ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 07, pp.33889-33893, July, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

THE PERFORMANCE OF STRAWBERRY CULTIVARS IN SOUTHERN BRAZIL

***Daniele Cristina Fontana, Carine Cocco, Maria Inês Diel, Matheus Milani Pretto, Evandro Holz, Anderson Werner, Valéria Testa, BraulioOtomarCaron, John Stolzle, Marcos Vinícius Marques Pinheiro and Denise Schmidt**

FederalUniversityof Santa Maria – AgronomyDepartment, Linha 7 de Setembro, s/n, BR 386 Km 40, 98400-000, Frederico Westphalen, Rio Grande do Sul, Brazil

ARTICLE INFO

Article History:
Received 21st April, 2016
Received in revised form
20th May, 2016
Accepted 24th June, 2016
Published online 16th July, 2016

Key words:

Fragaria x ananassa,
Environment, Quality.

ABSTRACT

Strawberry cultivation is widespread in several regions of the State of Rio Grande do Sul, and there is a high demand for strawberries by the consumer market; they are often an alternative income for family farmers. This research aimed to evaluate the agronomic performance of strawberry cultivars Albion, Camarosa, San Andreas, Camino Real, and Aromas in the climatic conditions found in Frederico Westphalen - RS. The experiment was conducted at the Federal University of Santa Maria campus Frederico Westphalen/RS in the year 2015, in the conventional conduction system in low tunnels. A randomized block design was used with four replications, eight plants per plot totaling 32 plants evaluated for each treatment. Phyllochron (°C day leaf $^{-1}$) was evaluated by estimating the inverse angular coefficient of the linear regression between the number of sheets in the main crown and the sum of thermal time accumulated from the transplant of the seedlings. The number of fruits, yield per plant, total acidity (TA), total soluble solids (TSS) and Ratio (TSS/TA) were also evaluated. The leaf emission rate was similar among the cultivars. The cultivar Camino Real highlighted by the larger production of fruits, averaged a superior mass (fruit plant$^{-1)}$ than the other cultivars. Albion, Camarosa, and San Andreas highlighted,in relation to quality parameters, the highest values of TSS.

Citation: Daniele Cristina Fontana, Carine Cocco, Maria Inês Diel, Matheus Milani Pretto *et al.* 2016. "The performance of strawberry cultivars in southern Brazil, *International Journal of Current Research*, 8, (07), 33889-33893.

INTRODUCTION

In the group of small fruits, strawberry (*Fragaria* x *ananassa* Duch.) is produced and consumed in the several regions of the world due to its attractive appearance and unique flavor, and it therefore has a guaranteed market in the major economies (FAOSTAT, 2015). This crop often sees high profitability in related to other crops, wide acceptance by the consumer market and diversity in marketing options (FACHINELLO *et al*., 2011). The world production of strawberries is 3.9 millions of tons per year (FAO, 2011). The main producing countries are China, USA, Turkey, Mexico, and Spain (FAOSTAT, 2015). Brazilian production in 2013 remained at 110,000 tons, with the states of Minas Gerais, São Paulo and Rio Grande do Sulproducing the majority (ANTUNES *et al*., 2014). According to Fiori *et al*. (2013), the production in Rio Grande do Sul is very significant with 18.4 tons being produced in 2013, finding widespread production centered in several cities in the state, often contributing to the composition of the family farmers' income. During the cultivation of strawberries, the induction of flowering and the beginning of strawberry fructification depends upon cultivar and the interaction of a number of internal physiological processes that are initiated by environmental factors including temperature, and day length (VERDIAL, 2004). When a cultivar is selected for a determined physiographic region and planted elsewhere, it will likely not present the same productive performance (OLIVEIRA and BONOW, 2012). According to Calvete *et al*. (2008) knowledge of a plant's phenology is important in setting the scheduling of production and, therefore, to seek strategies to expand the harvest period, allowing advantages in commercialization. The fruits of the different cultivars also differ compared with regards to their chemical parameters (acidity and soluble solids) which constitute the quality of strawberries, this relates not only to the uniformity, size and color of the fruits, but is also results in changes between the complex balance between sweetness,

Correspondingauthor: Daniele Cristina Fontana
FederalUniversityof Santa Maria – AgronomyDepartment, Linha 7 de Setembro, s/n, BR 386 Km 40, 98400-000, Frederico Westphalen, Rio Grande do Sul, Brazil.

aroma, texture (JOUQUAND *et al*., 2008) and nutritional value (RESENDE *et al*., 2008). In order to obtain desired characteristic sought by producers, and to satisfy the demand of consumers and ultimate success of a cultivar, this demonstrates the importance of the choice in cultivars adapted to a given planting site. The city of Frederico Westphalen - RS has not historically been used in strawberry cultivation, though, it is necessary to explore the possibility of strawberry cultivation, as it is an income option for small properties; there are however, few studies evaluating the adaptability of cultivars for the city. The aim of this study was to evaluate the agronomic performance of strawberry cultivars Albion, Camarosa, San Andreas, Camino Real and Aromas in the climatic conditions seen in FredericoWestphalen - RS.

MATERIALS AND METHODS

The experiment was conducted at an experimental area of the Federal University of Santa Maria, located in the city of Frederico Westphalen/RS, at a geographic location of 27º 23 S and 53º 25,74 W, at an altitude of 493 meters. The soil is classified as typical dystrophic Red Latosol, 20 clay texture, deep and well drained (EMBRAPA, 2006), belonging to region of Passo Fundo, and the climate is Cfaas defined by the Köppen climate classification. The treatments were composed of five strawberry cultivars Albion, Camarosa, San Andreas, Camino Real and Aromas, from Patagonia Agrícola nursery, located in the city of El Maitén, Argentina, with geographic coordinates of 42º3'S and 71º10'W, and altitude of 720 meters above the sea level. A randomized block design was used with four replications and eight plants per plot totaling 32 plants evaluated for each treatment. Soil preparation was done with plowing, harrowing, and fertilization according to the chemical analysis of the soil, and balanced in accordance with the cultivar's requirements (SANTOS E MEDEIROS, 2003). For fertilization, cattle manure was incorporation by harrowing, and was made on April 15th, 2015, at a dose of 5.5 kg/m^2. Before planting, a base fertilizationwas made with chemical fertilizer N-P-K at a dose of 55 g/m^2, of the formula 10-20-10, as recommended by the soil analysis. The soil analysis revealed a clay content of 64%, pH of 6.1, SMP index of 6.1, Phosphorus 2.4 (mg / L), Potassium 110.5 (mg / L), M.O. 2.2%, CTC 15 (cmolc / L), base saturation 78%, Al 0.0 (cmolc / L) and H+Al 3.3 (cmolc).The planting of seedlings was made according to the date of arrival at the planting site: Camarosa on June 02th, Camino Real June 03th, Albion June 08th, San Andreas and Aromas June 22th. The tunnels were placed on June 17th, 2015. Irrigation and fertirrigation were made through drip tape and the cultivation made according to the culture recommendations. The air temperature was measured inside the tunnels, and used to record the data of minimum and maximum air temperature. To calculate the medium temperature, it the following formula was used, where T represents the temperature:

$$Tmid = (Tmax \quad Tmin)/2 \tag{1}$$

The daily thermal sum (STd) was calculated according to the following equation (ARNOLD, 1960):

$$STd = (Tmid \quad Tb) \ /day \ \{^{o}Cday\} \tag{2}$$

The base temperature (Tb) was defined as the sum of daily thermal units above a lower base temperature, below which a plant will not grow, or will development at a negligible rate (ROSA, 2010).

The thermal sum was calculated from the transplanting of the seedlings in bags, and obtained the accumulated thermal sum (STa), which is the summation of the daily thermal sum;

$$STa = \sum Std \ \ \{^{o}Cday\} \tag{3}$$

The evaluations consisted of counting the number of leaves (LN), each three days, from the emission of the first fully expanded leaf untilfull bloom (a period in which the plant emits the second floral raceme) (MENDONÇA *et al*., 2012). Leaves were only counted when visible and the leaflets did not touch anymore;for the estimation of the phyllochron, a linear regression between the number of crown leaves and the accumulated thermal sum was performed. The phyllochron (°C day leaf^{-1}) was estimated as being the inverse of the angular coefficient of the linear regression (MENDONCA *et al*., 2012).Qualitative analyses were performed during the entire plant cycle, in order to eliminate specific characteristics of the harvest period. The analyses of titratable total acidity, and total soluble solids (°Brix) were performed in the laboratory.

The evaluations of the fruit quality parameters were performed in the Fruit Laboratory at UFSM *campus* Frederico Westphalen. The determination of total acidity was performed by titration with standardized solution of NaOH 0.1 mol L^{-1} and the data was expressed in % citric acid. The determination of soluble solids was performed with a manual refractometer, with an accuracy of ± 2%, and the results were expressed in ° Brix. From these values, the Ratio (TSS/TA) of strawberry fruits was determined.The fruit harvest began on August 4th, 2015, and for each cultivar the number of commercial fruits (NCF), mass of commercial fruit (MCF), number of non-commercial fruits (NNCF), mass of non-commercial fruit (MNCF in g plant-1) was determined. After reaching full maturity, the samples were collected twice a week and classified as being commercial or non-commercial. Non-commercial fruit were those which were deformed or weighed less than 6 grams.The results were submitted to analysis of variance, and the means were compared by Tukey test at 5% of error probability by the statistical program Genes (CRUZ, 2013).

RESULTS AND DISCUSSION

The data referring to local microclimate during the experiment conducted are shown in Figure 1. The maximum and minimum temperature registered inside the tunnels during the experiment between May and December was 46.6 and -0.7ºC respectively. The data in Figure 1 show the occurrence of temperatures above 30 ° C during the growth and development of the culture, a factor that may be related to low production achieved by the evaluated cultivars. In strawberry platns, regardless of the photoperiod, high and constant temperatures between 28 and 30 ° C are known to inhibit the floral differentiation of short days and neutral day cultivars (DURNER and POLING, 1998), the fruit become acidic with a low consistency and poor in flavor (lowTSS/TA values) (SANTOS *et al*., 2003).

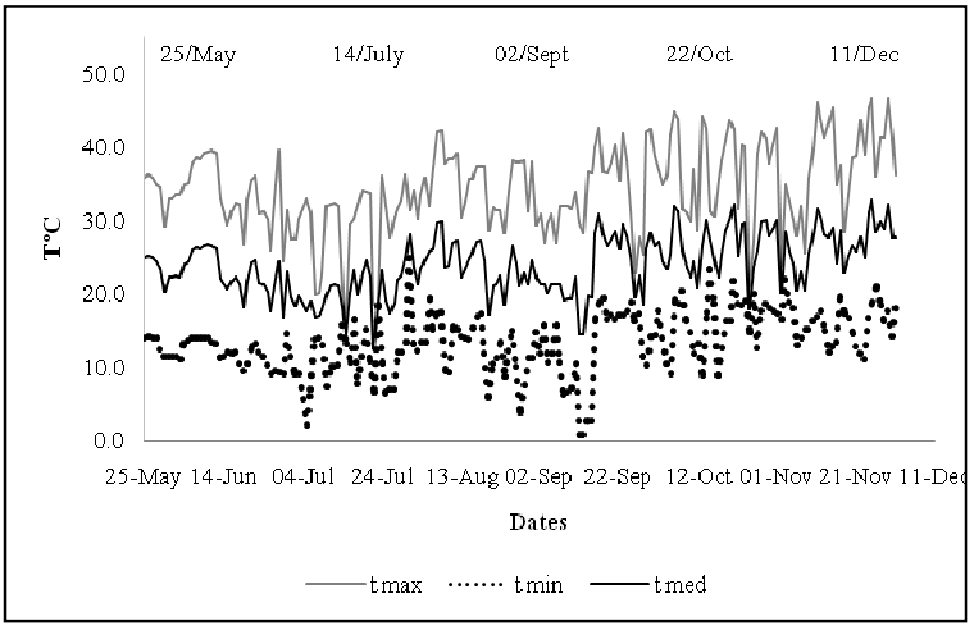

Figure 1. Medium, maximum and minimum temperatures registered inside low tunnels during the strawberry evaluation period in Frederico Westphalen, RS, 2015

Table 2.Phyllochron, Titratable Total Acidity [(TA) (% of citric acid)], Total Soluble Solids [(TSS) (° Brix)], Ratio (TSS/TA), Number of Commercial Fruits (NCF), Mass of Commercial Fruit [(MCF) (g plant-1)], Number of Non-Commercial Fruits (NNCF), Weight of Non-Commercial Fruit [(MNCF) (g plant-1)], of five imported cultivars of strawberry. Frederico Westphalen, RS, 2015

Cultivars	Phyllochron	TA	TSS	TSS/Acidity	NCF	MCF	NNCF	MNCF
Albion	182,11 a	1,32 a	8,3 a	6,25 a	15,12 a	239,89 b	5,07 a	37,17 ab
Camarosa	131,61 a	1,22 a	7,35 ab	6,25 a	16,52 a	249,7 b	4,65 a	31,95 b
San Andreas	146,33 a	1,25 a	7,1 ab	5,67 a	13,22 a	241,77 b	4,72 a	38,72 ab
Camino Real	136,61 a	1,22 a	6,4 b	5,32 a	20,57 a	395,35 a	6,57 a	60,95 a
Aromas	110,13 a	1,05 a	6,45 b	6,2 a	15,75 a	183,35 b	5,175 a	30,6 b
CV(%)	16,98	12,77	8,79	16,36	22,52	21,69	27,28	27,76

Means with the same letter in the column do not differ by Tukey test at 5% probability.

The analysis of variance between all variables showed a significant effect for the variables of soluble solids content (SS), mass of commercial fruit (MCF) and mass of non-commercial fruit (MNCF) for the evaluated cultivars. Regarding phyllochron, TA, and TSS/TA, NCF and NNCF,there were no significant differences and therefore demonstrates a that all cultivars had a similar performance in the location of study (Table 1).The cultivars of short days (Camarosa and Camino Real) are generally influenced by temperature and photoperiod; the entrance into reproductive period depends on these elements (day length shorter than 14 hours and temperatures lower than 25-26ºC), this is different than what occurs in neutral day cultivars that are less sensitive to photoperiod.

Considering the values of 'total soluble solids' (TSS), it was possible to verify that the fruits of Albion cultivar showed the highest values, with 8.3 °Brix, differing statistically from the Camino Real and Aromas cultivars which had the lowest values, 6.4 and 6.45 °Brix, respectively. This was however similar to the results obtained by Antunes (2013) in the nearby Pelotas/RS region, where cultivars had values of 6.23 °Brix for Camino Real and differ for Albion, with 6.59 °Brix.

Resende *et al*. (2010) found an average of only 5.91 °Brix for the cultivar Camarosa in the region of Guarapuava/PR, values below those observed for the same cultivar in this experiment, with 7.35 °Brix. This was similar to those found by Antunes (2010) in the region of Pelotas/RS, showing the effect of the cultivation area in this variable. According to Campbell *et al*., (2011), for strawberries, the minimum content of soluble solids is 7.0% and the maximum of titratable total acidity is 0.8%, that when are combined, constitute the fruit flavor. For the variable mass of commercial fruit (MCF), the cultivar Camino Real presented better performance, with a commercial production of 395 g plant-1, differing significantly from the others. Camarosa was found to produce a'mass of commercial fruit'near 249.7g plant^{-1}, followed by Aromas, Albion, and San Andreas, with average production of 241.77g, 239.89g and 183.35g plant^{-1}, respectively. These values differ from those found by Pereira *et al*. (2013) in a study conducted in the region of BomRepouso - MG for Camarosa and Aromas, of those found by Antunes *et al*. (2010) in Pelotas - RS, and of those obtained by Calvete *et al*. (2008) in a protected environment in the city of PassoFundo - RS. They are however superior to those reported by Passos *et al*. (2015) in Campinas - SP. For the same cultivar, Carvalho *et al*. (2013), in an

experiment conducted in Pelotas - RS, found an average of 563.4 g plant^{-1}. According AGRIANUAL (2006), the production of 700g per plant is considered an ideal yield. The ideal productivity of strawberries, according to Teixeira (2011) ranges from 25 to 50 t ha-1 or 800 g/plant, however, in this study, no cultivar reached these production levels. This fact may be related to weather variables in the year of 2015, which were considered atypical for region with frequent rainfall, low luminosity and high temperatures, factors which, together, caused losses in the production of strawberry fruit. Due to the photosynthetic deficiency suffered by the plants, they were observed to have relatively small flowers. Another factor related to the low production is linked to the season when the strawberries were planted, which was considered late for the strawberry cultivar. In hot climactic regions, this should be done from April 15th to May 30th (WREGE *et al*., 2007), in order to obtain benefits of better payment in periods of supply shortages.

As the planting occurred in June, the plants did not see suitable temperatures for development. June saw the lowest levels of solar radiation (Figure 1); at this time, with the short photoperiod, the plants started flowering (SONSTEBY & HEIDE, 2008), however, in the conditions of this experiment, the plants did not have well developed photosynthetic apparatus yet. Furthermore, in the field until the beginning of the second flowering, all cultivars had few leaves at the crown, thus causing low photosynthetic production due to the reduced foliar area, where aborted flowers were observed, and those that remained were relatively small. The late planting of seedlings is a problem that is a common to most strawberry producers in Rio Grande do Sul, because the imported seedlings arrive very late for the producers, and therefore lose productivity (COCCO *et al*., 2012).The differences between the cultivars can be observed in the productive characteristics of the cultivars, which are the result of the management adopted and the weather conditions in which they were subjected; two factors which need to be optimized if the plant is to reach its full production potential (DUARTE SON *et al*., 2007).The cultivars which presented the lowest commercial mass (Albion and Aromas) are not as strongly affected by photoperiod (neutral days), butare affected by the temperature. In this sense, the low production performance observed in these cultivars can be attributed to the occurrence of high temperatures in the growing period, combined with their intrinsic characteristics which resulted in the early induction of reproductive period with low accumulated reserves. Comparing the cultivars for the mass of non-commercial fruits, Camino Real showed the worst results, with 60.95 g plant^{-1}, better means were seen for Camarosa and Aromas, with 31.95 and 30.6 g plant^{-1}. These results are lower than those found by Passos *et al*. (2015) in a study conducted in the state of São Paulo for Camarosa, Camino Real, and for Calvete (2008) and in Passo Fundo/RS, for Camarosa. The imported strawberry plants have good phytosanitary quality, however their production may compromised when they are delivered to producers outside the ideal time for planting; because of this, the supply of national quality seedlings, could enable early planting in some regions, providing anticipated fruit production with better remuneration for the producer (COCCO *et al*., 2011).

Conclusion

The cultivar Camino Real demonstrated a larger production of fruits per plant. Albion, Camarosa, and San Andreas, in relation to quality parameters, had the highest values of SS.

REFERENCES

Antunes, L.E.C.; Ristow, N.; Krolow, A.; Carpenedo, S..; Reisser Junior, C.Produtividade e qualidade de cultivares de morangueiro. Horticultura Brasileira, Brasília, v.28, n.2, abr/jun. 2010.

Antunes, O.T.; Calvete, E. O.; Rocha, H. C.; Nienow, A. A.; Mariani, F.; Wesp, C. D. L. Floração, frutificação e maturação de frutos de morangueiro cultivados em ambiente protegido. Horticultura Brasileira, Brasília, v. 24, n. 4, P. 426-430, 2006.

Arnold, C.Y. Maximum-Minimumtemperature as a basis for computinggheatunits. American Society for Horticulture Science, v. 76, p. 682-692, 1960.

Calvete, E.O.; Mariani, F.; Wesp, C. D. L.; Nienow, A. A.; Castilhos, T.; Cecchetti, D. Fenologia, produção e teor de antocianinas de cultivares de morangueiro em ambiente protegido. Revista Brasileira de Fruticultura, vol.30, n.2,2008.Camargo, L.K.P.; Resende, J.T.V.; Tominaga, T.T.; Kurchaidt, S.M.; Camargo, C.K.; Figueiredo, A.S.T. 2011. Postharvest quality of strawberry fruits produced in organic and conventional systems. Horticultura Brasileira, 29: 577-583.

Carvalho, S.F.de; Ferreira, L.V.; Picolotto, L.; Correio Antunes, L.E.; Flores, R.F.; Amaral, P.R.; Weber, D.; Barbosa Malgarim, M. Comportamento e Qualidade de Cultivares de Morango (*Fragaria* x *ananassa*Duch.) na Região De Pelotas-RS. Revista Iberoamericana de TecnologíaPostcosecha, v. 14, núm. 2, 2013, p. 176-180 AsociaciónIberoamericana de TecnologíaPostcosecha, S.C. Hermosillo, México.

Cocco, C.; Andriolo, J.L.; Cardoso, F.L.; Erpen, L.; Schmitt, O.J. Crown size and transplant type on the strawberry yield. Scientia Agricola, 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. RevistaBrasileira de Fruticultura, v.34, n.4, p.1284-1288, 2012.

Cruz, CD 2013. Genes – a software package for analysis in experimental statistic and quantitative genetics. Actascientiarum. Agronomy. Maringá, v. 35, n. 3, p. 271-276, july-sept..

Fachinello, J.C.; Pasa, M.S.; Schmitz, J.D.; Betemps, D.L.Situação e perspectivas da fruticultura de clima temperado no Brasil. RevistaBrasileira de Fruticultura, vol.33, p. 109- 120, 2011.

FAO.Food and Agriculture Organization of the United Nations.2011, 04 de maio.FAOSTAT: AgriculturalProduction/strawberry. Disponível em : http://faostat.fao.org.

FAOSTAT. 2015. ProductionCrops. http://faostat3.fao.org/ browse/Q/QC/E

Fiori, J. Produtores iniciam plantio de morango no Rio Grande do Sul. Governo do Estado do Rio Grande do Sul: Notícias do Piratini, Desenvolvimento Rural. Disponível em:

http://www.estado.rs.gov.br/conteudo/17851/produtores-iniciamplantio-do-morango-no-rio-grande-do-sul Acesso em: dezembro de 2015.

IEA. INSTITUTO DE ECONOMIA AGRÍCOLA. 2013. Morango. In: Área e produção dos principais produtos da agropecuária do estado de São Paulo. Disponível em http://www.iea. sp.gov.br/out/bancodedados.html. Acessado em 25/02/2015.

Jouquand, J.; Chandler, C.; Plotto, A.; Goodner, K.A. A Sensory and chemical analysis of fresh strawberries over harvest dates and seasons reveals factor that affect eating quality. Journal of the American Society for Horticultural Science, v.6, n.133, p. 859-867, 2008.

Mendonca, H.F.C; Calvete, E. O.; Nienow, A. A.; Costa, R. C. D.; Zerbielli, L.; Bonafé, M. Phyllochron estimation in intercropped strawberry and monocrop systems in a protected environment. Revista Brasileira de Fruticultura [online]. 2012, v. 34, n.1, p. 15-23.Passos, F.A.; Trani, P.E.; Carvalho, C.R.L. Desempenho agronômico de genótipos de morangueiro. Horticultura Brasileira, v.33, n.2, 2015.

Pereira, W.R.; Souza, R.J.; Yuri, J.E.; Ferreira, S. Produtividade de cultivares de morangueiro, submetidas a diferentes épocas de plantio. Horticultura Brasileira, 31: 500-503, 2013.

Resende, J.T.V.; Camargo, L.K.P.; Argandoña, E.J.S.; Marchese, A.; Camargo, C.K. Sensory analysis and chemical characterization of strawberry fruits. Horticultura Brasileira, Brasília, v.26, n.3, p. 371-374, 2008.

Rosa, H.T. Emissão e crescimento de folhas e seus efeitos na produção de frutas de duas cultivares de morangueiro.Dissertação (Mestrado em Agronomia) - Centro de Ciências Rurais, Universidade Federal de Santa Maria, Santa Maria, 2010.

Santos, A.M.; Medeiros, A.R.M. (Ed.) Morango: produção. Pelotas: Embrapa Clima Temperado; Brasília: Embrapa Informação Tecnológica, 2003. p. 24-30. (Frutas do Brasil, 40).

Sonsteby, A.; Heide, O.M. Temperature responses, flowering and fruit yield of the June-bearing strawberry cultivars Florence, Frida and Korona. ScientiaHorticulturae, 119 (2008), p. 49–54.

Strassburger, A.S.; Peil, R.M.N.; Scwengber, J. E.; Medeiros, C.A.B.; Martins, D.S. Crescimento do morangueiro: influência da cultivar e da posição da planta no canteiro. Ciência Rural, Santa Maria, v.41, n.2, p.223-226, 2011.

Verdial, M.F. Frigoconservação e vernalização de mudas de morangueiro (Fragaria X ananassaDuch.) produzidas em sistema de vasos suspensos. Piracicaba: ESALQ. 71p (Tese de doutorado). 2004.

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. Documentos, 187. Pelotas: Embrapa ClimaTemperado, 2007, 27 p.

****