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Quality Index of Passion Fruit Seedlings by Using Physically Parameters

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Abstract

Passion fruit (*Passiflora edulis*) has aroused interest from producers, leading to an intense demand for technical information, especially for obtaining quality seedlings. The objective of this study was to evaluate passion fruit seedlings according to age and morphological characteristics. The experiment was carried out at the seedling nursery of the State University of Montes Claros, Campus Janaúba-MG, Brazil, from March to June 2017. The cultivars BRS Gigante Amarelo, BRS Rubi do Cerrado, BRS Pérola do Cerrado and Redondo Amarelo were evaluated, distributed in randomized blocks with five replications, in a split-plot scheme (4 × 4). There was an adjustment of the model (IQM = 6.3857 − 0.3892 NL + 3.3512 SD − 0.2063 SPAD + 0.0730 LA), which proposes a quality parameter of passion fruit seedlings, high level of significance and coefficient of determination, necessary for the reliability and accuracy of the results obtained. Considering the proposed model (IQM), there is no need for destructive analysis, and evaluations can be performed in the nursery itself as soon as a seedling lot reaches the recommended height of 30 cm. The evaluated characteristics contribute significantly to the quality of the seedling, and it is recommended, besides the height measurement, to evaluate the number of leaves, the stem diameter, the leaf area and the SPAD index, because the combination of these parameters will guarantee the necessary quality of the seedlings to be transplanted in the field.

Keywords: *Passiflora edulis*, cultivars, seedling production, commercial standard

1. Introduction

Passion fruit is a plant adapted to the tropical climate, with a wide geographical distribution. The genus Passiflora is estimated to contain over 400 species of which approximately 146 are native to Brazil (Oliveira et al., 2019; Koch et al., 2019). Brazil is the world's largest producer of passion fruit with an annual production of about 700,000 tons of fruit (Zacharias et al., 2016; AGRIANUAL, 2018).

The crop has been recognized as a good alternative for cultivation, arousing the interest of growers in the expansion of orchards and generating an intense demand for technical information, especially in obtaining good quality seedlings (Smiderle & Souza, 2016; Nascimento et al., 2017). Seedling is one of the most important inputs in the implementation of an orchard and may influence the production and profitability of the crop (Santos et al., 2017). In passion fruit cultivation, the cost of a seedling represents about 19.20% of the inputs used at the implementation of the crop (AGRIANUAL, 2011).

The reduction of the time to obtain seedlings with ideal quality for planting in the field, as well as the knowledge of the ideal stage for such, are important factors. Hastening the transplantation in the field means a reduction in the production cost of the same, leading to a reduction in the final cost of the seedlings (Simões et al., 2012). The lack of knowledge about the moment of transferring the seedlings to the field may result in their loss, caused by factors such as leaf area, height, and diameter improper for the development of the seedling, making it susceptible to suppressed growth.

The use of tests to define the seedling quality standard for planting can provide numerous benefits, adding some values that are often required by the market (Gomes et al., 2002). The morphological parameters are physically or visually determined and have greater acceptance of the nurseries, measuring the quality of the seedlings by the height of aerial part, neck diameter, leaf area, root system dry weight, and aerial part dry weight (Binotto et al., 2010; Eloy et al., 2013; Posse et al., 2018).

However, morphological variables should not be considered individually to determine the quality of seedlings, mainly due to the strong relationship between them. In an unbalanced situation, for example, it can lead to loss of quality, with the risk of selecting larger but weak seedlings, discarding smaller but more vigorous seedlings (Nicoletti et al., 2015). It is noteworthy that the selection of quality seedlings, considering aspects such as vigor and root/sprout ratio, favor the adaptation to different cultivation conditions (Lima et al., 2016). It becomes vital to know which variables can be useful in selecting high-quality seedlings.

Based on the above, the objective of this study was to evaluate passion fruit seedlings according to age and morphological characteristics in order to obtain a specific quality standard.

2. Material and Method

The work was carried out between March and June 2017, at the seedling nursery of the State University of Montes Claros, Campus Janaúba-MG, Brazil. The passion fruit cultivars evaluated were: BRS Gigante Amarelo, BRS Rubi do Cerrado and BRS Pérola do Cerrado, whose seeds came from Embrapa Cerrados. It was also evaluated the cultivar Redondo Amarelo, marketed by the company Topssed®. Importantly, to obtain a model that represents the quality of passion fruit seedlings, such cultivars were considered random in this experiment. This means that the inferences obtained can be extrapolated to other passion fruit cultivars, not evaluated in this experiment.

The substrate used was prepared with sand, manure and Red Latosol in the proportions of 1:4:10 respectively. For the production of seedlings, 18×8 cm^3 polyethylene bags were used. The cultivar BRS Pérola do Cerrado was treated with promaline solution (16 mL promalin + 986 mL water) for three minutes to increase seed germination percentage. The seeds were planted two to three centimeters deep and covered with one centimeter of substrate. Irrigation was performed three times a day for 40 minutes by an inverted micro-sprinkler (nozzle flow of 75 L h^{-1}). The temperature and relative humidity of the greenhouse were 25 ºC and 60%, respectively.

The experimental design was in randomized blocks with five replications, and the treatments were arranged in a split-plot scheme (4 × 4). The plots were constituted by the cultivars and the subplots by the assessments carried out in time, being 40, 54, 68 and 82 days after emergence. The experimental unit consisted of eight seedlings.

Seven variables were considered at 40 days after emergence and repeated for three further measurements every 14 days: a number of leaves (NL), performed by counting the leaves of each seedling; seedling height (HGT), measured from the substrate level to the last leaf insertion with the aid of a ruler graduated in centimeters; neck diameter (ND), measured at a height of three centimeters from the substrate, with the aid of a digital caliper and results expressed in millimeters; leaf area (LA), measuring the length (LL) and width (LW) of the third leaf from the base, using a digital caliper, following the equation $LA = -2.3201 + 0.5994 \times (LL \times LW)$ proposed by Schmildt et al., 2016; and relative chlorophyll content (SPAD index), performed on the third fully expanded leaf from the base using the Minolta SPAD-502 portable chlorophyll meter.

The variables were submitted to the adherence tests to the homogeneity of variances and normality of the residuals, by Bartlett and Lilliefors tests ($p < 0.05$). Given the assumptions, we performed the analysis of variance ($p < 0.01$), where, according to the significance of interactions, qualitative data (cultivars) were compared by Tukey test ($p < 0.01$); and the quantitative data (ages) studied by regression, in which significant models were adjusted ($p < 0.01$) to explain the biological factor in question.

Based on the obtained data, it was proposed a model that expressed the quality of the seedlings when they reached the recommended height for commercialization of 30 cm. For this, the complete model was proposed, given by:

$$IQM = NL + SD + LA + SPAD + (Ctrl) + \varepsilon \quad (1)$$

Where,

IQM = Quality of seedling at 30 cm height; NL = Number of leaves; SD = stem diameter; LA = leaf area; SPAD = Relative Chlorophyll Index; Ctrl = Effect of local control (block and subplot blocking); ε = Effect of residue.

To adjust the model, we used the "Stepwise Backward" methodology and predefined the contribution of the regression coefficients to the model at 5% significance by the Student's T test. All statistical analyzes were performed with the help of R Statistical Software, Version 3.5.

For validation, data obtained from seedling evaluations were entered into the model and according to the obtained value, the quality of the seedlings was classified. The ideal IQM was attributed to values around 30. Lower values indicated that the seedlings have not yet reached the maximum quality needed for transplantation. Higher values indicated that there was a delay in seedling removal from the nursery or an imbalance in seedling morphological characteristics.

3. Results

There was a significant interaction between cultivars and age of the seedlings for all evaluated traits. 'BRS Gigante Amarelo', 'BRS Pérola do Cerrado', 'Redondo Amarelo' and 'BRS Rubi do Cerrado' obtained a significant linear increase in height of 0.8, 0.7, 0.7 and 0.2 cm, respectively, each day. There is a lower height performance in the 'BRS Rubi do Cerrado' at all ages evaluated, and the highest heights shown in the 'BRS Gigante Amarelo', 'Redondo Amarelo' and the 'BRS Pérola do Cerrado' (Figure 1).

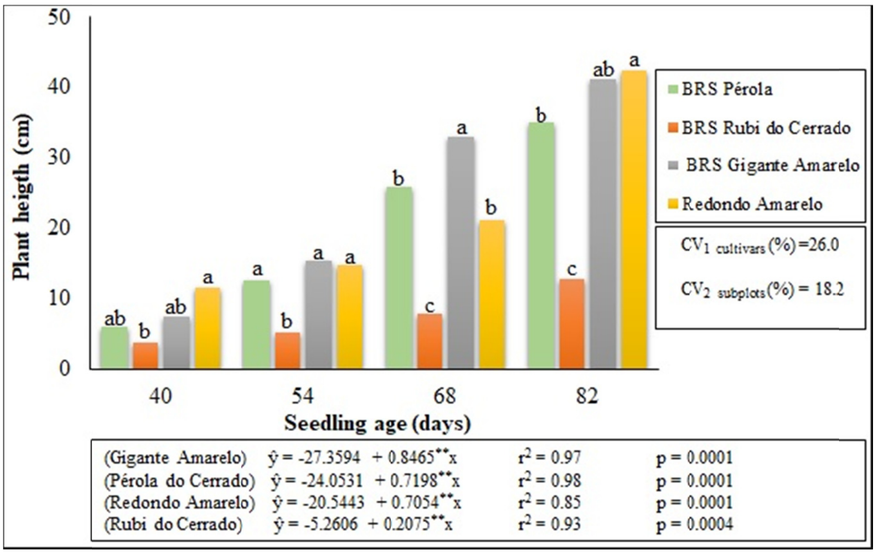

Figure 1. Height of passion fruit seedlings, in centimeters, according to their age. Distinct averages between cultivars for each seedling age differ from each other by Tukey test at 5% error significance

Stem diameter increased linearly on the considered days, with an increase of 0.05, 0.06, 0.06 and 0.03 mm each day for the cultivars BRS Gigante Amarelo, BRS Pérola do Cerrado, Redondo Amarelo and BRS Rubi do Cerrado, respectively. In the first evaluation, the cultivars did not differ in stem diameter, however, in the other ages, the BRS Rubi do Cerrado obtained a smaller diameter than the others (Figure 2). Considering marketing standardization, when the seedlings reached a height of 30 cm, they obtained a stem diameter of 3.83 mm for 'BRS Gigante Amarelo', 4.60 mm for 'Redondo Amarelo', 4.05 mm for 'BRS Pérola do Cerrado' and 5.04 mm for the 'BRS Rubi do Cerrado', at 170 days in the nursery.

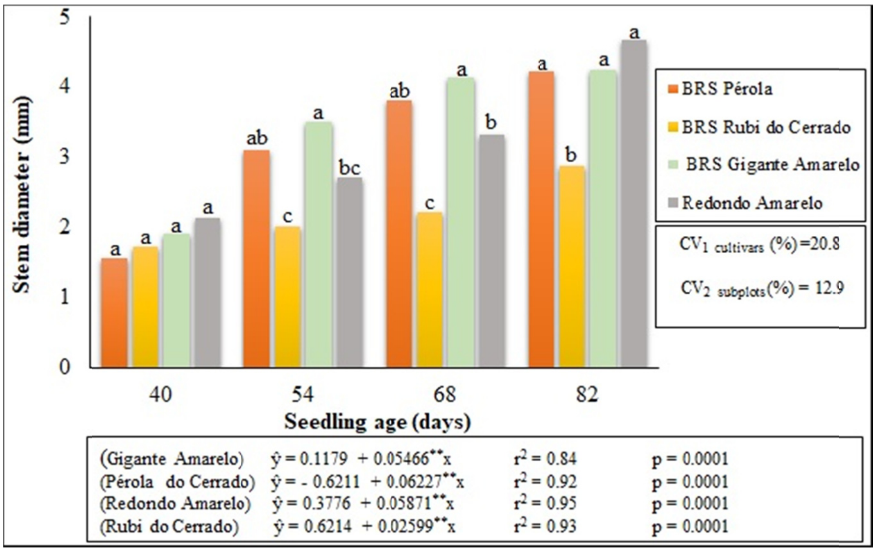

Figure 2. Stem diameter of passion fruit seedlings, in millimeters, according to their age. Distinct averages between cultivars for each seedling age differ from each other by Tukey test at 5% error significance

The number of leaves increased significantly by 0.15, 0.12, 0.09 and 0.08 leaves for the cultivars BRS Gigante Amarelo, BRS Pérola do Cerrado, Redondo Amarelo and BRS Rubi do Cerrado, each day. The 'BRS Gigante Amarelo' obtained larger number of leaves, particularly in comparison with the 'Redondo Amarelo' and 'BRS Rubi do Cerrado' (Figure 3). Considering the height for seedling commercialization, the average number of leaves observed in the cultivars were 9.8 leaves for 'BRS Gigante Amarelo', 9.9 for 'BRS Pérola do Cerrado', 8.6 for 'Redondo Amarelo' and 14.4 for 'BRS Rubi do Cerrado'.

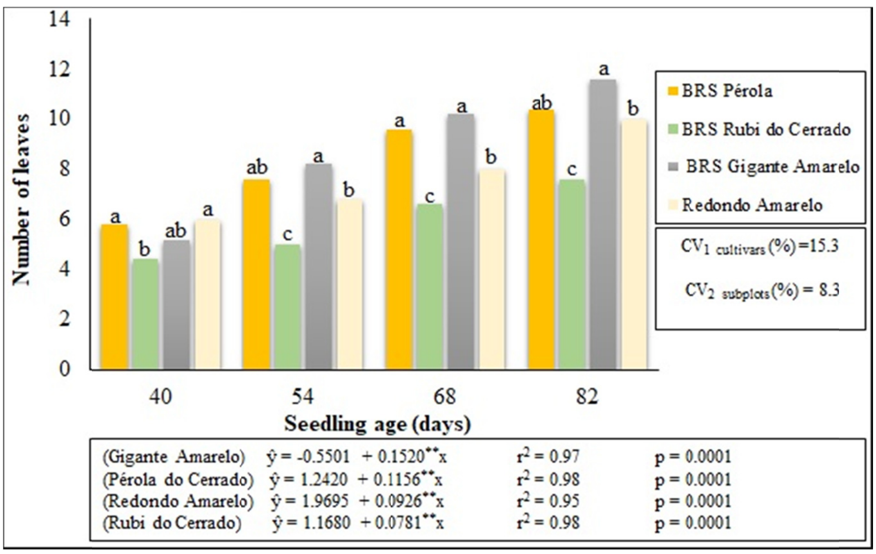

Figure 3. Number of leaves in passion fruit seedlings, according to their age. Different averages between cultivars for each seedling age differed by the Tukey test at 5% significance

The leaf area, as well as the other evaluated characteristics, especially the number of leaves, increased with the age of the seedlings, having an increase in the area of 11.02 cm^2 for 'BRS Gigante Amarelo', 7.31 cm^2 for 'BRS Pérola do Cerrado', 6.83 cm^2 for the 'Redondo Amarelo' and 2.89 cm^2 for the 'BRS Rubi do Cerrado' each day. From 54 days on, the cultivars differed in leaf area, with the highest values associated with 'BRS Gigante Amarelo' and the lowest values for 'BRS Rubi do Cerrado' (Figure 4). Considering the leaf area related to the height of the seedling for commercialization, the observed LA was 329.35 cm^2 for 'BRS Gigante Amarelo', 277.66 cm^2 for 'Pérola do Cerrado', 256.37 cm^2 for 'BRS Redondo Amarelo' and 399.13 cm^2 for the 'BRS Rubi do Cerrado'.

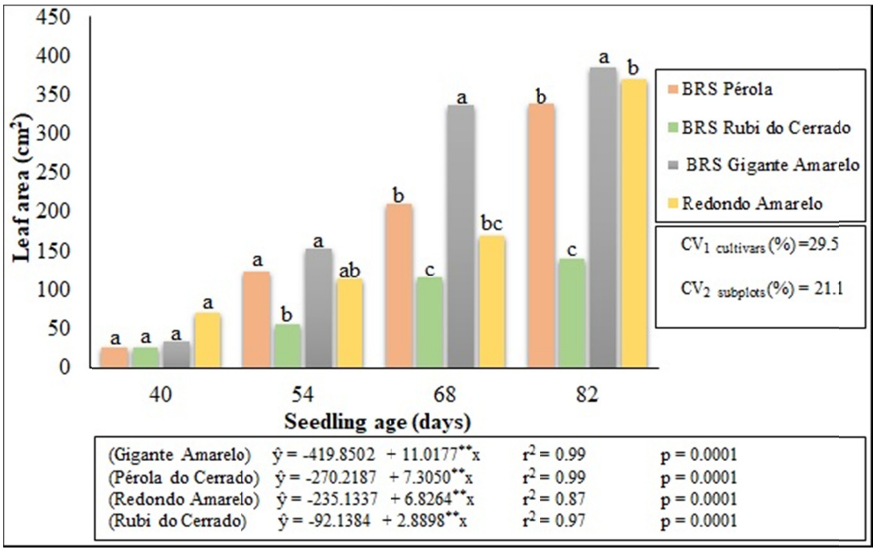

Figure 4. Leaf area of passion fruit seedlings, in square centimeters, according to their age. Different averages between cultivars for each seedling age differed by the Tukey test at 5% significance

The SPAD index of the passion fruit seedlings did not differ significantly according to the age of the seedlings, except for the 'Rubi do Cerrado' which increased by 0.24 in the index value each day. The considered cultivars present homogeneity in the measured SPAD index (Figure 5).

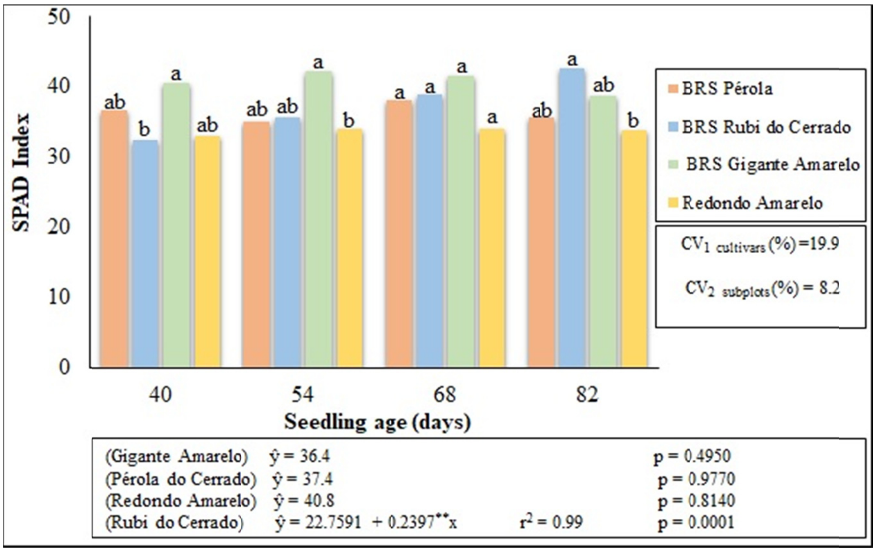

Figure 5. SPAD index of passion fruit seedlings, according to their age. Distinct averages between cultivars for each seedling age differ from each other by Tukey test at 5% error significance

It is possible to observe that, separately, all the variables considered at the seedling stage have similarities and differences, especially regarding the cultivar considered. An analysis is necessary to unite all information simultaneously to identify an optimal quality standard. So considering all these there was the adjustment of the model below:

$$IQM = 6.3857^{**} - 0.3892^{*} NL + 3.3512^{**} SD - 0.2063^{*} SPAD + 0.0730^{**} LA \quad (2)$$

$$R^2 = 0.91 \quad p = 0.00001 \quad CV (\%) = 20.82$$

The model was of high significance and high coefficient of determination, necessary for the reliability and veracity of the results obtained (Jr. et al., 2009). Analyzing the significant regression coefficients in the model, we can observe the influence of the variables number of leaves, stem diameter, SPAD index and leaf area to understand the response in relation to seedling quality. The variable height was not used in the model because it had a fixed value of 30 centimeters, as already indicated by Lima and Cunha (2004).

4. Discussion

Due to the lack of norms for the quality standard of passion fruit seedlings, some nurseries in Brazil follow the recommendation of Lima and Cunha (2004). In which the transplanting of the seedlings is indicated when they reach the approximate height of 30 cm. Therefore, the evaluated cultivars obtained different ages for height standardization, being 68 days for ‘BRS Gigante Amarelo’, 72 days for ‘Redondo Amarelo’, 75 days for ‘BRS Pérola do Cerrado’ and more than 82 days for the ‘BRS Rubi do Cerrado’. This differentiation in the cultivars growth can be attributed to the specific genetic conformation of each one, distinguishing the residence time of each cultivar in the nursery, reflecting directly on the costs of seedling production.

It is advantageous for the seedlings to reach the appropriate height in the shortest possible time. This enables anticipation of seedlings planting and reduction of production costs. According to Junqueira et al., 2014, production costs for 180, 150, 120, 90, and 60 day old passion fruit seedlings were R$ 2.10, R$ 1.83, R$ 1.58, R$ 1.33 and R$ 1.10, respectively. The amount of inputs is the same for seedling production, but the plants that spent the more time in a greenhouse required a greater amount of care, increasing the hand labor costs.

The use of aerial part height as a parameter to determine seedling quality has always been used effectively among nurseries, since it is easy to measure and does not require destructive analysis to obtain results (Pias et al., 2015; Moura et al., 2015), considered as one of the oldest parameters in the classification and selection of seedlings (Parviainen, 1981).

Although height is an important variable, it should not be used separately to determine seedling quality, as it can be greatly influenced by environmental variations, population density and seedling nutritional levels, which vary according to the fertilization provided (Nicoletti et al., 2015). Very tall seedlings with smaller diameters indicate a low quotient of robustness, which may affect its functionality and development in the field. Thus, for the correct seedling classification, it is necessary to associate this variable with others morphological parameters of quality (Santos et al., 2017).

The neck diameter is the most observed characteristic to indicate the seedlings survivability in the field (D’Avila et al., 2011), having a correlation with the average size of the root system, as well as the height is related to the number of leaves and leaf area (Eloy et al., 2013). According to Smiderle et al. (2017), the height of aerial part, combined with neck diameter, is one of the most important morphological characteristics to estimate seedling growth after permanent planting in the field.

Although the leaf number trait, when evaluated separately does not mean an accurate seedling quality response, when combined with height is an excellent trait in the standard of seedling quality analysis (Miyake et al., 2017). According to Silva (2006), the NL emitted by passion fruit seedlings is a characteristic used to define the time when the plants are able to transplant to the field, that is, the time of formation of the seedling, which was considered when they had eight fully expanded leaves. Thus, the cultivars studied are within the standard proposed by the author for planting in the field, considering seedlings with 30 cm of height.

The number of leaves is related to the leaf area and can be considered a parameter for productivity, increasing the interception rate of solar radiation, leading to increased metabolism and productivity of plants (Souza et al., 2011; Tessaro et al., 2013). According to Taiz et al. (2017), floral induction of certain species only occurs when the plant has a specific number of leaves so that there is sufficient transmission or synthesis of floral stimulus to the apex.

The leaf area is an important feature for the establishment and development of any crop as it is responsible for the large photosynthetically active area of the seedling, resulting in growth in the height and diameter of the neck (Rudek et al., 2013). Using accurate estimates of leaf area is a key point to ensure the quality of seedlings to be planted (Nicoletti et al., 2015).

The measurement of chlorophyll content is very interesting in evaluating seedling quality. This can be correlated with the leaf nitrogen content of the plants, that is, the higher the chlorophyll content, the higher the concentration of N in the plants, consequently, the better the passion fruit seedlings quality. Santos et al. (2011) evaluating different sources of N (ammonium sulfate, ammonium nitrate and urea) in the initial growth of yellow passion fruit plants, observed that the plants obtained very close values with SPAD index of 56.36, 57.17 and 59.02 for chlorophyll content. Bertani et al. (2019) evaluating the feasibility of using the SPAD index as indicative of the nutritional status of plants in relation to nitrogen, observed to be a good index, since they presented approximate values of nitrogen content.

However, external aspects such as substrate volume, fertilization, time of year, seedling density in the nursery, seedling age, as well as the characteristics of the different cultivars on the influence on the morphological variables of the seedlings, need to be more strictly observed. The adjusted model takes into account the differentiation in the development of the different passion fruit cultivars, which can be attributed to their genetic conformation, specific to each cultivar, making different the time of residence of each one in the nursery, this model can be considered for different cultivars. The use of these equations may vary according to seedling production conditions, as environmental and management conditions vary according to production site (Nicoletti et al., 2015).

There is a modeling methodology for seedling quality evaluation considered efficient and recommended by several authors. This model is the Dickson Quality Index (DQI) proposed by (Dickson et al., 1960), which indicates the quality standard of seedlings for transplantation. However, in order to obtain the DQI, the seedling is subjected to destructive analysis, since this method takes into account, besides other factors, the dry matter of the aerial part and the root system, which often makes it unfeasible for nurseries because it takes time and cost to get this information (Binotto et al., 2010).

Considering the model proposed in the present study (IQM), there is no need for destructive analysis, and evaluations can be performed in the nursery itself, once a seedling lot reaches the recommended height of 30 cm. Thus, for high quality seedlings, under the conditions of the present study, it will be necessary beyond the established height of 30 cm, an average of 10 leaves, 4 mm of stem diameter, a value of 38 in the SPAD index and leaf area of 300 square centimeters.

5. Conclusions

The greatest height, diameter and leaf area of plants were found in the cultivars 'BRS Gigante Amarelo' and Redondo Amarelo. The highest number of leaves was found in the cultivars 'BRS Gigante Amarelo' and 'BRS Pérola'. The highest SPAD index was found in the cultivar 'BRS Gigante Amarelo'.

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