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Scientific Article

Controlled release, organic or organomineral fertilizers for areca palm production

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Abstract

The areca palm is an ornamental plant widely used in Brazil for decoration and landscaping. The proper use of fertilizers and balanced fertilization are among the main factors that promote the rapid development of these plants and affect their technical and economic aspects. Because of the need to elucidate areca palm nutrition, this study aimed to evaluate the use of mineral (conventional or controlled release), organic, or organomineral fertilizers in the production of areca palm in pots. The experiment was conducted for a year under a 70% shading screen using a completely randomized design, with seven treatments and six replications. The treatments consisted of different fertilizers: control: no fertilizer; mineral: 10-10-10; controlled release mineral: 14-14-14, mineral with 50% N and K release controls: 16-06-18, mineral: 13-05-13, organomineral: 16-06-09, and organic. The experiment consisted of measuring the vertical height of the plant and determining the Falker Chlorophyll Index (FCI) a and b. All fertilizers used in the experiment provided gains in growth and green color (Chlorophyll Index) in the areca palm grown in pots relative to the absence of fertilization. The three-month controlled-release fertilizer treatment produced the best results, positively impacting the areca palm production, both in terms of plant height and color, which are attributes that increase the product's commercial value.
Keywords: *Dypsis lutescens* H.Wendl., fertilization, ornamental plant, plant nutrition.

Resumo

Fertilizantes de liberação controlada, orgânico ou organomineral para produção de palmeira areca

A palmeira areca é uma planta ornamental amplamente utilizada no Brasil para decoração e paisagismo. O uso adequado de fertilizantes e adubação equilibrada estão entre os principais fatores que promovem o rápido desenvolvimento dessas plantas e afetam seus aspectos técnicos e econômicos. Devido à necessidade de elucidar a nutrição da palmeira areca, este estudo teve como objetivo avaliar o uso de fertilizantes minerais (de liberação convencional ou controlada), orgânicos ou organominerais na produção de palmeira areca em vasos. O experimento foi conduzido por um ano sob tela de sombreamento de 70% em delineamento inteiramente casualizado, com sete tratamentos e seis repetições. Os tratamentos consistiram de diferentes fertilizantes: sem fertilizante; mineral 10-10-10; mineral de liberação controlada 14-14-14, mineral 16-06-18, com 50% do N e K de liberação controlada, mineral 13-05-13, organomineral 16-06-16 e orgânico. O experimento consistiu em medir a altura vertical da planta e determinar o Índice de Clorofila de Falker (FCI) a e b. Todos os fertilizantes utilizados no experimento proporcionaram ganhos de crescimento e de cor verde (Índice de Clorofila) na palmeira areca cultivada em vaso em relação à ausência de adubação. O tratamento com fertilizante mineral de liberação controlada 14-14-14, em três meses, apresentou os melhores resultados, impactando positivamente a produção da palmeira areca, tanto em altura quanto em cor da planta, atributos que aumentam o valor comercial do produto.
Palavras-chave: adubação, *Dypsis lutescens* H.Wendl., nutrição de plantas, planta ornamental.

Introduction

The areca palm belongs to the Arecaceae family, which comprises 65 species domesticated in Madagascar, Tanzania, and various islands in the Indian Ocean. It is widely used as an ornamental plant owing to its strong antioxidant and anticancer properties (El-Ghonemy et al., 2019). In Brazil, the areca palm is an ornamental plant with considerable commercial value and is cultivated on a large scale for decoration and landscaping. To maintain its commercial value, it must be kept in shadow to avoid burning and the development of yellowish leaves (Ramos et al., 2019).

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Commercial cultivation of garden plants, shrubs, and trees occupies an area of 15,600 ha in Brazil, divided into 530 ha under shading and 13,738 ha outdoors, with annual revenues of approximately R$10.9 billion and a growth of 15% in the last year (IBRAFLOR, 2022). According to Junqueira and Peetz (2017), commercial floriculture is a critical segment of Brazilian agribusiness. Due to its profitability, floriculture has aroused the interest of various producers and presents an alternative to horticulture. However, the flower cultivation production chain is still little explored and poorly studied in Brazil, making it difficult to find scientific literature on this topic (Costa and Chiba, 2017).

Knowing which fertilizer to apply during production and maintenance is critical for cultivating ornamental plants. However, the use of fertilizers to nurture ornamental plants is currently based solely on the experience of fertilizer growers and manufacturers, resulting in very high dose indications being recommended for a particular crop (Álvarez et al., 2014).

The proper use of fertilizers and balanced fertilization are among the main production factors contributing to the rapid development of plants and their technical and economic aspects (Emer et al., 2020).

Considering the need for more research on areca palm nutrition, this study aimed to evaluate the use of mineral (conventional or controlled release), organic, or organomineral fertilizers in the production of areca palms in pots.

Materials and Methods

This research was conducted in the state of São Paulo (latitude: 24°61’84’’S, longitude: 47°84’53’’W, altitude: 39 m). The experiment was conducted in a vegetation house covered with a shading screen that allowed 70% of light to penetrate.

Our study used an entirely randomized design, with seven treatments and six repetitions, and the research period extended from September 2019 to September 2020. The treatments (Table 1) evaluated different fertilizers.

Table 1. Treatments used in the experiment and their application periods.

Year/month Treatments	2019			2020							
	10	11	12	1	2	3	4	5	6	7	8
No fertilizer (control – CT)											
Mineral fertilizer NPK (10-10-10) - MF	*		*		*		*		*		*
Controlled release fertilizer – Forth Cote (14-14-14) - CRF	*			*			*			*	
Mineral fertilizer with 50% N and K controlled release (Forth Produtor 18-06-18) - PCRF	*			*			*			*	
Mineral fertilizer with micronutrients (Forth Jardim 13-05-13) - MFMi	*		*		*		*		*		*
Organomineral (16-06-09) - OM	*		*		*		*		*		*
Organic fertilizer - O	*			*			*			*	

Note: * corresponds to fertilization treatments in the specific months.

For each portion of the experiment, a 5-L pot containing Palmeira areca seedlings was used. Forty-two pots with plants of the same size were selected for the experiment containing six seedlings per pot. The seedlings had been propagated by seeds and transplanted to the pots. The selected plant lot had germinated four months previously. The pots containing areca palm trees were arranged in six rows, with seven plants each, so that the pots were 50 cm away from each other.

Chemical analysis of the soil used for the seedlings was performed. The analysis was conducted following the methodology of Raij et al. (2001) and presented the following attributes: pH ($CaCl_2$) of 5.6; M.O. 58 g dm^{-3}; 354 mg dm^{-3} P; 6.3, 79, 21, 0; 126 MMOLC dm^{-3} K, Ca, Mg, Al, and CTC, respectively; and 84% of soil bases.

The fertilizer doses (Table 2) were based on the dose used by the producer (approximately 90 g of 10-10-10 during the year, standardized at 9 g of N per plant). Fertilizer application was also based on producer practices (fertilization every 45 days) and fertilizer release time (e.g., Forth Cote Classic 14-14-14 with three months’ release).

The substrate used was a mixture of ravine-land soils with organic and mineral fertilizers. It was very rich in organic fertilizer (58 g dm^{-3}), P (353 mg dm^{-3}), and K (246 mg dm^{-3}).

Fertilization was performed manually from October 2019 to August 2020. It was divided every two months for treatments MF, MFMi, and OM, and every three months for treatments CRF, PCRF, and O. The total amount of nutrients applied in each treatment is shown in Table 2.

Table 2. Amount of nutrients applied (in grams per vase) according to the fertilizers used in the treatments.

Fertilizer	Total	Per application	N	P	K	Ca	Mg	S	B	Mn	Zn	Fe	Cu	Mo
	---------- g pot^{-1} ----------													
CT	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MF	90	15	9.0	9.0	9.0	-	-	-	-	-	-	-	-	-
CRF	65	16	9.0	9.0	9.0	-	-	5.0	-	-	-	-	-	-
PCRF	50	12,5	9.0	3.0	9.0	0.85	1.0	0.80	0.03	0.05	0.05	-	-	-
MFMi	70	11,5	9.0	3.5	9.0	0.69	0.69	9.7	0.04	0.07	0.14	0.14	0.03	0.01
OM	57	10	9.0[1]	3.4[1]	5.1[1]	*	*	*	*	*	*	*	*	*
O	900	225	9.0[2]	15.3[2]	22.5[3]	*	*	*	*	*	*	*	*	*

CT: no fertilizer; MF: Mineral fertilizer (10-10-10); CRF: Controlled release fertilizer (14-14-140; PCRF: Partial controlled release fertilizer (50% N and K – 18-06-18); MFMi: Mineral fertilizer with micronutrientes (13-05-13); OM: Organomineral (16-06-09); O: Organic; 1. The contribution of the organic fraction was not considered; 2. Calculated considering the rate of 50% mineralization per year; 3. Calculated considering the rate of 100% mineralization per year; * Values not declared by the manufacturer

For irrigation, micro-sprinklers with a flow rate of 4 L/h-1 were used and activated whenever the company detected the need for irrigation due to evapotranspiration (Table 3). All experimental pots were placed on ground-level ceramic blocks, thus avoiding direct contact with the soil.

Table 3. Meteorological data from the station closest to the experiment during the experimental period.

Time Course (Month)	Maximum Absolute Temperature	Minimum Absolute Temperature	Maximum Monthly Temperature	Minimum Monthly Temperature	Average Temperature	Evapotranspiration (ETP)	Precipitation	Rainy days
	---------- ºC ----------					------- mm ------		
Year - 2019								
September	33.2	12.2	19.3	14.0	16.6	13	70	5
October	35.6	14	27.7	17.6	22.7	106	41	16
November	38	11.3	26.2	17.8	22	108	128	18
December	35.4	13.1	28.8	18.3	23.6	125	68	12
Year - 2020								
January	37.4	13.7	30.6	17.7	24.2	135	150	19
February	38.0	14.0	28.7	18.2	23.4	102	233	20
March	34.8	13.8	28.7	16.4	22.6	98	146	14
April	33.8	9.4	26.6	13.1	19.8	69	24	10
May	26.6	2.7	21.8	9.0	15.4	47	27	10
June	25.8	6.3	19.5	9.8	14.7	38	142	19
July	30.2	2.8	20.3	9.8	15.1	37	20	4
August	31.2	5.0	20.1	10.3	15.2	49	113	17
September	35.6	10.2	25.5	16.5	21.0	84	9	11

Source: CIIAGRO Online (2021)

The effect of fertilizers on the plants was determined by indirect measurements of chlorophyll a and b, performed with a chlorophyll meter (chlorofiLOG® CFL 1030, Falker), which measures the amount of radiation transmitted through the leaves optically at three different wavelengths, two in the red range near the chlorophyll absorption peaks and one in the near-infrared infrared). The central part of the leaf blade of the chosen leaves was used for the measurement. Units of measurement for Falker's chlorofiLOG® were the Falker Chlorophyll Index A (FCI A) and Falker Chlorophyll Index B (FCI B). Falker's chlorofiLOG® operates on the same principle as Konica's SPAD-502 chlorophyll meter. This equipment is used worldwide, and hundreds of studies have proven the correlation of the equipment measurements with biochemical chlorophyll analysis. In any case, in this article, we treat the measure as an indirect measure of chlorophyll, as recommended by Malavolta (2006).

To determine the parameters related to plant growth, plant height was measured by measuring the height from the substrate up to the top of the plant shoots.

The analyses were performed shortly after the first fertilizer application and then 30 days after the first application. Further analyses were performed 150, 240, and 330 days after the first fertilizer treatment.

After data collection, the SISVAR V 5.6 program (Ferreira, 2019) was used to subject the data to variance analysis ($p < 0.05$) with application F, and the average characteristics were compared using the Scott–Knott test ($p < 0.05$) and ($p < 0.01$). For plant height, we considered a factorial scheme (fertilizers × dates), and the data in relation to the dates were adjusted by the linear model using regression analysis. For the ICF data (chlorophyll), the interaction was not performed because it is an instant measure that may vary and, therefore, does not fit a linear or quadratic model.

Results and Discussion

For plant height, the interaction between fertilizers and evaluation dates was significant ($p < 0.0008$). In the first 150 days of the experiment, the fertilizers used did not provide significant height gains in the areca plants (Figure 1). Between 150 and 240 days after the start of fertilizer application, there was a more accentuated growth in height, differentiating all treatments with fertilizers from the control, without fertilization. After 150 days from the beginning of fertilization, the plants grew by 14 cm, from 64 to 78 cm in height.

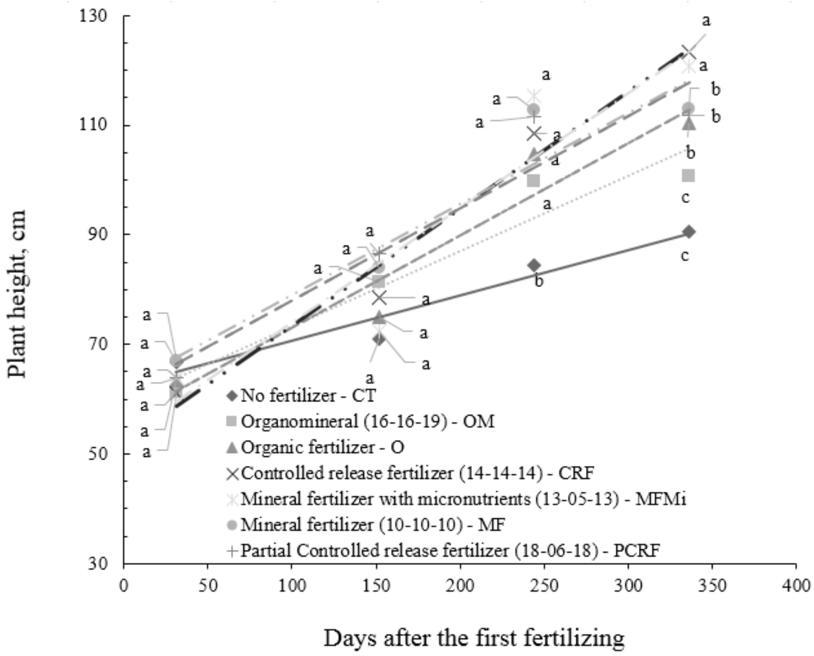

Figure 1. Plant height as a function of applying different fertilizers at intervals during the experiment. Each point represents the average of six repetitions. The average followed by the same letter does not differ between treatments, within a date, by the Scott–Knott test. Presenting CV = 11.25%. Regression equations: No fertilizer – $\hat{y} = 62.60 + 0.083x$; $R^2 = 0.94$; Organomineral (16-06-09) - $\hat{y} = 59.63 + 0.137x$; $R^2 = 0.93$; Organic fertilizer – $\hat{y} = 56.33 + 0.168x$; $R^2 = 0.93$; Controlled release fertilizer (14-14-14) - $\hat{y} = 52.15 + 0.214x$; $R^2 = 0.97$; Mineral fertilizer with micronutrients - $\hat{y} = 53.11 + 0.210x$; $R^2 = 0.88$; Mineral fertilizer NPK - $\hat{y} = -6\text{-}2.53 + 0.166x$; $R^2 = 0.91$; Partial Controlled release fertilizer (18-06-18) - $\hat{y} = 61.27 + 0.169x$; $R^2 = 0.92$.

Between 240 and 330 days after fertilization, there was a greater differentiation of treatments with respect to plant height when CRF (14-14-14) and MFMi (13-05-13), with conventional release produced taller plants (123 cm and 121 cm, respectively).

We found that organomineral fertilization and the absence of fertilization produced plants with lower heights (101 and 91 cm, respectively). In addition, organomineral fertilizer showed a lower percentage of K (in mineral form) (Table 2) compared to the two fertilizers that produced greater heights.

Depending on the number of days after the start of fertilization, it was observed that CRF (14-14-14) and MFMi (13-5-13) produced a growth rate of approximately 2.1 cm every 10 days, while in treatments OM (16-06-09), PCRF (18-06-18) and MF (10-10-10), the plants grew, on average, 1.7 cm every 10 days, which was more than the growth of plants in organic fertilizer and no fertilizer (1.3 and 0.8 cm every 10 days, respectively).

Thus, the plants of CRF (14-14-14) treatment reached a height of 1.0 m (adding 48 cm) 224 days before receiving the last rate of fertilizer, with three 16 g applications being used per pot (48 g). For MF (10-10-10) to grow at the same rate (48 cm), five applications of 15 g per pot (75 g) and 288 days (60 days more) were required. Notably, MF (10-10-10) is the fertilizer used by the company that performed the experiment and most ornamental plant producers.

It appeared that PCRF (18-06-18), the fertilizer with 50% controlled release of nitrogen and potassium, was not as efficient as CRF (14-14-14), the fertilizer with 100% controlled release of N, P, and K, in which the plants were 12 cm more than PCRF.

Controlled release fertilizer produced a slow release of nutrients over the three months, depending on the temperature and soil moisture. Through slow release, this type of product controls the nutrients provided to the plant over a long period, with continuity of supply, and is superior to conventional fertilizers (Almeida et al., 2019).

It was observed that, except for no fertilizer treatment, from day 210 onwards, there was a marked growth of plants under all treatments, with some stability in plant height at 330 days. Guardia et al. (2021) observed a similar effect in Jeriva palms (*Syagrus romanzoffiana* (Cham.) Glassman), where there was an increase in the height of palms transplanted under different shading conditions from the fifth month onwards, with some stability in the size of these plants in the 10th month.

Seedling height is an important criterion for seedling buyers, as plants are marketed in pots of different volumetric capacities according to the minimum and maximum heights of the plants.

According to Veiling Holambra (2021), plants are classified and separated into homogeneous lots, with height being a unifying criterion across the entire production chain, where producers, wholesalers, retailers, and consumers follow the same criteria to determine the product quality.

Thirty days after the first application of fertilizers, it was not possible to observe differences between treatments with respect to chlorophyll A (Figure 2) and chlorophyll B (Figure 3) Falker (ICF a and ICF b) indices. In this period, the composition of the substrate used by the company, probably provided the necessary nutrients for the plant because the various fertilizers used in the experiment would not have affected the chlorophyll levels within such a short time.

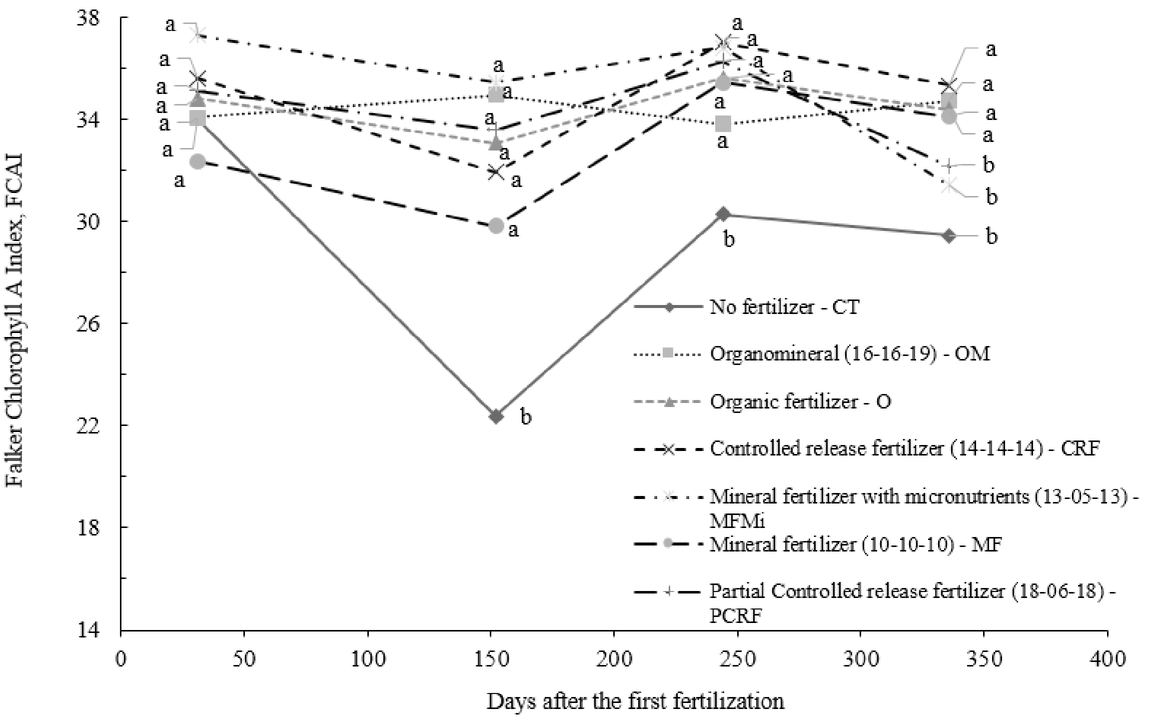

Figure 2. Falker Chlorophyll Index A (FCI A) in the leaves of the areca palm as a function of applying different fertilizers at intervals during the experiment. Each point represents the average of six repetitions. The average followed by the same letter does not differ between treatments, within a date, by the Scott–Knott test. CV = 9.70%

After 150 d of fertilization, the lack of nutrient application reduced FCI a by 35%, from 34 to 22 ICF a (Figure 3), and ICF b by 46%, from 15 to 8 ICF b (Figure 4), leaving the plants of control treatment (no fertilizer) with a less intense green coloration. This made them less attractive and less suitable for sale than the plants in the other treatments. At this time, ICF a was lower only in control treatment, and ICF b was higher in CRF (14-14-14) and MFMi (13-05-13).

The color of ornamental plants plays a key role in consumers' purchase of products and is a qualitative aspect directly influenced by mineral nutrition (Furtini Neto et al., 2015).

In addition, lower chlorophyll levels may reflect lower photosynthetic rates and reduced plant growth, as observed in the present study (Figure 4), due to lower carbohydrate accumulation (Taiz et al., 2017). A reduction in ICF due to the absence of nitrogen fertilization was also observed by Milani et al. (2021) in cut gerberas grown in pots.

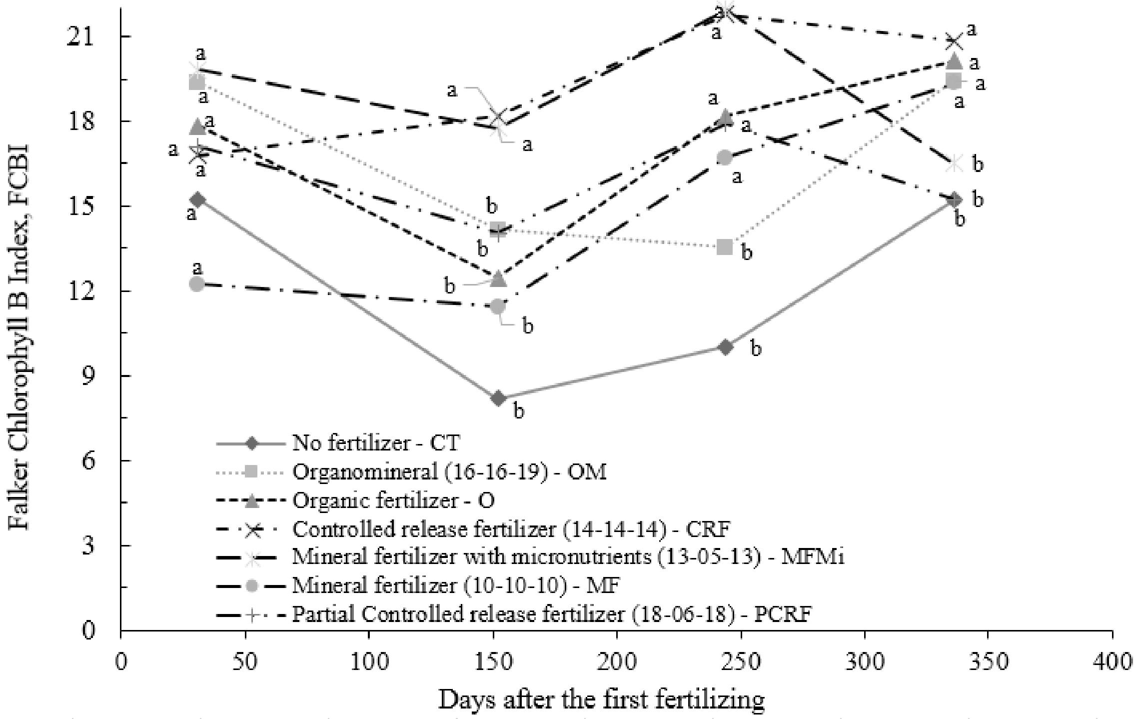

Figure 3. Falker Chlorophyll Index B (ICF) for the leaves of the areca palm as a function of applying different fertilizers at intervals during the experiment. Each point represents the average of six repetitions. The average followed by the same letter does not differ between treatments, within a date, by the Scott–Knott test. CV = 25.98%.

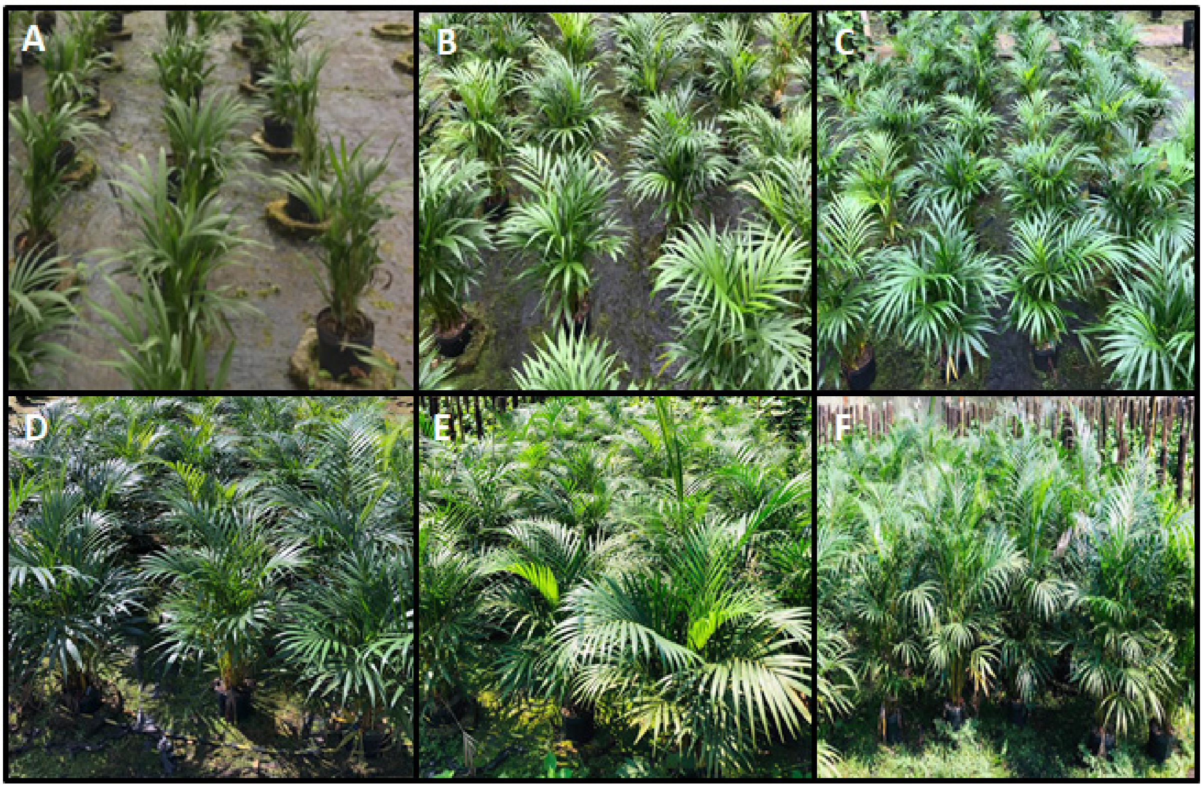

Figure 4. Areca palm at the beginning of experiment (A); Areca palm 60 days after the beginning of experiment (B); Areca palm 90 days after the beginning of experiment (C); Areca palm 180 days after the beginning of experiment (D); Areca palm 240 days after the beginning of experiment (E); Areca palm 365 days after the beginning of the experiment, corresponding to the end of experiment (F).

The highest values for the ICF and b indexes were observed 240 days after the first fertilization in almost all treatments except OM (16-06-09). This increase was partly due to the low light intensity at this time, leading to the production of more chlorophyll.

Between 210 to 240 days from the beginning of the fertilization, there were 19 days of rain, which further characterized the reduction of light. An increase in Chlorophyll Index due to lower solar irradiation was also observed by Xiong et al. (2015).

The plants of MF (10-10-10) treatment showed the greatest increase in ICF (7.9 ICF), although they still had a lower value than the other treatments at 240 days. On the other hand, CRF (14-14-14) and MF (10-10-10) showed more significant increases in ICF a (5.1 and 5.6 ICF, respectively), as they presented, together with no fertilizer treatment, the lowest ICF values at 180 days. The same effect was observed with ICF b in the control and organomineral treatment groups. Godoy et al. (2013) observed a similar effect in citrus plants.

Plants with lower nutrient concentrations favor the absorption of nutrients more than plants with higher concentrations (Malavolta, 2006), which may have provided N absorption from the substrate, favoring chlorophyll synthesis. In addition, no fertilizer plants were smaller (Figure 2) and required fewer nutrients to increase chlorophyll concentration. There was no difference in ICF a between the treatments that included fertilization.

At the end of the experiment, at 365 days, PCRF (18-06-18) and MFMi (13-05-13) presented the lowest ICF a and ICF b values, along with control treatment. Although PCRF (18-06-18) and MFMi (13-05-13) provided essential nutrients for chlorophyll synthesis, such as Mg, S, and Fe, this was not reflected in increasing ICF, as the substrate already contained high levels of these nutrients.

The color quality is critical for the sale of ornamental plants. Yellowish leaves can compromise plant sales as they may indicate several problems. Veiling Holambra (2021) wrote that yellow or burned leaves due to phytotoxicity are considered serious defects. The discolored leaves devalue the quality and may disqualify plants when symptoms occur in 5% of the lot, reaching up to 10% of the sheet. In this sense, the highest possible chlorophyll a and b content in plants increase the green color and improve quality and value.

MFMi (13-05-13) treatment provided a high growth rate and taller plants at the end of the experiment, equivalent to that achieved by the plants of CRF (14-14-14), which could not maintain the green color of the leaves (Figures 3 and 4). Although the N: K ratio of the two fertilizers was the same, the amount of P applied was much smaller in MFMi (13-05-13) than in CRF (14-14-14) (Table 2).

Broschat (2015a) noted that palm trees planted in sandy or limestone soils with low P content could grow well and maintain good quality without phosphate fertilization. Godoy et al. (2016) also observed that the accumulation of P by palm tree plants was low when cultivated in the field. Moreover, PCRF (18-06-18), which also provided lower ICF values in the palm trees at the end of the experiment, also provided less P.

The plants of OM (16-06-09) treatment showed higher ICF values, equivalent to plants of CRF (14-14-14); however, they had lower growth rates, as did control treatment plants. It was found that OM (16-06-09) presented a low K (N: K of 1.8:1) relative to the others, and the dose of K applied was 57% lower than other treatments (N:K 1:1), which may have reduced the height of these plants. According to Broschat (2015a), fertilizers with an N:K of 3:1 are commonly used in St. Augustine, Florida, to reduce the growth and overall quality of *Palmeira areca*. Broschat (2015b) noted that the ideal growth and quality of the areca palm tree were dependent on the high doses of N and K used in fertilization and that high doses of N doses relative to K resulted in a sharp reduction in quality.

Thus, it is possible to produce palm trees in a pot using controlled-release fertilizer (CRF 14-14-14) within three months. This method takes less time, a lower fertilizer dose (56% less), and less labor (one less application) compared to the MF (10-10-10) treatment commonly used by producers. Godoy et al. (2016), studying the accumulation and partitioning of biomass and nutrients in various ornamental plants, suggested that fertilization of the palm tree should be performed with NPK fertilizer at a ratio of 2:1:2. Broschat (2015b) also concluded that the use of controlled-release fertilizer over three months, with an N: K ratio of 1:1, is an appropriate option for fertilizing the areca palm tree.

Conclusions

All fertilizers used in the experiment improved growth and green color (Chlorophyll Index) in the areca palm cultivated in pots when compared to the absence of fertilization. The three-month controlled release fertilizer (14-14-14) was the treatment that produced the best results, positively impacting palm tree production and improving both plant height and color, attributes that increase its commercial value.

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Author Contribution

MVF: project idea, research development, results analyses, graphs and figures preparation, manuscript writing and review. **LJGG:** project idea, manuscript writing, statistic and review. **GS:** project idea, manuscript writing and review. **AGPR:** results analyses, graphs and figures preparation. **MAMP:** results analyses, graphs and figures preparation

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