendation about the most suitable period to perform the defoliation. The execution of this technique in advance can result in significant losses of carbohydrate reserves accumulated in the leaves, what will fatally result in losses in the production process, what makes studies of this nature quite convenient.

In the beginning of the flowering, observed in the month of August/2012, there was intense carbohydrate consumption for the formation of the vegetative and flower buds that resulted in the significant reduction in the foliar starches concentration. After the natural abscission, the competition for draining the carbohydrates was lower, favoring the elevation in the concentration of starch in the leaves in the month of September (Fig. 4-A), through the transportation of the roots, or the increase in the photosynthetic rates due to the elevation of the temperatures (Fig. 1-A) and beginning of the summertime [2].

Regarding the concentration of carbohydrates in the fruits, it became clear that, during their period of maturation between October and November, there was a reduction in the concentration of starch, and it was converted into reducing sugars and total reducing sugars, where the peak of the translocation of these carbohydrates to the fruits occurred, they are the main drains of the plant (Table 1). The observed behavior suggests that the availability of sugars increases when the fruits are in the initial phases of development, possibly, due to the high demand of photo-assimilated compounds, when they are consumption drains because they need a high amount of energy that is employed during the period of cell division [14].

After a period of approximately sixty days from the flowering, in addition to the higher demand of carbohydrates, the accumulation of total reducing sugars was favored by the meteorological conditions, specially the increasing in the average, maximum and minimum temperatures (Fig. 1-A), since, during springtime, the plants present an increase in the photosynthetic rates and consequently an increase in the concentration of carbohydrates in the leaves. The concentration of reducing sugars in fruits of the 'BRS Rubimel' peach tree were equivalent to the ones obtained by Marafon et al. [16], which reported that under subtropical climates conditions, in the region of Botucatu-SP, the concentration of reducing sugars varied from 1.59% to 2.21% being the highest values obtained in the genotypes Cascata 969, Cascata 848, Cascata 587, Precocinho, Diamante Mejorado e Oro Azteca.

Considerable changes in the reducing sugars concentrations are observed throughout the ripening of climacteric fruits, which increase after the harvest and during the storage due to the biosynthesis or the degradation of polysaccharides [17]. The concentration of these sugars decrease in the fruits after they are ripened, due to the breathing consumption.

Sucrose is the most common sugar in peaches, exceeding the quantity of reducing sugars, which confirms the data obtained at this work (Table 1) [8].

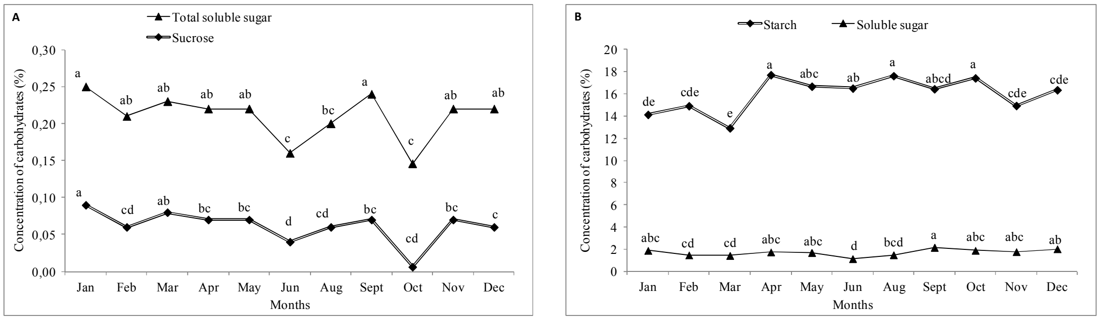

Fig. 3. Average concentrations of total reducing sugars and sucrose (A); starch and reducing sugar (B) in branches of the BRS Rubimel cultivar, in different sampling periods. Botucatu, SP. 2012. Averages followed by the same letter, for each carbohydrate, do not differ statistically by the Tukey test at 5%

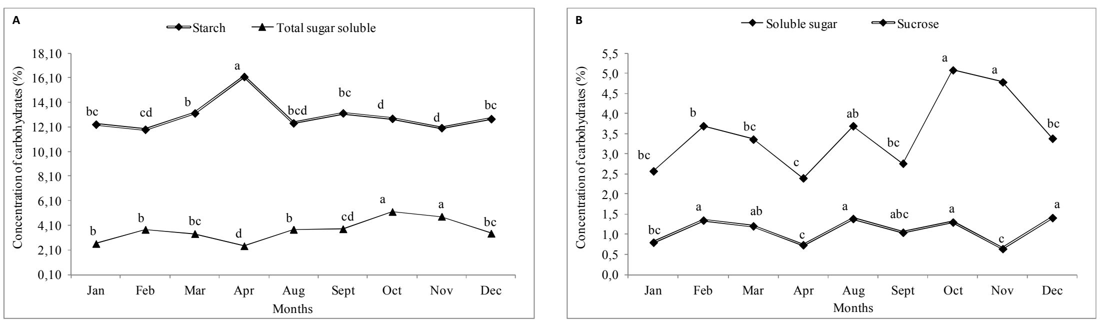

Fig. 4. Average concentrations of total reducing sugars and sucrose (A); starch and reducing sugar (B) in leaves of the BRS Rubimel cultivar, in different sampling periods. Botucatu, SP. 2012. Averages followed by the same letter, for each carbohydrate, do not differ statistically by the Tukey test at 5%

Table 1. Percentage (%) of reducing sugars, total reducing sugars and sucrose in the fruits of the peach tree cultivar BRS Rubimel. Botucatu, SP. 2012

Cultivar	Soluble sugar (%)	Total sugar soluble (%)	Sucrose (%)
BRS Rubimel	1,81	8,31	6,18

The concentration of reducing sugars (glucose + fructose) from 2.0% to 3.2% and of sucrose, from 4.9% to 8.0%, in peaches, these values are close to the results of Chitarra et al. [18], there was obtained 1.81% of reducing sugars and 6.18% sucrose.

4. CONCLUSION

There was fluctuation in the carbohydrate concentration in the roots, branches and leaves, according to the phenological stage of the cultivation. The starch was the carbohydrate that had the higher concentrations firstly in the roots, and later in the branches and leaves of the peach tree, not depending on the period of the sampling. In the ripe fruits, there was higher concentration of sucrose, followed by total reducing sugars and reducing sugars.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Leonel S, Pierozzi CG, Tecchio MA. Production and fruit quality of peach and nectarine trees in subtorrid climate of the state of São Paulo. Brazilian Fruits Journal. 2011;33:118-28. Brazil.
2. Roitsch T, Balibrea ME, Hofmann M Proels R, Sinha AK. Extracellular invertases:

metabolic enzyme and metabolic protein. Journal of Experimental Botany. 2003; 54(382):513-24.
3. Carvalho RIN, Zanette F. Carbohydrate content in buds and stems of apple *(Pyrus malus L.)* trees during autumn and winter in low occurrence of cold region. Brazilian Fruits Journal. 2004;26(2):202-05.
4. Araújo JPC, Rodrigues A, Scarpare Filho JA, Pio R. Influence of pruning renewal and control of rust in the carbohydrate reserves and early peach production. Brazilian Fruits Journal. 2008;30(2):331-35. Brazil.
5. Campos AG, Junqueira AH, Medeiros ARM, Nakasu BH. Cultivation of peach: Economic importance. Embrapa. 2005;4. Accessed on: 20 March 2015.
6. Trevisan R. Using green pruning, reflective plastics, anti-perspirant and potassium in the production of peaches. Brazilian Agricultural Research. 2006;41(10):1485-90.
7. Nelson N. A photometric adaptation of somogi method for determination of glicose. Journal Biological Chemistry. 1944;153:375-80.
8. Borba the MR, Scarpare Filho, JA, Kluge, RA. Carbohydrate content in peach subjected to different intensities of green pruning in tropical climate. Brazilian Fruits Journal. 2005;27(1):68-72. Brazil.
9. Scarpare Filho JA, Kluge RA, Tavares S. The culture of peach: Recommendations for growing in subtropical regions. 110th ed. Piracicaba (SP): ESALQ; 2003.
10. Mehouachi J, Iglesias DJ, Agustí M, Talón M. Delay of early fruitlet absción by Branco girdling in Citrus coincides with previous increases in carbohydrate and gibberelin concentrations. Plant Growth Regulation. 2009;58:15-23.
11. Rodrigues AC, Herter FG, Verissimo V, Campos AD, Milk GB, Silva JB. Balance of carbohydrates in flower bud of two pear (*Pyrus communis* L.) genotypes under mild winter conditions. Brazilian Fruits Journal. 2006;28(1):1-4.
12. Scaranari CF, Rasera MDCB, Barbosa W, Feldberg NP, Martins FP. Catalog of peach and nectarine cultivars. Pellets: Embrapa Temperate Mild. 2009;139.
13. Marquat C, Vandamme M, Gendraud M, Pétel G. Dormancy in vegetative buds of peach: Relation between carbohydrate absortion potentials and carbohydrate concentration in the bud during dormancy and its release. Scientia Horticulturae. 1999;79:151-62.
14. Zhan A & CX. Improve etanol yield through minimizing glycerolyeld in etanol fermetation of *Saccharomyces cerevisiae.* Chinese Journal of Chemical Engineering. 2008;16:620-25.
15. Carvalho RIN, Zanette F. Changes in glucose content, fructose and sorbitol in buds and stems of apple (*Pyrus malus L.*) tree during the dormancy. Rural Science. 2006;36(6):1916-19.
16. Marafon AC, Bacarin MA, Rodrigues AC, Verissimo V. Carbohydrate content in peach trees tissues (*Prunus persica* (L.) *Batsch*) cv. Jubilee in plants with and without symptoms of early-death during the dormancy period. Brazilian Fruits Journal. 2007;29(1):75-79. Brazil.
17. Chitarra IMF, Chitarra AB. Post-harvest of fruits and vegetables: Physiology and handling. 2nd ed. Mines: Federal University of Lavras; 2005. Brazil.
18. Chitarra MIF, Carvalho RV. Temperate fruits: peaches, plums and fig. Inform Agriculture. 1985;11(125):56-66. Brazil.

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