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RESEARCH ARTICLE

Field behavior of potted seedlings of strawberry plants in different growing seasons

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ABSTRACT

Since dependence on seedling importation has been a hindrance to strawberry farmers, production of national plants has become an alternative solution. This study aimed at evaluating the field behavior of potted seedlings of strawberry plants in a low tunnel system in different early growing seasons in Rio Grande do Sul, Brazil. The experiment was carried out at Embrapa Clima Temperado in 2015 and 2016 in a randomized block design, composed of a 4x3 factorial, four cultivars (Aromas, Camarosa, Festival and Oso Grande) and three growing seasons (March 16th, April 1st and April 16th). For all seasons, the cultivation was until November 30 in 2015 and October 31 in 2016. The following variables were determined: beginning and full blooming, beginning and length of harvest; number of fruits; mean fruit mass; and fresh mass per plant throughout early and total production. The cultivar Aromas presents lower flowering uniformity among plants (difference between beginning and full flowering) according to the two years of evaluation. Potted strawberry seedlings planted until early April 1st - Season 2 in Pelotas, RS, allow high early production, with production above 400 grams per plant. The cultivar Camarosa when planted on March 16 or April 1 had total yield per plant above 800 grams. All cultivars under study (Aromas, Camarosa, Festival and Oso Grande) have better plant development and higher total yield gains in years with higher temperature and lower rainfall in the initial phase and good rainfall distribution over the growing season. (2015) than in years with most frequent precipitation and lower temperature in the initial phase and poor rainfall distribution over the growing season (2016).

Keywords: Early fruiting; Early planting; *Fragaria x ananassa*; National seedlings

INTRODUCTION

Brazil, the largest strawberry producer in South America, has yielded about 120,000 ton in approximately 4,000 ha, mostly located in Minas Gerais (MG), São Paulo (SP) and Rio Grande do Sul (RS) states, at latitudes between 20° and 32° S (Kirschbaum et al., 2017). However, most strawberry plants used in the country have been imported from Patagonia (Argentina and Chile), due to excellent local growing conditions (Antunes and Peres, 2013; Gonçalves et al., 2016), which enable high resource (carbohydrate) accumulation (Cocco et al., 2016). This situation has made producers get increasingly dependent on plant importation and has obliged them to adapt cultivation to the period of plant arrival, which is often not the recommended one for growing strawberries in Brazil (Dal Picio et al., 2013).

An important factor that enables strawberry producers to show their productive potential is the right growing season (Rahman et al., 2014). Pelotas, RS, where the climate is mild, has temperatures that favor blooming and fructification. They range between 13ºC and 26 ºC, from May on. According to Passos et al. (2015), planting seasons should take place between March and April. However, it occurs in May and June lately, as the result of delay in the delivery of imported plants (Antunes and Peres, 2013). Thus, early production has been limited in winter months, which is the period with high sale prices due to low supply in the market (Cocco et al., 2015).

Production of national plants is an alternative solution to mitigate dependence on the importation of Chilean and Argentinian seedlings, which are expensive, damaged during transportation and, mainly, late regarding delivery to Brazilian producers (Janisch et al., 2012; Andriolo et al., 2014). In addition, production of potted seedlings

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cultivated without soil enables the development of high quality plants with low pathogen infestation in the right growing season and increases fruit production in the off-season (Janisch et al., 2012; Schmitt et al., 2016), thus, rendering good profit margins to producers.

Therefore, this study aimed at evaluating the field behavior of potted seedlings of different cultivars of strawberry plants in distinct growing seasons in Pelotas, RS, Brazil.

MATERIALS AND METHODS

The experiment was carried out in an experimental area that belongs to the Embrapa Clima Temperado, located in Pelotas, RS (31º40' S, 52º26' W, alt. of 60 m), Brazil, in 2015 and 2016.

Seedlings were yielded as proposed by Gonçalves et al. (2016), i. e., in a system without soil, with recirculation of nutritious solution and the use of carbonized rice husk as substrate. Propagules were rooted in 72-cell polystyrene trays with commercial substrate Hortaliças CA (Fertile peat®). On the planting day (March 16th), seedlings had grown for forty days after clipping (removal of the propagule from the matrix plant), i. e., ten days of initial rooting in a nebulization chamber (10-second irrigation every 30 minutes) and 30-day growth in acclimatization boxes.

The production system applied to the field was the conventional one that has been widely used in Pelotas, RS. Beds were about 1.1 m wide and 25 cm high, underlaid with black polyethylene film and covered with a low tunnel made of 150 micron thick transparent polyethylene Nortene (Paperplast, Brazil). Plants were placed in a triple-row pattern; both plants and rows were 0.3 m apart. Irrigation and fertirrigation (2,2 g calcium nitrate and 1,8 g potassium nitrate per yard meter per week) were conducted by dripping; drippers were 15 cm apart. Plague and disease control was carried out preventively, i. e., chemical treatments were applied and old and injured leaves were removed whenever symptoms of diseases were observed.

The following variables related to seedling behavior were analyzed: the beginning of blooming and the period between this beginning and full blooming (PBFB). Plants were monitored weekly; the day on which 50% of plants of the plot had at least an open flower was established as the beginning of blooming. PBFB (expressed as days) was determined by the difference between the day on which all plants emitted flowers and the one on which 50% of plants had at least one open flower. The day on which every plot had got 5% of total production of the cycle under evaluation was established as the beginning of harvest (expressed as days). Harvest duration was determined by counting the number of days between the first and last harvest of each cycle (expressed in days).

The fruits were harvested ripe with the epidermis completely red twice a week, counted and weighed on a digital scale (SF-400, YD Tech, China).Only commercial fruits, whose selection was based on their fresh mass, were included in the evaluation. Fruits which had either severe damage or fresh mass below 5 g were considered non-commercial ones and discarded.

The sum of the number and mass of fruits picked in all harvests carried out throughout the experiment was divided by the number of plants in the experimental plot, so as to obtain both total production (g plant^{-1}) and mean number of fruits (fruits plant^{-1}). Mean fruit mass (g fruit^{-1}) was found by the quotient between fresh mass per plant and the number of fruit per plant. Early production was the one obtained from the first harvest to the end of September. Fruit size, i. e., the mean length and diameter of twenty fruits per plot, was measured by a digital pachymeter (150mm, mtx®, China). Results were expressed as millimeters (mm).

The experimental design was carried out in randomized blocks, composed of a 4x3 factorial, four cultivars (Aromas, Camarosa, Festival and Oso Grande) and three planting seasons (March 16th – Season 1; April 1st – Season 2; and April 16th – Season 3), with four replicates and a 9 plant experimental unit. For all seasons, the cultivation was until November 30 in 2015 and October 31 in 2016. Data were submitted to the analysis of variance by the F-test and the mean comparison test (Tukey's test) was conducted at 5% error probability. All analyses were carried out by the Wistat 1.0 program.

RESULTS AND DISCUSSION

There was interaction among the cultivars and growing seasons regarding the beginning of blooming and the period between this beginning and full blooming throughout the 2-year experiment (Table 6).

Plants from the cultivar Aromas needed more time to begin blooming in 2015 (82.33 days) when they were planted on March 16th. Such behavior shows low uniformity among plants concerning floral induction (Table 1). Aromas needed, on average, 42 days more than Oso Grande to yield floral buds, a fact that may be related to their genetic features, since Oso Grande behaves as short-day plants while Aromas behaves as long-day plants (Pádua et al., 2015). Verdial et al. (2007) also observed this difference at the beginning of blooming in the materials used by their study. According to them, Oso Grande was the only cultivar that had flowery plants after 15 days in the treatment with no seedling vernalization, in comparison with the other cultivars under investigation. It is evidence of the fact that

Table 1: Beginning of blooming and period between beginning and full blooming (PBFB) of strawberry cultivars established in different growing seasons in 2015 and 2016. Pelotas/RS-Brazil

Cultivar	2015					
	Beg. blooming (days)			PBFB (days)		
	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
Aromas	82.33^{aA}	46.67^{aB}	36.33^{aB}	40.00^{aAB}	62.00^{aA}	31.33^{aB}
Camarosa	68.00^{aA}	41.67$^{a\ B}$	36.67^{aB}	22.67^{aAB}	12.67^{bB}	39.00^{aA}
Festival	41.00^{bA}	39.67^{aA}	35.33^{aA}	27.67^{aA}	17.00^{aA}	31.33^{aA}
Oso Grande	40.67^{bA}	28.00^{aA}	39.00^{aA}	38.67^{aA}	21.33^{bA}	29.00$^{a\ A}$
C.V. (%)		18.65			36.53	
Cultivar	**2016**					
	Beg. blooming (days)			**PBFB (days)**		
	Season 1	**Season 2**	**Season 3**	**Season 1**	**Season 2**	**Season 3**
Aromas	49.67^{aA}	52.33^{aA}	37.00^{bB}	59.00^{aA}	16.00^{aB}	21.33^{aB}
Camarosa	50.33^{aA}	43.00^{abA}	44.00^{bA}	14.33^{bA}	12.00^{aA}	5.67^{bA}
Festival	63.00$^{a\ A}$	47.67^{abB}	61.67^{aA}	10.67^{bA}	13.67^{aA}	3.00^{bA}
Oso Grande	54.67^{aA}	40.00^{bB}	49.00^{abAB}	6.67^{bA}	5.67^{aA}	15.33^{abA}
C.V. (%)		12.56			44.74	

Means followed by different small letters in a column and capital letters in a row differ among themselves at 5% error probability by the Tukey's test; CV: Coefficient of Variation. Season 1: (16/03 in 2015 and 2016); Season 2: (01/04 in 2015 and 2016); Season 3: (16/04 in 2015 and 2016)

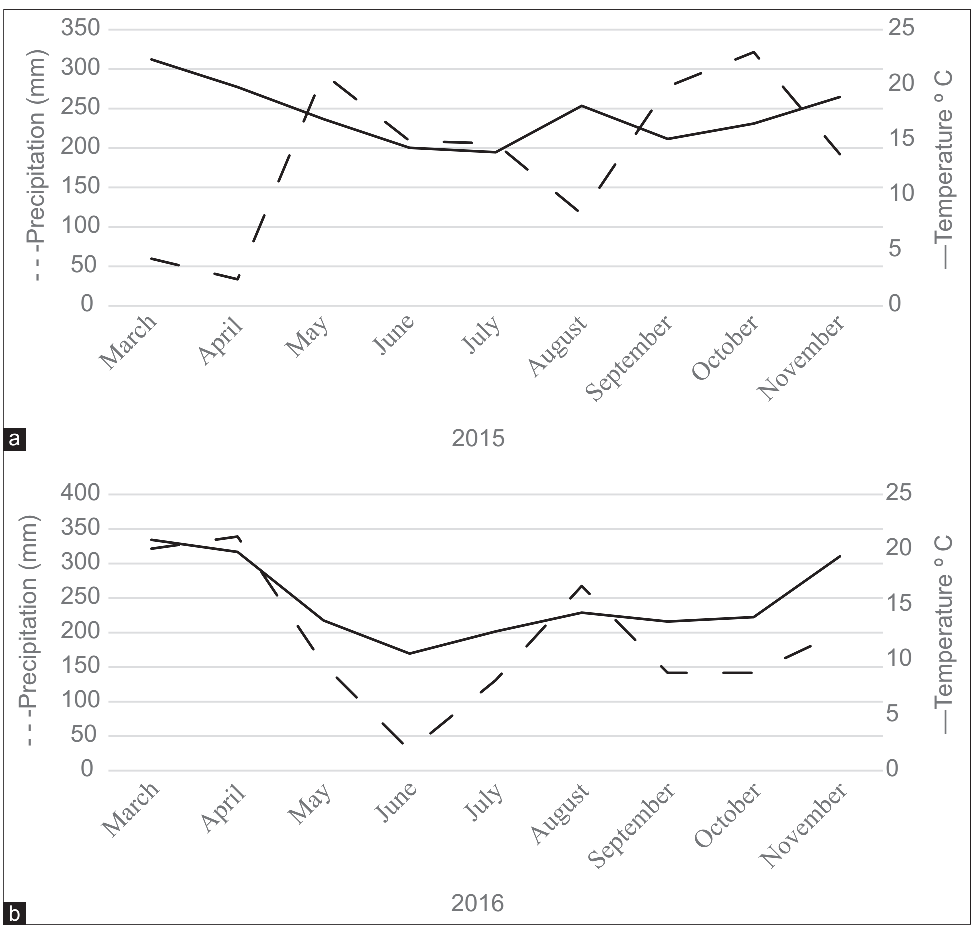

Fig 1. Data on precipitation (mm) and mean temperature (°C) in 2015 (a) and 2016 (b) provided by the Laboratório de Agrometeorologia at the Unidade Sede da Embrapa Clima Temperado, Pelotas, RS, Brazil.

Table 2: Harvest beginning and length (days) of strawberry cultivars established in different growing seasons in 2015 and 2016. Pelotas/RS‑Brazil

Cultivar	2015					
	Harvest beginning (days)			Harvest length (days)		
	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
Aromas	67.33^{aA}	71.33^{aA}	70.33^{aA}	186.0^{aA}	163.67^{aB}	148.67^{abB}
Camarosa	67.33^{aA}	66.67^{aA}	67.0^{aA}	182.67^{aA}	168.0^{aAB}	151.0^{abB}
Festival	61.33^{aA}	65.67^{aA}	53.0^{aA}	184.0^{aA}	169.33^{aA}	166.0^{aA}
Oso Grande	62.33^{aA}	51.33^{aA}	63.33^{aA}	184.33^{aA}	181.0^{aA}	135.67^{bB}
C.V. (%)		15.97			5.57	
Cultivar	**2016**					
	Harvest beginning (days)			Harvest length (days)		
	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
Aromas	137.25^{aA}	117.5^{bB}	0^{cC}	74.5^{aA}	46.75^{bA}	0^{cB}
Camarosa	104.25^{bB}	149.0^{aA}	136.75^{aA}	60.75^{aA}	57.25^{abA}	63.25^{aA}
Festival	110.75^{bA}	114.0^{bA}	116.0^{bA}	48.5^{aAB}	66.0^{abA}	18.5^{bcB}
Oso Grande	109.5^{bB}	117.25^{bAB}	129.25^{abA}	51.25^{aB}	86.0^{aA}	48.25^{abB}
C.V. (%)		9.52			36.42	

Means followed by different small letters in a column and capital letters in a row differ among themselves at 5% error probability by the Tukey's test; CV: Coefficient of Variation. Season 1: (16/03 in 2015 and 2016); Season 2: (01/04 in 2015 and 2016); Season 3: (16/04 in 2015 and 2016). Value '0': Aromas plants did not produce fruit in 2016, they died before the harvest began

early production and maturation are cultivar-dependent variables.

There was higher uniformity at the beginning of blooming among cultivars in growing seasons in 2015, as temperatures dropped between April and May (Figure 1). The number of days needed for plants to start their reproductive stage decreased as growing seasons advanced, since plants were exposed to low thermal amplitude, which enabled them to differentiate their vegetative spurs from the reproductive ones.

All cultivars required a smaller number of days between start and full bloom (PBFB) (Table 1) in 2016 compared to the same period in 2015. It may be explained by the fact that maximum and minimum temperatures in 2016 were lower than the ones in 2015, from April on (Figure 1). Besides, cold started in May (4 chill hours) and June (81 chill hours) and kept regular in the period under evaluation. However, no chill hours were recorded in May 2015 while there were 57 chill hours in June. According to Passos et al. (2015), in regions with mild climate, such as Pelotas, temperatures ranging between 13 and 26 ºC favor strawberry plant blooming and fructification.

Mild temperatures favored floral induction of strawberry plants, since the interval between the beginning and full blooming was shortened in the second year under evaluation, mainly in the case of short-day cultivars (Camarosa, Festival and Oso Grande), which needed less than 20 days for floral induction in all growing seasons (Table 1). Strawberry plants respond differently to the combination of temperature and day length in vegetative and reproductive stages. Floral induction takes place at low temperatures (below 15º C) and day length below 14 hours, in the case of short-day cultivars, whereas day-neutral cultivars are the ones that bloom when the photoperiod has above 14 hours of light per day (Hoffmann and Bernardi, 2006).

The first-year harvest started in May and finished on November 30th. In the second year, harvest began in June and finished on October 31st. In 2016, there was neither beginning nor continuation of harvest in the case of Aromas in the third growing season as the result of a high mortality rate in this treatment and of the fact that plants did not reach their productive stage. In general, plant mortality increased in all treatments in 2016. Plants had low radicular development when they were planted and were exposed to much precipitation in the first two months (Figure 1). It led to more diseases and affected the number of fruits, early and total production, which decreased, and the productive stage, which was shortened (Table 2).

Seedlings planted on March 16th and on April 1st started to yield in May 2015 and June 2016, whereas the ones planted on April 16th began to produce in June 2015 and July 2016. There was a 1-month delay in the production in 2016, i. e., it took place off-season when there was low supply in the market and high sale prices, which may be the double of the ones charged in the peak season (Antunes et al., 2015).

Harvest was longer in the first year under evaluation than in the second year. It ended in November 2015 due to plant exhaustion, which affected its production capacity, and in October 2016, when the end of harvest was brought forward because of increase in the mortality rate and consequent lack of production. Plants may get stressed due to their high production rates in previous months and, then, undergo exhaustion and decrease their productive stage (D'Anna et al., 2014).

Plants produced for about 6 months in the first and second seasons while the ones of the third season yielded for 5 months, because the beginning of harvest took place a month after the others. Plants of the first season had some more days to produce than the ones of the second season, an evidence of the fact that early seedling cultivation in the region favors production, by comparison with seedlings of the third season, which were planted one month later. Besides higher total production, higher early production is reached (Table 5). It is important to the farmers and enables this study to reach its objectives. Its data corroborate the ones found by Cocco et al. (2015), who carried out early cultivation in Pelotas, RS, in April, and got mean early production of 440.9 g.plant^{-1} in the cases of cultivars Aromas and Camarosa.

There was significant interaction between cultivars and growing seasons in the following variables: number of fruits (Table 3), mean fruit mass (Table 4) and fresh fruit mass per plant (Table 5), regarding both early and total production. The number of harvested fruits was higher in 2015 (Table 3) than in 2016. Plants that yielded more fruits (Table 3) produced fruits with lower mass (Table 4). It agreed with data collected by Carvalho et al. (2013), who investigated the behavior and quality of strawberry cultivars in Pelotas, RS, and observed that productivity is inversely proportional to fruit size in the cases of cultivars Camarosa, Camino Real and Festival.

The cultivar Oso Grande yielded a relatively low number of fruits (Table 3) and high mean fruit mass (Table 4) in the three growing seasons in 2015. As seasons went by, the number of fruits decreased in about 24 fruits and the mean mass increased up to 1.4 g.fruit^{-1}. Even though the number of fruits was below average in the second and third seasons, it was larger than the one found by Pádua et al. (2015). According to them, the cultivar Oso Grande yielded 18.40 fruits, whose mass was 9.78 g, when they were planted in May, one month after the third season of the experiment. It shows that the later this cultivar is planted, the fewer fruits it yields. Hence, lower production.

In both years, the cultivar Camarosa had number of fruits and mean fruit mass above average 48.41 and 21.45 fruits with 12.00 and 8.9 g in 2015 and 2016, respectively. It favors farmers, since they pick more fruits whose mass is widely accepted by consumers. These data agree with the ones found by Brugnara et al. (2011), who cultivated the cultivar Camarosa in an organic system and concluded that it was the most productive one and whose fruits were the largest ones in the west of Santa Catarina state. Such findings show its adaptability to climate variations and cultivation systems as the result of its genetic potential.

The first growing season in 2015 and the second one in 2016 were the best ones regarding early production. In the three growing seasons in 2015, early production was higher than in 2016, i. e., Camarosa yielded 551.74 and 563.14 g in the first and second seasons in 2015, respectively (Table 5). Due to delay in seedling cultivation in 2015, early production was lower: Aromas, Camarosa, Festival

Table 3: Mean number of strawberry fruits harvested in early and total production periods of cultivars established in different growing seasons in 2015 and 2016. Pelotas/RS-Brazil

Cultivar	2015					
	Early production			Total production		
	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
Aromas	35.65^{aA}	28.78^{abAB}	24.05^{aB}	68.13^{aA}	48.65^{aAB}	39.41^{aB}
Camarosa	42.70^{aA}	37.26^{aA}	15.88^{aB}	67.74^{aA}	63.02^{aA}	31.97^{aB}
Festival	36.25^{aA}	30.83^{aAB}	23.05^{aB}	56.75^{aAB}	62.31^{aA}	39.71^{aB}
Oso Grande	34.27^{aA}	18.57^{bB}	17.27^{aB}	51.93^{aA}	23.58^{bB}	27.77^{aB}
Mean		28.71			48.41	
C.V. (%)		15.73			20.05	
Cultivar	**2016**					
	Early production			**Total production**		
	Season 1	**Season 2**	**Season 3**	**Season 1**	**Season 2**	**Season 3**
Aromas	22.89^{aA}	15.42^{abAB}	0.00^{bB}	27.23^{aA}	15.75^{aAB}	0.00^{bB}
Camarosa	6.84^{abA}	13.86^{bA}	18.49^{aA}	22.37^{aA}	28.53^{aA}	36.91^{aA}
Festival	4.90^{abB}	33.26^{aA}	5.50^{abB}	13.43^{aB}	38.93^{aA}	5.50^{bB}
Oso Grande	3.19^{bB}	21.13^{abA}	8.25^{abAB}	15.92^{aA}	34.13^{aA}	18.75^{abA}
Mean		12.81			21.45	
C.V. (%)		63.76			49.34	

Means followed by at least one (the same) capital letter in the row and the same small letter in the column do not differ among themselves at 5% error probability by the Tukey's test; CV: Coefficient of Variation. Season 1: (16/03 in 2015 and 2016); Season 2: (01/04 in 2015 and 2016); Season 3: (16/04 in 2015 and 2016). Value '0': Aromas plants did not produce fruit in 2016, they died before the harvest began

Table 4: Mean fruit mass of strawberry plants (g fruit^{-1}) found in early and total production periods of cultivars established in different growing seasons in 2015 and 2016. Pelotas/RS-Brazil

Cultivar	2015					
	Early production (g fruit^{-1})			Total production (g fruit^{-1})		
	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
Aromas	14.70^{bA}	10.36^{cC}	11.82^{abB}	12.12^{aA}	10.41^{cAB}	9.98^{bB}
Camarosa	17.27^{aA}	15.00^{aB}	11.58^{abC}	12.87^{aA}	12.63^{abA}	11.03^{bA}
Festival	14.57^{bA}	12.26^{bB}	10.97^{bC}	11.75^{aA}	11.38^{bcA}	9.89^{bA}
Oso Grande	14.76^{bA}	13.07^{bB}	12.38^{aB}	13.40^{aA}	13.72^{aA}	14.80^{aA}
Mean		13.23			12	
C.V. (%)		3.58			7.72	
Cultivar	**2016**					
	Early production (g fruit^{-1})			Total production (g fruit^{-1})		
	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
Aromas	9.25^{a}A	10.74^{aA}	0.00^{bB}	9.19^{aA}	9.73^{aA}	0.00^{bB}
Camarosa	8.35^{a}A	9.47^{aA}	11.31^{aA}	10.50^{aA}	10.28^{aA}	12.23^{aA}
Festival	8.22^{a}A	9.07^{aA}	2.23^{bB}	10.55^{aA}	8.04^{aA}	1.78^{bB}
Oso Grande	9.81^{a}A	9.92^{aA}	9.34^{aA}	13.44^{aA}	10.17^{aA}	10.87^{aA}
Mean		8.15			8.9	
C.V. (%)		27.32			23.7	

Means followed by at least one (the same) capital letter in the row and the same small letter in the column do not differ among themselves at 5% error probability by the Tukey's test; CV: Coefficient of Variation. Season 1: (16/03 in 2015 and 2016); Season 2: (01/04 in 2015 and 2016); Season 3: (16/04 in 2015 and 2016). Value '0': Aromas plants did not produce fruit in 2016, they died before the harvest began

Table 5: Fresh fruit mass of strawberry plants (g.plant^{-1}) found in early and total production periods of cultivars established in different growing seasons in 2015 and 2016. Pelotas/RS-Brazil

Cultivar	2015					
	Early production (g.plant^{-1})			Total production (g.plant^{-1})		
	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
Aromas	427.45^{bA}	326.61^{cB}	327.67^{aB}	777.67^{aA}	541.95^{bcB}	471.59^{aB}
Camarosa	551.74^{aA}	563.14^{aA}	228.11^{bB}	820.34^{aA}	858.78^{aA}	407.64^{aB}
Festival	475.30^{abA}	444.21^{bA}	301.47^{abB}	689.38^{aA}	789.55^{abA}	450.77^{aB}
Oso Grande	497.54^{abA}	247.90^{cB}	269.33^{abB}	731.92^{aA}	310.67^{cB}	431.45^{aB}
Mean		388.37			606.78	
C.V. (%)		10.25			17.87	
Cultivar	**2016**					
	Early production (g.plant^{-1})			Total production (g.plant^{-1})		
	Season 1	Season 2	Season 3	Season 1	Season 2	Season 3
Aromas	304.57^{aA}	195.84^{aAB}	0.00^{bB}	348.23^{aA}	210.51^{aAB}	0.00^{bB}
Camarosa	122.57^{aA}	195.15^{aA}	297.82^{aA}	418.65^{aA}	388.98^{aA}	583.49^{aA}
Festival	86.28^{aB}	430.57^{aA}	50.50^{abB}	273.67^{aAB}	497.24^{aA}	50.50^{bB}
Oso Grande	71.22^{aA}	287.71^{aA}	121.18^{abA}	416.83^{aA}	434.21^{aA}	302.18^{abA}
Mean		180.28			326.29	
C.V. (%)		71.23			50.44	

Means followed by at least one (the same) capital letter in the row and the same small letter in the column do not differ among themselves at 5% error probability by the Tukey's test; CV: Coefficient of Variation. Season 1: (16/03 in 2015 and 2016); Season 2: (01/04 in 2015 and 2016); Season 3: (16/04 in 2015 and 2016). Value '0': Aromas plants did not produce fruit in 2016, they died before the harvest began

and Oso Grande decreased in 99.78, 323.63, 173.83 and 228.21 g plant^{-1}, respectively, between the first and third growing seasons.

Bringing forward seedling cultivation in the climate conditions in Pelotas (mild temperatures and intense cold in the period under evaluation) led to increase in early and total production (Table 5) of all cultivars under investigation. It is the ideal feature that enables farmers to get more profit. When cultivation was brought forward, seedlings had more time to develop and accumulate resources to grow larger flowers and fruits.

Temperature and photoperiod are the main environmental factors that influence strawberry plant growth and development; the former is the main limiting factor of productivity (Lopez-Aranda et al., 2011; Molina, 2016). Marchese et al. (2006) investigated physiological responses given by strawberry cultivars to different temperatures and photoperiods and observed that both Camarosa and

Table 6: Summary of analysis of variance for phenological variables in strawberry in 2015 and 2016. Pelotas/RS‑Brazil

Variation source	2015 GL	2015 SQ	2015 QM	2015 F	Variation source	2016 GL	2016 SQ	2016 QM	2016 F
	Early flowering					**Early flowering**			
Cultivar (F1)	3	2151,22	717,07	10,35*	Cultivar (F1)	3	805,64	268,54	6,99*
Planting date (F2)	2	3254,89	1627,44	23,51*	Planting date (F2)	2	488,22	244,11	6,35*
Interaction between F1 and F2	6	2277,11	379,52	5,48*	Interaction between F1 and F2	6	770,44	128,41	3,34*
Residue	24	1661,33	69,22		Residue	24	922,00	38,42	
Total	35	9344,55			Total	35	2986,30		
	Period between the beginning and full bloom					**Period between the beginning and full bloom**			
Cultivar (F1)	3	2280,11	760,04	5,91*	Cultivar (F1)	3	3413,89	1137,96	24,35 *
Planting date (F2)	2	142,72	71,36	0,55^{ns}	Planting date (F2)	2	984,22	492,11	10,53*
Interaction between F1 and F2	6	3202,89	533,73	4,14*	Interaction between F1 and F2	6	2783,78	463,96	9,93*
Residue	24	3088,67	128,69		Residue	24	1121,33	46,72	
Total	35	8713,89			Total	35	8303,22		
	Harvest start					**Harvest start**			
Cultivar (F1)	3	738,75	246,25	2,36 ^{ns}	Cultivar (F1)	3	13251,42	4417,14	39,03*
Planting date (F2)	2	8,67	4,33	0,04 ^{ns}	Planting date (F2)	2	7018,04	3509,02	31,00*
Interaction between F1 and F2	6	532,67	88,78	0,85 ^{ns}	Interaction between F1 and F2	6	42153,96	7025,66	62,07*
Residue	24	2292,5	104,20		Residue	24	3734,92	113,18	
Total	35	4160,75			Total	35	66229,92		
	Harvest duration					**Harvest duration**			
Cultivar (F1)	3	276,97	92,32	1,05^{ns}	Cultivar (F1)	3	4322,83	1440,94	4,05*
Planting date (F2)	2	6984,39	3492,19	39,65*	Planting date (F2)	2	9114,00	4557,00	12,83*
Interaction between F1 and F2	6	1624,94	270,82	3,07*	Interaction between F1 and F2	6	10438,67	1739,78	4,89*
Residue	24	1937,61	88,07		Residue	24	11721,33	355,19	
Total	35	11050,31			Total	35	35711,00		
	Number of fruits (early)					**Number of fruits (early)**			
Cultivar (F1)	3	372,31	124,1	6,08*	Cultivar (F1)	3	62,37	20,79	0,31^{ns}
Planting date (F2)	2	1766,67	883,34	43,27*	Planting date (F2)	2	1194,19	597,09	8,94*
Interaction between F1 and F2	6	444,96	74,15	3,63*	Interaction between F1 and F2	6	1918,14	319,69	4,79*
Residue	24	367,43	20,41		Residue	24	1601,76	66,74	
Total	35	3396,33			Total	35	4776,46		
	Number of fruits (total)					**Number of fruits (total)**			
Cultivar (F1)	3	2369,39	789,79	8,38*	Cultivar (F1)	3	1068,9	356,3	3,18*
Planting date (F2)	2	4205,15	2102,57	22,31*	Planting date (F2)	2	1236,53	618,26	5,52*
Interaction between F1 and F2	6	1586,52	264,42	2,80*	Interaction between F1 and F2	6	2610,67	435,11	3,88*
Residue	24	1696,71	94,26		Residue	24	2688,77	112,03	
Total	35	11444,28			Total	35	7604,88		
	Average fruit mass (early)					**Average fruit mass (early)**			
Cultivar (F1)	3	29,08	9,69	43,17*	Cultivar (F1)	3	88,37	29,46	5,94*
Planting date (F2)	2	84,95	42,47	189,23*	Planting date (F2)	2	111,4	55,7	11,23*
Interaction between F1 and F2	6	22,60	3,77	16,78*	Interaction between F1 and F2	6	188,99	31,49	6,35*
Residue	24	4,04	0,22		Residue	24	118,99	4,95	
Total	35	163,28			Total	35	507,76		
	Average fruit mass (total)					**Average fruit mass (total)**			
Cultivar (F1)	3	56,43	18,81	21,92*	Cultivar (F1)	3	200,99	66,99	15,06*
Planting date (F2)	2	7,45	3,75	4,34*	Planting date (F2)	2	140,36	70,17	15,78*
Interaction between F1 and F2	6	15,29	2,54	2,97*	Interaction between F1 and F2	6	185,96	30,99	6,97*
Residue	24	15,44	0,86		Residue	24	106,75	4,44	
Total	35	109,92			Total	35	634,06		
	Fresh fruit mass of plants (Early)					**Fresh fruit mass of plants (Early)**			
Cultivar (F1)	3	64317,83	21439,28	13,53*	Cultivar (F1)	3	11603,41	3867,8	0,23^{ns}
Planting date (F2)	2	256420,34	128210,17	80,94*	Planting date (F2)	2	174453,93	87226,96	5,29*
Interaction between F1 and F2	6	147242,39	24540,39	15,49*	Interaction between F1 and F2	6	356380,74	59396,79	3,60*
Residue	24	28511,66	1583,98		Residue	24	395775,65	16490,65	
Total	35	643734,63			Total	35	938213,72		
	Fresh fruit mass of plants (Total)					**Fresh fruit mass of plants (Total)**			
Cultivar (F1)	3	203990,47	67996,82	5,78*	Cultivar (F1)	3	409292,41	136430,8	5,04*
Planting date (F2)	2	599407,38	299703,69	25,49*	Planting date (F2)	2	154738,56	77369,28	2,85^{ns}
Interaction between F1 and F2	6	394631,28	65771,88	5,59*	Interaction between F1 and F2	6	424791,81	70798,63	2,61*
Residue	24	211571,5	11753,97		Residue	24	650044,73	27085,19	
Total	35	1804231,92			Total	35	1638867,5		

* significant at 5% level (p <0.05); ns: not significant (p≥0.05); GL: degrees of freedom, SQ: sum of squares, QM: mean square, F: observed value of F statistic.

Oso Grande, in autumn-winter periods at temperatures below 21ºC and about 12 hours of day light, emitted more flowers than cultivars submitted to higher temperatures and photoperiods.

Production distribution took place in six months (from June to November) in 2015 and in four months (from July to October) in 2016. The cultivar Camarosa had the highest means in the first year under evaluation, i. e., 820.34 and 858.78 g plant^{-1} in the first and second growing seasons, respectively (Table 5). Results were higher than data found by Cocco (2014), who planted seedlings from different areas in Pelotas, RS, in April and May, and observed that Camarosa was more productive, i. e., 638.0 g plant^{-1}, than Camino Real. It corroborates results found by Gonçalves et al. (2016), who found 850.5 g plant^{-1} in the case of

Camarosa which was established by seedlings on earth clods in Pelotas, RS.

CONCLUSIONS

The production of national strawberry seedlings is an alternative to the producer for production gains in periods of higher price of the product. The cultivar Aromas presents lower flowering uniformity among plants (difference between beginning and full flowering) according to the two years of evaluation. The highest rainfall in 2016 for all planting seasons detracted from the initial development of the seedlings and resulted in a delayed start of harvest by more than 30 days compared to the same period in 2015. Potted strawberry seedlings planted until early April (01/04) - Season 2 in Pelotas, RS, allow high early production, with production above 400 grams per plant. The cultivar Camarosa when planted on March 16 or April 1 had total yield per plant above 800 grams. All cultivars under study (Aromas, Camarosa, Festival and Oso Grande) have better plant development and higher total yield gains in years with higher temperature and lower rainfall in the initial phase and good rainfall distribution over the growing season. (2015) than in years with most frequent precipitation and lower temperature in the initial phase and poor rainfall distribution over the growing season (2016).

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Authors' contributions

'Becker', 'Aldrighi' and 'Antunes' designed the study. 'Becker' and 'Aldrighi' performed the experiment and data collection. 'Becker', 'Aldrighi' and 'Ferreira' wrote the work and performed the data analysis. 'Antunes' supervised the research. All authors read and approved the final manuscript.

REFERENCES

Andriolo, J. L., D. I. Janisch, M. Dal Picio, O. J. Schmitt and M. A. Lerner. 2014. Nitrogen accumulation and monitoring by strawberry stock plants for runner tips production. Rev. Hortic. Bras. 32: 273-279.

Antunes, L. E. C., C. R. Junior, G. K. Vignolo, and M. A. Gonçalves. 2015. Morangos do Jeito que o Consumidor Gosta. Campo Lavoura, Anuário HF, pp. 64-72.

Antunes, L. E. C. and N. A. Peres. 2013. Strawberry production in Brazil and South America. Int. J. Fruit Sci. 13: 156-161.

Brugnara, E. C., M. P. Colli, R. Nesello, L. A. F Verona, J. E. Schwengber and L. E. C Antunes. 2011. Avaliação de Cultivares de Morango para Produção Orgânica no Oeste de Santa Catarina. In: Anais do Congresso Brasileiro de Agroecologia. Vol. 6. Cadernos de Agroecologia, pp. 1-2.

Carvalho, S. F., L. V. Ferreira, L. Picolotto, L. E. C. Antunes, R. F. F. Cantillano, P. A. Amaral, D. Weber and M. B. Malgarim. 2013. Comportamento e qualidade de cultivares de morango (*Fragaria x ananassa* Duch.) na região de Pelotas-RS. Rev. Iberoam. Tecnol. Postcosecha. 14: 176-180.

Cocco, C., M. A. Gonçalves, L. Picolotto, L. V. Ferreira and L. E. C Antunes. 2015. Crescimento, desenvolvimento e produção de morangueiro a partir de mudas com diferentes volumes de torrão. Rev. Bras. Fruticult. 37: 961-969.

Cocco, C. 2014. Produção e qualidade de mudas e frutas de morangueiro no Brasil e na Itália. Doctoral Dissertation (Doctoral Thesis). Universidade Federal de Pelotas, Faculdade de Agronomia Eliseu Maciel, Pelotas.

Cocco, C., M. A. Gonçalves, C. R. Junior, A. C. Marafon and L. E. C. Antunes. 2016. Carbohydrate content and development of strawberry transplants from Rio Grande do Sul and imported. Rev. Bras. Fruticult. 38: e-581.

Dal Picio, M., J. L. Andriolo, D. I. Jänisch, O. J. Schmitt and M. A. Lerner. 2013. Fruit yield of strawberry stock plants after runner tip production by different cultivars. Rev. Hort. Bras. 31: 375-379.

D'Anna, F., G. Caracciolo, R. Alessandro and W. Faedi. 2014. Effects of plant type on two strawberry cultivars in Sicily. Acta Hortic. 149: 553-556.

Gonçalves, M. A., C. Cocco, G. K. Vignolo, L. Picolotto and L. E. C. Antunes. 2016. Comportamento produtivo de cultivares de morangueiro estabelecidos a partir de mudas com Torrão. Rev. Eletro. Cien. UERGS. 2: 277-283.

Hoffmann, A. and J. Bernardi. 2006. Sistemas de Produção de Morangos no Sistema Semi-Hidropônico. Embrapa Uva e Vinho, Sistemas de Produção, 2006. Available from: https://www.sistemasdeproducao.cnptia.embrapa.br/FontesHTML/Morango/MorangoSemihidroponico/introducao.htm. [Last accessed on 2017 Jan 23].

Janisch, D. I., J. L. Andriolo, V. Toso, K. G. F. Santos and J. M. Souza. 2012. Nitrogen for growth of stock plants and production of strawberry runner tips. Rev. Bragantia.71: 394-399.

Kirschbaum, D. S., C. E. Vicente, M. A. Cano-Torres, M. Gambardella, F. K. Veizaga-Pinto and L. E. C Antunes. 2017. Strawberry in South America: From the Caribbean to Patagonia. Acta Hortic. 1156: 947-956.

Lopez-Aranda, J. M., C. Soria, B. M. Santos, L. Miranda, P. Dominguez and J. J. Medina-Mínguez. 2011. Strawberry production in mild climates of the world: A review of current cultivar use. Int. J. Fruit Sci. 11: 232-244.

Marchese, A., J. T. V. Resende, R. Mintkewski, M. V. Faria, I. R. Nascimento, J. C. Marodin, D. B. Pires and P. H. Kaczmarczyk. 2006. Respostas Fisiológicas de Cultivares de Morango a Diferentes Regimes de Temperatura e Fotoperíodo. Anais CBO. Available from: http://www.abhorticultura.com.br/biblioteca/Default.asp?id=5989. [Last accessed on 2017 Feb 16].

Molina, A. M. R. 2016. A Cultura do Morangueiro (*Fragaria x ananassa* Duch.) no Estado de Santa Catarina: Sistemas de Produção e Riscos Climáticos. (Master's Dissertation), Universidade Federal de Santa Catarina, Florianópolis.

Pádua, J. G., J. D. Filho, T. H. Araujo, S. G. Pereira, E. L. Carmo,

F. E. C. Costa and M. S. C. Dias. 2015. Desempenho agronômico e comportamento de cultivares de morangueiro quanto à mancha-de-pestalotiopsis e às podridões dos frutos. Rev. Agrogeoambiental. 7: 65-74.

Pádua, J.G., L. C. D. Rocha, E. D. Gonçalves, T. H. Araújo, E. L. Carmo and R. Costa. 2015. Comportamento de cultivares de morangueiro em Maria da Fé e Inconfi dentes, sul de Minas Gerais. Rev. Agrogeoambiental. 7: 69-79.

Passos, F. A., P. E. Trani and C. R. L. Carvalho. 2015. Desempenho agronômico de genótipos de morangueiro. Rev. Hortic. Bras. 33: 267-271.

Rahman, M. M., M. M. Rahman, M. M. Hossain, Q. A. Khaliq and M. Moniruzzaman. 2014. Effect of planting time and genotypes growth, yield and quality of strawberry (*Fragaria x ananassa* Duch.). Sci. Hortic. 167: 56-62.

Schmitt, O. J., J. L. Andriolo, E. Schultz, M. A. Lerner, J. M. Souza and M. Dal Picio. 2016. Produção de estolhos de cultivares de morangueiro em função da condutividade elétrica da solução nutritiva. Rev. Hortic. Bras. 34: 294-301.

Verdial, M. F., J. T. Neto, K. Minami, J. A. S. Filho, P. J. Christoffoleti, F. V. Scarpare, J. F. Barela, J. S. Aguila and R. A. Kluge. 2007. Vernalização em cinco cultivares de morangueiro. Rev. Ciência Rural. 37: 976-981.