ISSN 0100-2945 http://dx.doi.org/10.1590/0100-29452016581

CARBOHYDRATE CONTENT AND DEVELOPMENT OF STRAWBERRY TRANSPLANTS FROM RIO GRANDE DO SUL AND IMPORTED[1]

CARINE COCCO[2], MICHÉL ALDRIGHI GONÇALVES[3], CARLOS REISSER JUNIOR[4], ANDERSON CARLOS MARAFON[5], LUIS EDUARDO CORRÊA ANTUNES[4]

ABSTRACT — Obtaining high yields in strawberry crop requires the use of transplants with high sanitary and physiological quality. Thus, the present study aimed to evaluate the effect of the origin of strawberry transplants on quality, carbohydrate content and subsequent development and field production. Treatments covered four transplant origins: Argentina, Chile, Chuí (Rio Grande do Sul, Brazil) and São Francisco de Paula (Rio Grande do Sul, Brazil) and two cultivars (Camarosa and Camino Real) in experimental design of randomized blocks with four replicates, conducted between April and December 2010. Carbohydrate content in crown and roots was evaluated, as well as the growth and development of transplants and plant yield. Regardless of cultivar and origin of transplants, crown diameter values exceeding 8 mm were considered the minimum standard internationally established. Transplants propagated in Chui showed 100% mortality 20 days after planting, while losses were not recorded in Argentina and Chile transplants. Camarosa transplants from Chile showed the highest content of total soluble sugars in reserve organs, while higher starch content was obtained in Argentinean transplants. The high carbohydrate content in reserve organs in Argentina and Chile transplants led to greater fruit production.
Index terms: *Fragaria x ananassa*, bare root transplants, total sugar, yield.

CONTEÚDO DE CARBOIDRATOS E DESENVOLVIMENTO DE MUDAS DE MORANGUEIRO DE ORIGEM DO RIO GRANDE DO SUL E IMPORTADAS

RESUMO — A obtenção de elevadas produções na cultura do morangueiro é dependente da utilização de mudas com elevada qualidade sanitária e fisiológica. Assim, o presente estudo teve como objetivo avaliar a influência do local de origem das mudas de morangueiro, na qualidade, conteúdo de carboidratos e posterior desenvolvimento e produção a campo. Os tratamentos abrangeram quatro origens das mudas: Argentina, Chile, Chuí (Rio Grande do Sul, Brasil) e São Francisco de Paula (Rio Grande do Sul, Brasil) e duas cultivares (Camarosa e Camino Real), em delineamento experimental de blocos ao acaso, com quatro repetições, conduzido no período entre abril e dezembro de 2010. Avaliaram-se o conteúdo de carboidratos na coroa e nas raízes, o crescimento e o desenvolvimento das mudas e a produção das plantas. Independentemente da cultivar e da origem da muda, os valores de diâmetro da coroa foram superiores a 8 mm, considerado o padrão mínimo estabelecido internacionalmente. Mudas propagadas no Chuí apresentaram 100% de mortalidade aos 20 dias após o plantio, enquanto não foram registradas perdas nas argentinas e chilenas. Mudas de ‘Camarosa’, provenientes do Chile, apresentaram maior conteúdo de açúcares solúveis totais nos órgãos de reserva, enquanto maior teor de amido foi obtido em mudas argentinas. O maior conteúdo de carboidratos nos órgãos de reserva, em mudas argentinas e chilenas, reverteu em maior produção de frutas.
Termos para indexação: *Fragaria x ananassa*, mudas de raízes nuas, açúcares totais, produtividade.

[1](Paper 137-15). Received May 18, 2015. Accepted: March 17, 2016.
[2]Teacher at University Caxias do Sul, Street Francisco Getúlio Vargas, 1130 - Petrópolis, Caxias do Sul - RS, CEP 95070-560. E-mail: carinecocco@yahoo.com.br
[3]PhD student at the Graduate Program in Agronomy, Federal University of Pelotas, Pelotas - RS. Email: aldrighimichel@gmail.com
[4]Researcher at Embrapa Clima Temperado, Pelotas - RS. E-mail: carlos.reisser@embrapa.br, luis.antunes@embrapa.br
[5]Researcher at Embrapa Tabuleiros Costeiros, Research and Development Execution Unit, Rio Largo - AL. E-mail: anderson.marafon@embrapa.br

INTRODUCTION

In the conventional strawberry production system (*Fragaria x ananassa* Duch.) in Brazil, bare root transplants are generally used for crop establishment (ANTUNES; PERES, 2013). Although physiologically a perennial species, crop renewal after a productive cycle is common practice among producers due to the phytosanitary problems in the soil, which limit production in the subsequent year, generating an annual demand of 175 million transplants (ANTUNES; PERES, 2013). As the national production of transplants is not enough to meet this demand, it is necessary to import Chilean and Argentine transplants, mainly in Rio Grande do Sul, where certified commercial plant nurseries are scarce.

In order to obtain high yields, one of the essential prerequisites is the use of vigorous transplants with high physiological and phytosanitary quality (COCCO et al., 2011, MENZEL; SMITH et al., 2012), capable of providing high survival rate after transplantation, rapid vegetative growth and development of new organs such as flowers and fruits. Torres-Quezada et al. (2015) indicate crown diameter above 8 mm as the main parameter of transplant quality, having a strong influence on the early and total fruit production.

In the southern hemisphere, in temperate and subtropical regions, the planting of matrixes for the production of commercial transplants occurs between September and November (KIRSCHBAUM et al., 2012). During summer, high temperatures and long photoperiod are the climatic conditions that stimulate the vegetative propagation of strawberry tree through the emission of stolons (BRADFORD et al., 2010). At the end of the summer and beginning of autumn, the reduction of temperatures and photoperiod favors the accumulation of carbohydrates in reserve organs, resulting in increased thickness of crown and roots (PERTUZÉ et al., 2006; MENZEL; SMITH, 2012). The low nocturnal temperatures during this period decrease the plant energy expenditure due to the reduction in cellular respiration, increasing the liquid photosynthesis and, consequently leading to greater carbohydrate accumulation (KIRSCHBAUM et al., 2012; PALENCIA et al. 2013).

Carbohydrates stored in the reserve organs play a fundamental role in the recovery of plant growth after transplantation, as well as in the production of the first flowers and fruits (ESHGHI et al., 2007). These physiological processes are dependent on the accumulated reserves until the plant acquires autonomy in energy production and supply (BARTCZAK et al., 2010). Thus, the greater the amount of carbohydrates accumulated during summer and autumn, the greater the productive potential of transplants, especially for the early production of fruits (SONSTEBY et al., 2013; TORRES-QUEZADA et al., 2015).

The deposition of reserve substances in strawberry transplants is influenced by genetic factors and also by environmental factors such as year and site of transplant production (MALTONI et al., 2009). In Rio Grande do Sul, a considerable part of the strawberry transplants used comes from Chilean and Argentinean nurseries, although agroclimatic zoning indicates regions with favorable climatic conditions for the production of these transplants in this Brazilian state (WREGE et al., 2007). The supply of the domestic demand for quality transplants produced in the country has been configured as a necessity for new strawberry production systems in order to reduce import dependency and to enable the crop expansion through the production of fruit during all year.

In this sense, it is emphasized that studies conducted in order to evaluate the quality and the production of fruits from locally produced transplants, as compared to imported ones, are scarce.

Thus, the aim of this work was to evaluate the influence of the origin of strawberry transplants on the content of carbohydrates in fruit reserve organs, development and production.

MATERIAL AND METHODS

The experiment was installed at Embrapa Clima Temperado, Pelotas - RS, during the period from April to December 2010. The geographical coordinates of the site are: 31º40’S and 52º26’W, with average altitude of 60 m, where in the coldest month, the average temperature is about 12.5° C and in the hottest month, 23.3 ° C, with average annual rainfall of 1,200 mm and rains regularly distributed throughout the year.

The cultivars used in the experiment were: ‘Camarosa’ and ‘Camino Real’, both classified as of short days. The transplants used in the experiment came from four different sites: (1) Argentinean transplants produced in the Patagonia Agricola S.A. plant nursery located in the municipality of El Maitén, Argentina, with geographical coordinates of 42º3’S and 71º10’W, with altitude of 720 m asl; (2) Chilean transplants imported from the Agricola Llahuen S.A. Chilean plant nursery located in Los Angeles, Biobío province, Chile, 37º28’S, 72º21’W and altitude of 145 m asl; (3) national seedlings produced in the municipality of São Francisco de Paula, Pasa plant nursery, located in the northeast region of Rio Grande do Sul, 29º26’S, 50º34’W and altitude of 900 m asl (4) national seedlings produced in the municipality of Chuí in a commercial producer in extreme southern Rio Grande do Sul, 33º41’S and 53º27’W, and altitude of 22 m asl. The regions of São Francisco de Paula and Chuí were indicated by agroclimatic zoning as suitable for the production of strawberry transplants (WREGE et al., 2007). Bare root transplants were used, without leaves, and no root pruning was performed before planting.

Soil preparation was carried out by plowing followed by harrowing and formation of rows. Soil fertility correction was performed according to chemical analysis results based on the recommendations for strawberry cultivation described in the Manual of Fertilization and Liming for the States of Rio Grande do Sul and Santa Catarina (SOCIEDADE BRASILEIRA DE CIÊNCIA DO SOLO, 2004). After fertilization, drip irrigation system was installed, with two drip lines in each plot with spacing of 0.15 m between drippers. Subsequently, black plastic mulching with 40 µm of thickness was placed to cover the rows. The production system used was conventional type in the soil in beds with one meter of width, 0.25 m of height and 20 m of length, with three rows of plants in each bed with spacing of 0.30 m between plants and 0.30 m between rows. Low tunnels were built on rows, with low density polyethylene transparent film (LDPE), with 100 µm of thickness.

Due to the different edaphoclimatic conditions of transplants propagation sites, which influenced the maturation and harvest season, their planting in the experimental area took place at different dates. Transplants from Chuí were planted on April 26, from São Francisco de Paula on April 28, from Argentina on May 11, and those from Chile on May 25. The control of the opening and closing of tunnels, pest and disease management, as well as irrigations and fertigations were carried out according to technical recommendations for the crop.

At the time of field planting, samples constituted of 20 transplants per treatment were selected to determine the crown diameter (mm), with the aid of a digital caliper. Root dry mass (g) was obtained after drying in oven with forced air circulation at 65 ° C until constant mass was obtained between two consecutive determinations and subsequent weighing of the dried material. Crown samples were also dried for carbohydrate determinations. Dry roots and crown samples were milled separately in a Willey mill for 3 minutes and used in the determination of total soluble sugars and starch (mg g^{-1} DM) using the method described by McCready (1950).

In the field, the mortality of transplants was evaluated at 20 days after planting, and necrosed plants and those without new visible leaflets were considered dead. Fruit harvest began in August, extending until December 7, when higher temperatures and longer photoperiod stimulated vegetative propagation, reducing fruit production. Fruits were collected with 100% of epidermis with reddish color in the stage of complete maturation, being counted and weighed in a digital scale. The sum of the number and mass of fruits obtained in all harvests throughout the experiment was divided by the number of plants in the experimental plot to obtain production per plant (g $plant^{-1}$). The average fruit mass (g $fruit^{-1}$) was obtained by the quotient between fresh mass per plant and number of fruits per plant. For evaluations, only marketable fruits were considered, being selected based on the fresh mass. Fruit with fresh mass less than three grams was considered non- marketable and were discarded. Early production was considered as that obtained until the end of September. At the end of the experiment, the survival of plants in each treatment was recorded, considered as the number of plants with totally green leaves in each plot.

Treatments consisted of the combination of factors cultivar and origin of transplants. The experimental design was randomized blocks in a 2x4 factorial arrangement, with four replicates and 12 plants per plot. Data were submitted to analysis of variance by the F test and the means of treatments were compared by the Tukey test (5% of error probability), using the Sisvar Statistical Software (FERREIRA, 2011). Variables expressed in percentage were transformed into $arcsen\sqrt{\%}$.

RESULTS AND DISCUSSION

There was a significant interaction between factors origin of transplants and cultivar, for crown diameter and root dry mass, at planting time (Table 1). Greater crown diameter was verified in transplants propagated in Argentina, for both cultivars. Despite the differences between the sites of origin, the values were higher than the minimum standard established in international literature (8 mm) (PERTUZÉ et al., 2006) and in Brazil (3 mm), according to ordinance No. 172, of October 10, 2011, published by the Ministry of Agriculture.

It was verified that Argentinean and Chilean

'Camarosa' transplants showed greater root dry mass. For 'Camino Real', the highest root dry mass was obtained in transplants from Chile. On the other hand, transplants from Chuí showed lower root dry mass both for 'Camarosa' and 'Camino Real' cultivars. Among national transplants those with smaller crowns were obtained in São Francisco de Paula, but larger root mass was obtained.

Differences in crown diameter and root dry mass among the different transplant origins may be related to the number of transplants produced by matrix in plant nurseries. In Argentinean and Chilean transplants, 35-50 daughter plants per m^2 are maintained (PERTUZÉ et al., 2006). In the case of domestic nurseries, the average production is 100 transplants per m^2 (VERDIAL et al., 2009). Higher density can cause competition for essential growth factors, such as nutrients, light and water, negatively affecting individual growth and resulting in less reserve accumulation (KIRSCHBAUM et al., 2012). It is noteworthy that at the moment of transplant evaluation, those from Chuí had root system with characteristic appearance of necrosis, and darkening of the plant vascular system was observed. Phytopathological analysis revealed the presence of the fungus *Verticilium* spp., which causes verticilium wilt and plant collapse. According to Muramoto et al., (2014), the occurrence of this pathogen is common, especially when no techniques for soil disinfestation during the production phase of transplants are used.

Twenty days after transplantation, a period considered fundamental for crop establishment, differences were observed in the mortality of transplants among propagation sites (Table 2). It was verified that transplants propagated in Chuí presented 100% mortality. For this reason, productive data are not shown in Table 4. In contrast, in the same evaluation, transplants from Argentina and Chile did not present mortality, a fact that confirms their quality characteristics regarding the phytosanitary aspect. At the end of the experiment, greater survival of Argentinean transplants was observed, not differing from Chilean ones. Plant mortality during the cycle was 6.5%, 10.4%, 29.2% and 100% for transplants propagated in Argentina, Chile, São Francisco de Paula and Chuí, respectively. One of the explanations for the greater sanity of imported transplants seems to be related to soil disinfestation before the planting of matrixes, held in these places, where traditional strawberry nurseries are installed. In addition, the geographical location of Patagonia provides a privileged isolation condition (PERTUZÉ et al., 2006).

Regarding the total soluble sugars and starch content in crown and roots of transplants, there was a significant interaction between propagation site and cultivars (Table 3). Crowns of 'Camarosa' transplants from Chile showed higher soluble sugar content than those from other propagation sites, with an average of 60.1% higher than that obtained in transplants from Chuí, which had the lowest content. On the other hand, 'Camino Real' presented higher soluble sugar contents in the crown in Chilean and Argentinean transplants compared to national transplants. Among national transplants, 'Camino Real' from São Francisco de Paula presented higher value for this variable, being 23.1% higher than those from Chuí.

In roots, the total soluble sugars content was higher in Chilean transplants in both cultivars, differing from the other propagation areas. The lowest sugar contents in both reserve organs and cultivars were found in transplants propagated in Chuí.

The starch content was higher in the crown and roots of Argentinean transplants, differing from the other propagation sites, for both cultivars. Chilean and national transplants propagated in São Francisco de Paula presented intermediate and similar values among themselves for this parameter.

The content of carbohydrates stored in root and crown affects vegetative growth, floral initiation, fruit size and storage capacity of transplants stored in cold chamber (MALTONI et al., 2009; MENZEL; SMITH, 2012). The energy readily available for plant growth is determined by total non-structural carbohydrates, which are not part of cellular structures such as cell wall and include substances such as starch and soluble sugars (MENZEL; SMITH, 2012). While soluble sugars are readily available for cell metabolism, starch must be pre-hydrolyzed into glucose units prior to being metabolized.

The accumulation of reserve carbohydrates seems to be related to the occurrence of low temperatures during the growth period of transplants in the plant nursery. Low temperatures are associated with the reduction of plant respiration and, consequently, with lower energy expenditure and increase in liquid photosynthesis (ESHGHI et al., 2007). As far as floral induction is concerned, the thermal amplitude between day and night is one of the most important environmental factors (SONSTEBY et al., 2013). The flowering sign appears to be a hormonal response induced by gibberellins, which are mediated by the accumulation of sucrose in reserve organs. Thus, high thermal amplitude can accelerate the accumulation of sucrose, which induces the synthesis of gibberellins, with consequent signaling for the transition from apical meristem to flowering (KUROKURA et al., 2013).

There was no significant interaction between cultivars and propagation site for the productive parameters (Table 4). The number of fruits, fresh mass produced per plant and average mass of fruits obtained in the early production period were higher in Argentinean plants, differing from other propagation sites. The number and fresh mass of fruits produced from Argentinean transplants during the early period were, respectively, 89.5% and 199.4% higher than those found in Chilean transplants, and 44.0% and 135.3% higher than those produced in São Francisco de Paula. As expected, Chilean transplants with higher crown diameter and reserve content showed higher precocious and total yield. Bartczak et al. (2010) reported that the use of poor-quality transplants can lead to a drop in production, which is impossible to recover through management techniques during the crop cycle. Thus, although early planting positively influences leaf emission and root system growth, is not able to ensure high yield compared to those originally characterized as low physiological quality.

These results have a direct implication in the context of production and marketing of fruits, since the availability of strawberries in the early period, when the market price is high, generates a higher economic return to producers (ANTUNES; PERES, 2013). Thus, there is need for use of techniques such as early planting and transplants with high physiological and sanitary quality that make possible the early production, guaranteeing more advantageous prices. It should be noted that, despite the high physiological quality of Chilean transplants, the low early production in this study occurred due to the late planting of these transplants (05/25/2010), during which the low temperatures of late autumn and early winter in the Rio Grande do Sul are little favorable to vegetative growth, limiting photosynthesis and delaying the beginning of production. It should be noted that the different planting dates of transplants from production areas are due to their climatic differences, which influenced the growth rate, accumulation of reserves and maturation of transplants and, consequently, the harvest dates.

The number and fresh mass of fruits in the total period were similar to those of the early period, being superior for plants propagated in Argentina. In contrast, lower values for the same variables were verified in transplants propagated in Chile and in São Francisco de Paula. In spite of the early planting of transplants propagated in São Francisco de Paula, the lower content of reserves compared to imported transplants possibly caused negative impacts on fruit production.

Analyzing cultivars, it was verified that ‘Camarosa’ stood out in relation to the number and fresh mass of fruits, both in the early production period, in which it presented values 30.4% and 32.5% higher than ‘Camino Real’ cultivar, respectively, and in the total production period, with values for these variables 48.5% and 33.7% higher, respectively. However, the average fruit mass obtained in the total production period was higher for ‘Camino Real’ compared to ‘Camarosa’ cultivars, whose main explanation is related to their genetic characteristics.

In commercial nurseries for the production of bare root transplants, leaves are usually removed during harvesting and cleaning, being marketed without leaves or only with the youngest leaflet (COCCO et al., 2012). In this context, the resumption of shoot and root growth is dependent on the amount of carbohydrates stored in reserve organs. As the plant subsequently produces new leaves, flowers and crowns, yield becomes more dependent on the photosynthetic capacity and the plant growth rate (ESHGHI et al., 2007). Palha et al. (2002) observed positive correlation (r = 0.73) between early fruit production and carbohydrate concentration in roots, emphasizing its importance for the establishment and growth of strawberry transplants.

Although agroclimatic zoning in Rio Grande do Sul points to regions of low altitude and high latitude as suitable for the production of strawberry transplants, as in the case of Chuí, where it is possible to produce transplants with good crown size, health problems have been verified due to the low technological level used, damaging the quality of transplants. On the other hand, despite the high altitude (900 m), the low physiological quality and productive performance presented by transplants produced in São Francisco de Paula was surprising, since the average temperatures in this region are generally lower than the state average. Based on the above, the low production of the national transplants can be explained by two main hypotheses. The first is related to the low accumulation of cold hours below 10ºC in nurseries of Rio Grande do Sul during the months from January to April, whose value is less than 100 hours (WREGE et al., 2007), considered insufficient for the deposition of high amounts of carbohydrates in the reserve organs of transplants (TANINO and WANG, 2008). The other hypothesis is associated to the time when transplants are harvested in nurseries of Rio Grande do Sul. For growers to be able to carry out the early planting of transplants, they should be harvested in the beginning of autumn, when low cold accumulation is still recorded, which is insufficient for the accumulation of carbohydrates in reserve organs.

The supply of national transplants with high physiological quality could enable early planting in some regions, providing fruit production during periods of low supply of strawberries (COCCO et al., 2011). It should also be noted that other countries with climatic conditions similar to those of Rio Grande do Sul have been able to adapt the production techniques of transplants with high physiological and sanitary quality, as is the case in southern Italy. Thus, further studies should be conducted to improve transplant production techniques in Brazil in order to make this productive chain sustainable.

TABLE 1 - Crown diameter (mm) and root dry mass (g) in strawberry transplants from different production sites. Pelotas / RS, 2014.

Propagation site	Crown diameter (mm)		Root dry mass (g)	
	Camarosa	Camino Real	Camarosa	Camino Real
Argentina	14.53 Aa *	15.74 Aa	2.32 Aa	0.93 Bb
Chile	10.62 Bc	14.01 A b	2.05 Aa	1.30 Ba
Chuí	12.64 Ab	12.92 Ab	0.68 Ac	0.46 Bc
S. F. de Paula	10.70 Ac	10.68 Ac	1.60 Ab	0.97 Bb
VC. (%)	6.7		10.7	

* Means followed by the same letter, uppercase and lowercase in the column, for each variable, do not differ by the Tukey test at 5% error probability.

TABLE 2 - Mortality rate in strawberry transplants at 20 days after planting and plant survival rate at the end of the growth cycle of transplants of different origins. Pelotas / RS, 2014

Propagation site	Mortality 20 days after planting (%)	Survival at end of cycle (%)
Argentina	0.0 c	93.5 a
Chile	0.0 c	89.6 a
Chuí	100.0 a	0.0 c
São Francisco de Paula	12.5 b	70.8 b
Cultivars		
Camarosa	26.0 a	72.9 a
Camino Real	30.2 a	54.1 b
V. C. (%)	17.5	19.7

* Means followed by the same letter in the column for each variable do not differ by the Tukey Test at 5% error probability. ** Percentage data were transformed into $arcsen\sqrt{\%}$.

TABLE 3 - Total soluble sugars and starch content (mg g^{-1} DM) in crown and roots of strawberry transplants with different propagation sites. Pelotas / RS, 2014.

Propagation site	Soluble sugars (mg g^{-1} DM)		Starch (mg g^{-1} DM)	
	Camarosa	Camino Real	Camarosa	Camino Real
		Crown		
Argentina	202.65 Ab	183.39 Ba	144.66 Aa	98.41 Ba
Chile	236.65 Aa	203.44 Ba	39.82 Ab	26.41 Bb
Chuí	147.79 Ac	129.78 Bc	24.71 Ac	25.09 Ab
S. F. de Paula	153.46 Ac	159.79 Ab	15.97 Ac	15.56 Ac
V.C. (%)	5.87		10.82	
		Roots		
Argentina	202.93 Ab	176.65 Bb	293.13 Aa	158.80 Ba
Chile	253.76 Aa	210.67 Ba	65.89 Ab	46.82 Ab
Chuí	105.41 Ad	52.56 Bc	22.07 Ac	15.93 Ab
S. F. de Paula	172.44 Ac	177.61 Ab	40.05 Abc	30.33 Ab
V.C. (%)	5.72		19.21	

* Averages followed by the same letter for each variable, upper case and lower case in the column, do not differ by the Tukey test at 5% error probability.

TABLE 4 - Number (NF), fresh mass (MF) and average fresh mass (MMF) of fruits per plant, produced in the early and total period using strawberry transplants of different cultivars and propagation sites. Pelotas / RS, 2014.

Propagation site	Early Production			Total production		
	NF	MF	MMF	NF	MF	MMF
		(g plant^{-1})	(g fruit^{-1})		(g plant^{-1})	(g fruit^{-1})
Argentina	7.2 a*	156.0 a	21.7 a	42.0 a	706.7 a	16.8 ab
Chile	3.8 b	52.1 b	13.8 b	31.2 b	551.7 b	17.9 a
S.F. de Paula	5.0 b	66.3 b	13.4 b	26.6 b	415.7 b	15.8 b
				Cultivar		
Camarosa	6.0 a	104.1 a	16.5 ns	39.8 a	638.0 a	15.9 b
Camino Real	4.6 b	78.8 b	16.1	26.8 b	477.1 b	17.7 a
V. C. (%)	20.1	21.4	12.1	17.3	19.5	8.1

* Means followed by the same letter, lowercase in the column, for each variable, do not differ by the Tukey Test at 5% probability level.

CONCLUSIONS

Strawberry transplants imported from Argentina show higher crown diameter and higher carbohydrate content in reserve organs, leading to higher early and total fruit production.

Despite the early planting, the low reserves of transplants from São Francisco de Paula limits their productive potential.

National nurseries are not yet capable of supplying high-quality transplants that will enable them to compete with imported transplants.

ACKNOWLEDGMENTS

To the Coordination for the Improvement of Higher Education Personnel (CAPES) for the granting of scholarship to the first author, BEX 9734 / 11-2 and CNPq for granting financial aid and research grants.

REFERENCES

ANTUNES, L.E.C.; PERES, N.A. Strawberry Production in Brazil and South America. **International Journal of Fruit Science**, New York, v.13, n.1-2, p.156-161, 2013.

BARTCZAK, M.; LISIECKA, J.; KNAFLEWSKI.M. Correlation between selected parameters of planting material and strawberry yield. **Folia Horticulturae,** Cracóvia, v.22, n.1, p.9-12, 2010.

BRADFORD, E.; HANCOCK, J.F.; WARNER, R.M. Interactions of temperature and photoperiod determine expression of repeat flowering in strawberry. **Journal of the American Society for Horticultural Science**, Alexandria, v.135, n.2, p.102-107, 2010.

COCCO, C.; ANDRIOLO, J.L.; CARDOSO, F.L.; ERPEN, L.; SCHMITT, O.J. Crown size and transplant type on the strawberry yield. **Scientia Agricola**, Piracicaba, v. 68, n. 4, p. 489-493, 2011.

COCCO, C.; FERREIRA, L.V.; GONÇALVES, M.A.; PICOLOTTO, L.; ANTUNES, L.E.C. Strawberry yield submitted to different root pruning intensities of transplants. **Revista Brasileira de Fruticultura**, Jaboticabal, v.34, n.4, p.1284-1288, 2012.

ESHGHI, S.; TAFAZOLI, E.; DOKHANI, S.; RAHEMI, M.; EMAM, Y. Changes in carbohydrate contents in shoot tips, leaves and roots of strawberry (*Fragaria × ananassa* duch.) during flower-bud differentiation. **Scientia Horticulturae**, New York, v.113, n.3, p.255-260, 2007.

FERREIRA, D.F. Sisvar: A computer statistical analysis system. **Ciência e Agrotecnologia,** Lavras, v.35, n.6, p.1039-1042, 2011.

KIRSCHBAUM, D.S.; LARSON, K.D.; WEINBAUM, S.A.; DEJONG, T.M. Accumulation pattern of total nonstructural carbohydrate in strawberry runner plants and its influence on plant growth and fruit production. **African Journal of Biotechnology**, Nairobi, v.11, n.96, p.16253-16262, 2012.

KUROKURA, T.; MIMIDA, N.; BATTEY, N.H.; HYTÖNEN, T. The regulation of seasonal flowering in the Rosaceae. **Journal of Experimental Botany**, Lancaster, v.64, n.14, p.4131-4141, 2013.

MALTONI, M.L.; MAGNANI, S.; RANIERI, M.; FAEDI W. Qualli sono i fattori che influenzano la qualità del prodotto. **Frutticoltura**, Bologna, n.6, p.22-27, 2009.

MCCREADY, R.M.; GUGGOLZ, J.; SILVIERA, V. OWENS, S. Determination of starch and amylase in vegetables. **Analytical Chemistry**, Washington, v.22, n.9, p.1156-1158, 1950.

MENZEL, C.M.; SMITH, L. Relationship between the levels of non-structural carbohydrates, digging date, nursery-growing environment, and chilling in strawberry transplants in a subtropical environment. **HortScience**, Alexandria, v.47, n.4, p.459-464, 2012.

MURAMOTO, J.; BAIRD, G.; KOIKE, S.T.; BOLDA, M.P.; KLONSKY, K.; ZAVATTA, M.; SHENNAN, C. Integrated rotation systems for soilborne disease, weed and fertility management in strawberry vegetable production. **Acta Horticulturae**, The Hague, v.1044, p.269-274, 2014.

PALENCIA, P.; MARTÍNEZ, F.; MEDINA, J.J.; LÓPEZ-MEDINA, J. Strawberry yield efficiency and its correlation with temperature and solar radiation. **Horticultura Brasileira**, Brasília, DF, v.31, n.1, p.93-99, 2013.

PALHA, M.G.S.; TAYLOR, D.R.; MONTEIRO, A.A. The effect of digging date and chilling history on root carbohydrate content and cropping of 'Chandler' and 'Douglas' strawberries in Portugal. **Acta Horticulturae**, The Hague, v.567, p.511-514, 2002.

PERTUZÉ, R.; BARRUETO, M.; DIAZ, V.; GAMARDELLA, M. Evaluation of strawberry nursery management techniques to improve quality of plants. **Acta Horticulturae**, The Hague, v.708, n.1, p.245-248, 2006.

SOCIEDADE BRASILEIRA DE CIÊNCIA DO SOLO. **Comissão de química e fertilidade do solo. Manual de adubação e calagem para os estados do Rio Grande do Sul e Santa Catarina**. Porto Alegre: SBCS/CQFS, 2004. 400p.

SONSTEBY, A.; OPSTAD, N.; HEIDE, O.M. Environmental manipulation for establishing high yield potential of strawberry forcing plants. **Scientia Horticulturae**, New York, v.157, p.65-73, 2013.(1)

TANINO, K. K.; WANG, R. Modeling chilling requirement and diurnal temperature differences on flowering and yield performance in strawberry crown production. **HortScience,** Alexandria, v.43, n.7, p.2060-2065, 2008.

TORRES-QUEZADA, E.A.; ZOTARELLI, L.; WHITAKER, V.M.; SANTOS, B.M.; HERNANDEZ-OCHOA, I. Initial crown ciameter of strawberry bare-root transplants affects early and total fruit yield. **HortTechnology**, Alexandria, v.25, n.2, p.203-208, 2015.

VERDIAL, M.F.; NETO, J.T.; MINAMI, K.; FILHO, J.A.S.; CHRISTOFFOLETI, P. J.; SCARPARE, F. V.; KLUGE, R. A. Fisiologia de mudas de morangueiro produzidas em sistema convencional e em vasos suspensos. **Revista Brasileira Fruticultura**, Jaboticabal, v.31, n.2, p.524-531, 2009.

WREGE, M.S.; REISSER JÚNIOR, C.; ANTUNES, L.E.C.; OLIVEIRA, R.P.D.; HERTER, F.G.; STEINMETZ, S; GARRASTUZU, M.C.; MATZENAUER, R.; SANTOS, A.M.D. **Zoneamento agroclimático para produção de mudas de morangueiro no Rio Grande do Sul.** Pelotas: Embrapa Clima Temperado, 2007, 27 p. (Documentos, 187).