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

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 13°C and 26 °C, 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
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 (31°40’ S, 52°26’ 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 and 2016).
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 Verdi 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

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  | Beg. blooming (days) 2015 | PBFB (days) 2015 | Beg. blooming (days) 2016 | PBFB (days) 2016 |
|-----------|---------------------------|------------------|---------------------------|------------------|
|           | Season 1 | Season 2 | Season 3 | Season 1 | Season 2 | Season 3 | Season 1 | Season 2 | Season 3 |
| Aromas    | 82.33AA | 46.67AB | 36.33AB | 40.00AB | 62.00AA | 31.33AB |
| Camarosa  | 68.00AA | 41.67AB | 36.67AB | 22.67AB | 12.67AB | 39.00AA |
| Festival  | 41.00AA | 39.67AB | 35.33AB | 27.67AB | 17.00AB | 31.33AB |
| Oso Grande| 40.67AA | 28.00AA | 39.00AA | 38.67AA | 21.33AB | 29.00AA |
| C.V. (%)  | 18.65   |         |         | 36.53   |         |         |         |         |         |

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.
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 °C 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 15° 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 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   | Early production |              | Total production |              |
|------------|------------------|--------------|------------------|--------------|
|            | Season 1 | Season 2 | Season 3 | Season 1 | Season 2 | Season 3 |
| Aromas     | 35.65ab  | 28.78ab   | 24.05ab  | 68.13ab | 48.65ab | 39.41ab |
| Camarosa   | 42.70ab  | 37.26ab   | 15.88ab  | 67.74ab | 63.02ab | 31.97ab |
| Festival   | 36.25ab  | 30.83ab   | 23.05ab  | 56.75ab | 62.31ab | 39.71ab |
| Oso Grande | 34.27ab  | 18.57ab   | 17.27ab  | 51.93ab | 23.58ab | 27.77ab |
| Mean       | 28.71    |            | 15.73    |            | 48.41    | 20.05    |
| C.V. (%)   | 56.31    |            | 23.58    |            | 27.77    | 20.05    |

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       | 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 aA | 10.36 cC | 11.82 abA |   | 12.12 aA | 10.41 abA | 9.98 abc |   |
| Camarosa       | 17.27 aA | 15.00 abA | 11.58 cC |   | 12.87 aA | 12.63 abA | 11.03 abA |   |
| Festival       | 14.57 aA | 12.26 abA | 10.97 abC |   | 11.75 aA | 11.38 abA | 9.89 abA |   |
| Oso Grande     | 14.76 aA | 13.07 abA | 12.38 abA |   | 13.40 aA | 13.72 abA | 14.80 abA |   |
| Mean           | 13.23    |            |            |   | 12.60    |            |            |   |
| C.V. (%)       | 3.58     |            |            |   | 7.72     |            |            |   |

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       | 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 aA | 326.61 abA | 327.67 abA |   | 777.67 aA | 541.95 abA | 471.59 abA |   |
| Camarosa       | 551.74 aA | 563.14 abA | 228.11 abA |   | 820.34 aA | 858.78 abA | 407.64 abA |   |
| Festival       | 475.30 abA | 444.21 abA | 301.47 abA |   | 689.38 aA | 789.55 abA | 450.77 abA |   |
| Oso Grande     | 497.54 abA | 247.90 abA | 269.33 abA |   | 731.92 aA | 310.67 abA | 431.45 abA |   |
| Mean           | 388.37    |            |            |   | 606.78   |            |            |   |
| C.V. (%)       | 10.25     |            |            |   | 17.87    |            |            |   |

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...
Oso Grande, in autumn-winter periods at temperatures below 21°C and about 12 hours of daylight, 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

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

| Year | Variation source | GL | SQ | QM | F |
|------|------------------|----|----|----|---|
| 2015 | Early flowering |    |    |    |   |
|       | Cultivar (F1)    | 3  | 2151.22 | 717.07 | 10.35* |
|       | Planting date (F2) | 2  | 3254.89 | 1627.44 | 21.51* |
|       | Interaction between F1 and F2 | 6  | 2277.11 | 379.52 | 5.48* |
|       | Residue | 24 | 1661.33 | 69.22 | |
|       | Total | 35 | 9344.55 | |
|       | Period between the beginning and full bloom |    |    |    |   |
|       | Cultivar (F1)    | 3  | 2280.11 | 760.04 | 5.91* |
|       | Planting date (F2) | 2  | 142.72 | 71.36 | 0.55* |
|       | Interaction between F1 and F2 | 6  | 3202.89 | 533.73 | 4.14* |
|       | Residue | 24 | 1088.67 | 128.69 | |
|       | Total | 35 | 8713.09 | |
| 2016 | Harvest start |    |    |    |   |
|       | Cultivar (F1)    | 3  | 738.75 | 246.25 | 2.36** |
|       | Planting date (F2) | 2  | 8.67 | 4.33 | 0.04** |
|       | Interaction between F1 and F2 | 6  | 532.67 | 88.78 | 0.88** |
|       | Residue | 24 | 1292.5 | 104.20 | |
|       | Total | 35 | 4165.75 | |
|       | Number of fruits (early) |    |    |    |   |
|       | Cultivar (F1)    | 3  | 372.31 | 124.2 | 20.79 |
|       | Planting date (F2) | 2  | 1766.67 | 883.34 | 41.27* |
|       | Interaction between F1 and F2 | 6  | 444.96 | 74.15 | 3.63* |
|       | Residue | 24 | 367.43 | 20.41 | |
|       | Total | 35 | 11963.33 | |
|       | Number of fruits (total) |    |    |    |   |
|       | Cultivar (F1)    | 3  | 2166.39 | 789.79 | 8.38* |
|       | Planting date (F2) | 2  | 4205.15 | 2102.57 | 22.31* |
|       | Interaction between F1 and F2 | 6  | 1586.52 | 264.42 | 2.89* |
|       | Residue | 24 | 1696.71 | 94.26 | |
|       | Total | 35 | 11444.28 | |
|       | Average fruit mass (early) |    |    |    |   |
|       | Cultivar (F1)    | 3  | 20.28 | 9.69 | 41.17* |
|       | Planting date (F2) | 2  | 84.95 | 42.47 | 189.23* |
|       | Interaction between F1 and F2 | 6  | 22.60 | 3.77 | 16.76* |
|       | Residue | 24 | 4.04 | 0.22 | |
|       | Total | 35 | 163.28 | |
|       | Average fruit mass (total) |    |    |    |   |
|       | Cultivar (F1)    | 3  | 56.43 | 18.31 | 21.92* |
|       | Planting date (F2) | 2  | 7.45 | 3.75 | 4.34* |
|       | Interaction between F1 and F2 | 6  | 15.29 | 2.54 | 2.97* |
|       | Residue | 24 | 15.44 | 0.86 | |
|       | Total | 35 | 109.92 | |
|       | Fresh fruit mass of plants (Early) |    |    |    |   |
|       | Cultivar (F1)    | 3  | 6431.83 | 21439.28 | 13.55* |
|       | Planting date (F2) | 2  | 256420.34 | 128210.17 | 80.94* |
|       | Interaction between F1 and F2 | 6  | 147242.39 | 24540.39 | 15.69* |
|       | Residue | 24 | 2851.66 | 1583.98 | |
|       | Total | 35 | 643734.63 | |
|       | Fresh fruit mass of plants (Total) |    |    |    |   |
|       | Cultivar (F1)    | 3  | 201099.47 | 679968.82 | 7.78* |
|       | Planting date (F2) | 2  | 594947.38 | 2099703.69 | 25.49* |
|       | Interaction between F1 and F2 | 6  | 394631.28 | 657718.8 | 5.59* |
|       | Residue | 24 | 211571.5 | 11755.97 | |
|       | Total | 35 | 1804311.92 | |

*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.
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.

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