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Evaluation of the agronomic potential of strawberry genotypes (*fragaria* × *ananassa duch*) in an organic soilless environment

Avaliação do potencial agronômico de genótipos de morango (*fragaria* × *ananassa duch*) em ambiente orgânico sem solo

Evaluación del potencial agronómico de genotipos de fresa (*fragaria* × *ananassa duch*) en un medio orgánico sin suelo

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Abstract
The current scenario in strawberry cultivation is the adoption of the off-ground method in substrate, which reduces the relevance of the planting period in the transplanting process. This study aimed to carry out an agronomic characterization of strawberry genotypes grown out of the ground, under an organic production system. An experimental design with subdivided plots was used for each pair of genotypes, where the plots represented the genotypes themselves and the subplots represented the months of evaluation. Each genotype was evaluated in three replicates, totaling 18 plants in each. The evaluations included phenological aspects, commercial classification, coloring, plant characterization, and production aspects. The data was analyzed using variance, with differences between means evaluated using the Tukey test at 5% probability. Throughout the evaluations, DN3 outperformed DN6 in terms of diameter, number of fruits, production and chlorophyll content, while being phenologically later. Among the short-day genotypes, DC10 stood out with greater diameter, chlorophyll content and production at harvest, demonstrating precocity in relation to DC01. However, due to the late planting, the production of the short-day genotypes was lower than expected, revealing a more significant impact of this practice.
Keywords: Agricultural sustainability; Genetic evaluation; Ecological; Productivity; Agronomic innovation.

Resumo
O cenário atual no cultivo do morango é a adoção do método fora do solo em substrato, o que reduz a relevância do período de plantio no processo de transplante. Este estudo teve como objetivo realizar a caracterização agronômica de genótipos de morango cultivados fora do solo, em sistema orgânico de produção. Foi utilizado um delineamento experimental com parcelas subdivididas para cada par de genótipos, em que as parcelas representavam os próprios genótipos e as subparcelas representavam os meses de avaliação. Cada genótipo foi avaliado em três repetições, totalizando 18 plantas em cada uma. As avaliações incluíram aspectos fenológicos, classificação comercial, coloração, caracterização da planta e aspectos de produção. Os dados foram analisados por meio de variância, com diferenças entre as médias avaliadas pelo teste de Tukey a 5% de probabilidade. Ao longo das avaliações, o DN3 superou o DN6 em termos de diâmetro, número de frutos, produção e teor de clorofila, sendo fenologicamente mais tardio. Entre os genótipos de dias curtos, o DC10 se destacou com maior diâmetro, teor de clorofila e produção na colheita, demonstrando precocidade em relação ao DC01. Entretanto, devido ao plantio tardio, a produção dos genótipos de dias curtos foi menor do que o esperado, revelando um impacto mais significativo dessa prática.
Palavras-chave: Sustentabilidade agrícola; Avaliação genética; Ecológicas; Produtividade; Inovação agronômica.

Resumen
El escenario actual en el cultivo de fresa es la adopción del método fuera de suelo en sustrato, lo que reduce la relevancia del periodo de plantación en el proceso de trasplante. Este estudio tuvo como objetivo realizar una caracterización agronómica de genotipos de fresa cultivados fuera de suelo, bajo un sistema de producción orgánica. Se utilizó un diseño experimental con parcelas subdivididas para cada par de genotipos, donde las parcelas representaban a los propios genotipos y las subparcelas a los meses de evaluación. Cada genotipo se evaluó en tres repeticiones, con un total de 18 plantas en cada una. Las evaluaciones incluyeron aspectos fenológicos, clasificación comercial, coloración, caracterización de la planta y aspectos productivos. Los datos se analizaron mediante varianza, evaluándose las diferencias entre medias mediante el test de Tukey al 5% de probabilidad. A lo largo de las evaluaciones, DN3 superó

a DN6 en diámetro, número de frutos, producción y contenido en clorofila, siendo fenológicamente más tardío. Entre los genotipos de día corto, DC10 destacó con mayor diámetro, contenido en clorofila y producción a cosecha, demostrando precocidad respecto a DC01. Sin embargo, debido a la plantación tardía, la producción de los genotipos de día corto fue inferior a la esperada, revelando un impacto más significativo de esta práctica.
Palabras clave: Sostenibilidad agrícola; Evaluación genética; Ecológico; Productividad; Innovación agronómica.

1. Introduction

Strawberry production and the market (*Fragaria × ananassa Duch*.) have been expanding due to the sensory and nutritional characteristics of the fruit, combined with the attractive marketing value, which reaches approximately 23 reais per kilo (Anami et al., 2022). Between 2011 and 2021, Brazilian production increased by 31%, reaching 218,881 tons. This growth is driven by the adoption of new cultivation technologies, such as innovative planting methods, new varieties and management strategies. The economic attractiveness of the crop also stands out, especially for producers with smaller areas (Octaveus et al., 2023; Antunes et al., 2022).

The attractiveness of strawberry production for farmers highlights the importance of research into new genetic materials to evaluate their performance in Brazilian conditions. These evaluations not only guide producers in choosing the most suitable genotype for their regions, but also strengthen national breeding programs, increasing the commercial availability of cultivars (Alves et al., 2020).

It is essential to note that strawberry genotypes are categorized based on photoperiod and temperature. Short-day materials are suitable for inducing flowering during periods with shorter days and temperatures below 15°C, such as in the fall and winter months. On the other hand, day-neutral genotypes do not depend on the length of days for flowering to occur, but are mainly influenced by temperature, ideally not exceeding 28°C (Zeist et al., 2019).

Off-ground cultivation in substrate has boosted the growth of the planted area and strawberry production. This technique, commonly carried out in protected environments, uses fertigation systems and substrate planting (Palombini et al., 2023). In recent years, there has been a significant migration from soil cultivation to this approach, representing 70% of the strawberry production area in the state of Rio Grande do Sul. This change is motivated by advantages such as no crop rotation, ergonomic benefits, lower incidence of disease, earlier harvesting and higher yields per area (Henz, 2010).

Growing outside in substrate has changed the traditional determinants of planting time, which used to be based on the needs of the cultivar and local conditions. Now, farmers consider criteria such as the installation of the protected environment and the origin of the seedlings (Gallace et al., 2019). With 60% of seedlings from international nurseries subject to logistical delays, coupled with difficulties in acquiring materials for the protected environment and a lack of planning, planting often takes place late. In Brazil, short-day cultivars are planted from March to May, and neutral-day materials from June to July (Marco et al., 2019).

The organic strawberry growing system is on the rise, with the aim of reducing the use of chemical inputs, cutting costs and mitigating environmental impact, resulting in the production of high-quality fruit (Cervantes et al., 2019). As the demand for healthy food grown without pesticides increases, organic cultivation practices for strawberries are arousing interest among both consumers and farmers, reflecting the search for health, profitability and environmental preservation (Sampietro et al., 2023; Sidhu et al., 2022).

The planting period of strawberry plants has a significant influence on their growth, regardless of the genetic materials and cultivation method (Park et al., 2023). Environmental factors such as temperature, light, photoperiod and humidity impact flower induction, flower and fruit production, quality and yield (Sausen et al., 2020). Research into the implications of late planting is crucial for the successful development of the crop under various conditions. This study aimed to carry out an agronomic characterization of strawberry genotypes grown out of the ground, under an organic production system.

2. Methodology

The study was conducted in the experimental area of the horticulture department of the Federal University of the Southern Frontier (UFFS), located in Laranjeiras do Sul, Paraná, Brazil, at 25°24'28" S and 52°24'58" W, at an altitude of approximately 840 meters. According to the Köppen-Geiger system of 1948, the region is classified as having a temperate climate (Cfb), with average annual temperatures of between 18 and 19ºC and annual rainfall ranging from 1800 to 2000 mm (Caviglione et al., 2000).

The research was carried out between August 2022 and December 2022, recording minimum and maximum temperatures of 9.48°C and 30.13°C, respectively. With regard to accumulated rainfall, a total of 2403.81 mm was observed during the study period (UFFS, 2023). The experiment used four different strawberry genotypes obtained from the Agro-Veterinary Sciences Center (CAV) of the Santa Catarina State University (UDESC). The materials used included two short-day genotypes, designated as DN3 and DN6, as well as two neutral-day genotypes identified as DC01 and DC10. These were offered to the Federal University of the Southern Frontier for experiments to be carried out in the soil and climate conditions of the municipality of Laranjeiras do Sul, in the state of Paraná. The genotypes were grown outside, using a substrate housed in trough-type containers, and managed under an organic production system.

The experimental design adopted for each pair of genotypes was a randomized design in subdivided plots. The plots were designated by genotypes, while the subplots represented the months of evaluation (from August to May). Each genotype was replicated three times, totaling 18 plants per repetition. The controlled environment used for both sets of genotypes consisted of a greenhouse-type structure with dimensions of 2.5 m high, 8.0 m wide and 50.0 m long.

In the out-of-ground growing system, commercial gutters made from recyclable material from carton packs, known as W-shaped gutters, were used. These gutters were 6.00 m long, 0.30 m wide at the top, 0.13 m wide at the base and 0.20 m high. The troughs were arranged on benches 0.90 m high, each containing two troughs spaced 0.40 m apart. This arrangement was chosen due to its resistance and durability, guaranteeing an environment conducive to plant growth.

The substrate used was adapted from the formulation proposed by Mazon (2019) for the organic cultivation of strawberry plants outside the soil. This substrate consisted of a mixture of 31.80% sieved soil, 8.07% vermiculite, 24.84% organic compost such as poultry litter, 34.78% Tecnomax commercial substrate (class F), composed of vermiculture, pine/eucalyptus bark, ash, coconut fiber and rice husk. In addition, 0.49% limestone was added. After the troughs had been filled with the substrate, they were covered with plastic mulch, 20 microns thick, black on one side and white on the other, with the white side facing upwards. This practice aimed to optimize growing conditions, providing a suitable environment for the plants to thrive.

The seedlings were planted on August 9, 2022, marking the beginning of the first growing cycle. The spacing between the plants was set at 0.20m. Drip irrigation was automated. In general, the frequency was set at three times during the day, with four-minute pulses. On hotter days, due to rising temperatures, a fourth irrigation was introduced throughout the day. During spring and summer, when temperatures were higher and humidity lower, a sprinkler system was installed at the bottom of the benches, which was activated simultaneously with the irrigation. This measure aimed to ensure ideal humidity conditions for plant growth.

Fertilization was carried out using a non-recirculating fertigation system, using inputs permitted in organic farming, such as supermagro, sugarcane molasses and bokashi. The electrical conductivity was kept between 1.1 and 1.2 dS.cm-1 during the vegetative growth phase and between 1.5 and 1.8 dS.cm-1 during the reproductive phase (Antunes et al., 2016). The frequency of fertilization was adjusted according to climatic conditions and the needs of the plants, generally occurring four times a week.

To control phytophages and phytopathogens, phytosanitary sprays were applied weekly, varying in terms of their action, including protective sprays, fungicides and insecticides. All the sprays used were permitted for organic strawberry cultivation, such as 1% horsetail sprays (*Equisetum fluviatile L.*), 1% milk sprays, 1% wheat flour sprays, 1% garlic sprays (*Allium sativum L.*), among others. Yellow and blue commercial adhesive traps were placed on the benches, with four traps per bench, spaced 1.5 meters apart and at a height of 1.5 meters from the ground. These traps were replaced every two weeks. To repel insect pests and attract natural enemies, repellent and attractive plants such as rue (*Ruta graveolens L.*), chives (*Allium schoenoprasum L.*) and lavender (*Lavandula latifolia Mill.*) were planted along the edges of the gutters.

In February, the short-day plants were drastically pruned in the second half of the month, while the neutral-day plants were pruned in the first half of March. When pruning, all the leaves of the plants were removed, preserving only the new shoots. Subsequently, fertigation was administered with half the dose of fertilizer for two weeks. All these procedures were carried out in accordance with the recommendations of VIgnolo et al. (2018).

The assessments carried out on the plants were categorized into phenological, plant characterization and production aspects. The phenological assessments followed the methodology proposed by Antunes et al. (2006), considering the start of flowering when 50% of the plants had at least one flower open. From this point onwards, the start dates of the parameters were determined, including the period from transplanting to the start of flowering (T-F), the start of flowering to the start of harvesting (IFIC), and from transplanting to the start of harvesting (T-IC), as well as the start of transplanting to the start of stolon emission (T-IE).

Plant characterization assessments were carried out on a monthly basis, except for the short-day genotypes, which were not assessed in February due to drastic pruning, and the neutral-day materials, which were assessed from March onwards. In accordance with the Standards of the Brazilian Program for the Modernization of Horticulture, the commercial classification of the harvested fruit was carried out, taking into account the class, serious defects (absence of calyx and sepals, immaturity, rot, serious deformation, deep damage and past) and slight defects (uncharacteristic color, deformation, hollow, rot, anthracnose, superficial damage and presence of foreign material).

Other evaluations included diameter, soluble solids content, fruit length and unit mass. Unit mass (in grams) was determined using a semi-analytical digital scale. Fruit diameter and length measurements were taken using a digital caliper, with the results expressed in millimeters. For the soluble solids analysis, a sample of fruit juice was collected and added to a Hanna Hi96801 digital refractometer with automatic temperature compensation, giving the result in degrees °Brix.

The color parameters were expressed as L* (corresponding to clarity/luminosity), a* (defining the transition from green (-a*) to red (+a*)), b* (representing the transition from blue (-b*) to yellow (+b*)), where the further away from the center (=0), the more saturated the color; C* (chromaticity or color intensity) and the Hue angle (º H), where 0º = red, 90º = yellow, 180º = green and 360º = blue. Soluble solids (°Brix), titratable acidity (TA), SS/TA ratio (%) and pH. Then the total chlorophyll content, measured with a Falker Clorofilog model CFL 1030 chlorophyll meter. The Falker chlorophyll index (FCI) was expressed from these measurements, taken on two leaves per plant.

The production aspects were analyzed weekly, recording the number of fruits per plant and the fresh mass of the fruits, measured on a digital scale and expressed in grams. The data obtained was subjected to analysis of variance and differences between means were compared using the Tukey test at 5% probability. All evaluations were carried out using the Sisvar 5.6 program (Ferreira, 2011).

3. Results and Discussion

The evaluations were carried out with the neutral-day (DN3 and DN6) and short-day (DC01 and DC10) genotypes. Severe defects (absence of calyx and sepals, immaturity, rot, severe deformation, deep damage and past) were not observed. As for mild defects, uncharacteristic coloration, deformation, hollowness, anthracnose, surface damage, presence of foreign material and rot (1%) were identified. The genetic diversity of the genotypes evaluated is fundamental to guaranteeing the crop's resilience in challenging environments, such as organic cultivation without soil (Brandt et al., 2022). This diversity can be vital for coping with variable climatic conditions and pathogen pressures (Folta, 2019).

The absence of serious defects, such as absence of calyx and sepals, immaturity, rot, severe deformation, deep damage and past, is in line with studies that emphasize the importance of these aspects in the commercial acceptance of the fruit (Takeda et al., 2018). The identification of mild defects, such as uncharacteristic coloration, deformation, hollowness, anthracnose, surface damage, presence of foreign material and 1% rot, is in line with research addressing phytosanitary challenges in strawberry cultivation (Martins et al., 2021). The results point to the need for future research exploring the optimization of management practices in organic soilless environments, considering the interaction between genotypes, cultural practices and soil health (Magagnini et al., 2022).

Fruit mass is a crucial factor due to consumer preference for larger, more attractive fruit. However, there were no statistically significant differences in average mass between neutral-day and short-day strawberry genotypes (Table 1). This suggests uniformity in this respect, indicating that the choice between these genotypes can be made based on agronomic criteria or other characteristics, in addition to fruit size. It is important to note that consumer preference is not limited to fruit size alone, and other attributes such as taste, texture and aroma can play a crucial role in the purchasing decision. Therefore, the full evaluation of these genotypes should consider a wider range of sensory characteristics to meet consumer expectations (Araújo et al., 2022).

Table 1 - Mass (g), firmness (FIR), pH, soluble solids (SS), titratable acidity (AT) and soluble solids/titratable acidity ratio (SS/AT) of genotypes DN03 and DN06 (neutral day) and DC01 and DC10 (short day) of (Fragaria X Ananassa Duch.) during the 5 months of evaluation.

Genotypes	**MAS (%)**	**FIR (N)**	**pH**	**SS (ºBrix)**	**AT ***	**SS/AT**
DN03	15, 34 a	0,31 a	1,02 a	4,55 a	0, 19 a	5, 67 aB
DN06	14, 90 a	0, 30 a	0, 86 a	7, 50 a	0, 98 aBc	0, 11 a
DC01	13,39 a	0,32 a	1,43 a	4, 23 a	0, 36 aB	11, 50 b
DC10	15, 05 a	0, 28 a	2,13 a	8, 01 a	1, 36 Bc	0, 092 a
Média	14, 73	0, 30	1,55	4, 14	0, 78	4, 33
CV (%)	44, 41	60, 83	0, 54	2, 57	2, 29	4,21

Averages followed by equal letters do not differ by Tukey's test at the 5% probability level, lowercase letters in the column; uppercase letters in the row. Source: Personal archive.

No significant differences were identified between the genotypes in relation to firmness in all the fruit evaluated. The preservation of flesh firmness is often considered a crucial quality parameter in post-harvest handling, as it is associated with better storage conditions and a more attractive visual appearance (Brackmann et al., 2011). Evaluating pH is a crucial parameter in defining the final destination of the fruit. Fruits with a less acidic pH are generally destined for fresh consumption, while those with higher levels of acidity are preferably destined for industrialization processes. This measure plays a vital role in decisionmaking regarding the application and use of fruit in different segments of the food industry (Alves et al., 2019). The evaluations between the strawberry genotypes with neutral days and short days showed no statistically significant differences.

The measurement of soluble solids is indicative of the fruit's stage of ripeness, with sugars being mainly responsible for the increase in this content throughout ripening. According to the Brazilian Program for the Modernization of Horticulture (PBMH), fruit maturity is categorized based on the minimum soluble solids content, measured in degrees Brix. For strawberries, the classification ranges from poor (6.0 ºBrix) to excellent (16.0 ºBrix), establishing quality standards related to the soluble solids content (Farnezi et al., 2020). In the analysis of soluble solids content, there was no statistically significant difference between all the genotypes evaluated.

Titratable acidity denotes the amount of organic acids in the fruit and is a fundamental quality attribute in balance with the sugar content. Several of these acids are volatile, playing a crucial role in the development of the characteristic aroma of fruit (Cordeiro et al., 2019). The results of the evaluations revealed the highest levels of titratable acidity, with 0.98% for genotype (DN06) and 1.36% for (DC10), showing a significant difference compared to the other treatments.

The evaluation of fruit flavor is commonly carried out by the relationship between titratable acidity and soluble solids, where an adequate balance between these components contributes to a better fruit flavor (Cecatto et al., 2022). A statistical difference was observed between the genotypes, with (DC01) showing 11.50% and (DN06) 5.67% for the ratio of soluble solids to titratable acidity. To ensure a more pleasant taste in strawberries, it is desirable that they have minimum values of 7.0% soluble solids and maximum values of 0.8% titratable acidity. In other words, the higher the soluble solids and the lower the titratable acidity of the fruit, the better it tastes. This ideal combination has a positive effect on strawberry flavor (Domingues et al., 2018).

The diameter of strawberry fruit plays a crucial role in commercial classification, as highlighted by Ronque (1998) and regulated by MERCOSUR/GMRes 85/96 (1996). Analysis of the transverse diameter of the fruit follows a classification, divided into classes. Class 1 includes fruit with a cross-sectional diameter above 25 mm, while class 2 includes fruit with a diameter between 10 and 25 mm. In this study, the neutral-day genotypes had diameters ranging from 25.57 to 25.73, falling into class 1, while the short-day genotypes had diameters between 23.13 and 19.93, falling into class 2. These results highlight the variation in fruit dimensions between the different genotypes and production-day categories.

The importance of larger fruit is clear, as it simplifies both the harvesting and packing process, resulting in more efficient operations. In addition, the larger size increases the value of the fruit in the eyes of the consumer market, potentially generating more significant financial gains for the producer (Schiavon et al., 2021). However, no significant difference was observed in this respect in the neutral-day and short-day strawberry genotypes.

Color evaluation is crucial for the commercial classification of products and varieties, and is a primary criterion in commercial decisions. The internal color of the strawberry, which is important in industrial use, together with the concentration of pigments, is indicative of maturity and quality. Color, in turn, influences aesthetic perception by consumers (Fagherazzi et al., 2021). No significant differences were observed in the color indices between all the genotypes. However, there was a difference in the Hue angle between the neutral day genotype DN06 (0.40) and the short day genotype DC0 (0.58)1. On the other hand, no statistical difference was identified in the chroma saturation index.

There was an increase in vegetative growth for both the DC01 and DC10 genotypes over the months of evaluation. Both short-day genotypes show a steady increase in vegetative growth each month. Notably, during the months of evaluation, the DC10 genotype maintained a superior performance compared to DC01.

The short-day strawberry shows optimized growth in mild temperatures and shorter days, according to Assis & Canesin (2015). In this research, environmental conditions with shorter days and temperatures stimulated the growth of the materials.

According to Rahman (2014), later planting reduces the number of leaves and crowns due to unfavorable climatic conditions for growth.

Vignolo et al. (2011) analyzed short-day cultivars, Camarosa and Camino Real, transplanted in May, obtaining chlorophyll indices of 44.3 and 47.6, similar to those verified for the DC10 genotype. Light plays a crucial role in plant development, regulating processes such as growth and photosynthesis (BECKER et al. 2019). Analysis of the chlorophyll data in this research reveals higher levels in the months with shorter days. When the days become longer, there is a reduction in chlorophyll levels. Streit et al. (2005) highlight the adaptation of plants to the light environment, directly influencing growth.

The day-neutral genotype, DN3, showed plants with a larger diameter and higher chlorophyll levels in all the months of evaluation (Table 2), highlighting that DN3 consistently provided higher chlorophyll indices. Both day-neutral materials showed an increase in chlorophyll levels over the months of evaluation. Chlorophyll values similar to those of this research were recorded in an experiment with strawberry plants in Spain and in an off-ground system, obtaining average indices of 39.52, close to those verified in the months of December, according to Palencia et al. (2016).

Table 2 - Plant diameter (mm), fruit length (mm), color (color index (CI), Hue angle, chroma saturation index) and total chlorophyll (TCI) of day-neutral (DN3 and DN6) and day-short (DC01 and DC10) genotypes during the five months of evaluation.

Genotypes	Fruit diameter (mm)	Fruit length (mm)	Color index (CI)	Hue angle	Chroma saturation index	Total chlorophyll (IFC)
DN03	25,57 c	33, 74 a	67, 29 a	0, 48 aB	27, 83 a	38, 62 cA
DN06	25, 73 c	32, 69 a	64, 77 a	0, 40 a	31, 38 a	33, 99 bB
DC01	23, 13 Bc	29, 61 a	59, 08 a	0, 58 b	34, 34 a	40,18 Ba
DC10	19, 93 aB	31, 10 a	65, 77 a	0, 47 aB	32, 85 a	43, 38 aB
Média	23, 20	31, 84	64, 82	0, 49	32, 26	39, 04
CV (%)	29, 62	21, 42	41, 00	25, 33	24, 02	14, 39

Averages followed by equal letters do not differ by Tukey's test at the 5% probability level, lowercase letters in the column; uppercase letters in the row. Source: Personal archive.

The higher total chlorophyll content in the day-neutral genotype, DN3, explains the more expressive vegetative growth in the plants of this material, since the chlorophyll in the leaves reflects the amount of nitrogen absorbed by the plant, influencing growth and productivity (Santos & Castilho, 2015). The reduction in total chlorophyll levels in the DN3 and DN6 genotypes during the period of greatest vegetative growth may be related to the leaves adapting to the light in the environment. Environments with high light intensity activate protective mechanisms such as photoinhibition and photooxidation, resulting in a reduction in chlorophyll levels in December, January and February (Wurz et al., 2021).

For both neutral-day materials evaluated, the month of December was more expressive, influenced by the higher temperatures in November and December 2022. Despite the theoretically unfavorable conditions for fruit development, the harvest took place in the warmest months of the year. This pattern can be explained by the strawberry's characteristic of reaching its productive peak approximately five months after transplanting, as observed by Antunes et al. (2016).

For the farmer, the manifestation of the productive peak during challenging production periods can represent an advantage. This is because marketing prices are determined by the relationship between supply and demand. Thus, having fruit available at times of lower supply can result in higher sales values. However, it is important to consider that the volume produced during this period can be reduced (Silva et al., 2017).

The results of the total production over the nine months of this experiment exceed the values found by Brandt et al. (2022) in research with day-neutral genotypes transplanted at the recommended time, recording 162 to 298 grams per plant for a five-month cycle. It is worth noting that, in an organic production system during a 10-month cycle, the total production of strawberry plants varies from 700 grams to 1.0 kg per plant, depending on the cultivar (Antunes et al., 2017).

In this experiment, it is believed that the more pronounced vegetative growth of day-neutral material DN3 contributed to higher fruit production compared to DN6 (Table 3). However, late planting had a negative impact on total production values. As highlighted by Richter et al. (2017), when plants are affected by the environment, they direct their resources towards survival, to the detriment of fruit production, resulting in a reduction in the size and quantity of fruit produced.

Table 3 - Number of fruits per plant and yield per plant (g) of the strawberry genotypes. Genotypes (DN3 and DN6) and of short days (DC01 and DC10), during the five months of evaluation.

Genotypes	Number of fruits per plant	Production per plant (g)
DN03	16, 83 bA	160, 06 bA
DN06	13, 20 bA	133, 06 cB
DC01	8, 06 bB	62, 96 dB
DC10	9, 46 bB	79, 39 cB
Total	47, 55	435, 47
CV (%)	21, 43	22, 69

Averages followed by equal letters do not differ by Tukey's test at the 5% probability level, lowercase letters in the column; uppercase letters in the row. Source: Personal archive.

The highest number of fruits per plant was recorded in November 2022 for the short-day DC10 genotype evaluated, suggesting a possible accumulation of reserves in the plant. Breeding programs aim for genotypes with rapid reserve accumulation to promote early production. It is worth noting that the peak production of short-day strawberries, when planted at the right time, occurs in September and October. However, the strawberry plants in this experiment showed peak production later than indicated for this type of material, as stated by Antunes et al. (2020).

Strawberry planting time has an impact on fruit production per plant in short-day cultivars. In Bom Repouso-MG, Pereira et al., (2013) observed that plants transplanted in August had lower fruit formation, with records of 4.44, 8.75 and 16.24 fruits per plant for the "Camarosa", "Festival" and "Oso Grande" varieties, respectively.

As for the production per plant over five months, the research results show 260.30 grams for DC01 and 315.65 grams for DC10. These figures are considered relatively low. In a 150 m2 greenhouse with 2000 plants, the estimated total production would be 49.58 kg for DC01 and 62.13 kg for DC10. (2013), for short-day cultivars, early planting is generally beneficial in Brazil's soil and climate conditions, and a delay of around three months can reduce production per plant by more than 200 grams.

The highest yield per plant for both genotypes occurred before pruning, in December 2022 (98.20g for DC01 and 110.20g for DC10). The decrease in production of short-day cultivars is related to the increase in temperatures and the incidence of radiation. Peak production varies according to genetic characteristics and climatic conditions, and is strongly influenced by the planting date of the seedlings. In late plantings, it has been observed that neutral-day genotypes show greater vegetative growth and fruit production compared to short-day genotypes, as indicated by Liz et al. (2020).

4. Conclusion

The evaluations indicated that the neutral day genotype, DN3, outperformed DN6 in vegetative and productive growth, while the short day genotype, DC10, outperformed DC01. Late planting affected the short-day genotypes more than the day-neutral ones in this experiment.

The number and production of fruit per plant of DN3 are within the expected range for an organic system, whereas for the short-day genotypes, they are lower. This study highlights the viability of genotypes for agroecological and organic systems.

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