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RURAL ENGENEERING

Water productivity in irrigated coconut palms in humid tropical climate conditions in eastern Brazilian Amazon

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ABSTRACT: The growing demand for coconut water has led to the expansion of irrigated green dwarf coconut cultivation; however, the inefficient use of water has contributed to the degradation and waste of water resources, making fundamental studies aiming to optimize the use of water. The objective of this study was to determine the physical productivity and water productivity of green dwarf coconut palms under the climatic conditions of Santa Izabel do Pará, eastern Amazonia, Brazil. The experiment was carried out from 2020 to 2021, in a green dwarf coconut plantation spaced 7.5 m x 7.5 m in a triangle, at Fazenda Reunidas Sococo, with an area of approximately 7 ha. Water productivity (WP) was determined both in terms of fruit production (WP_f) and coconut water production (WP_{ca}), through the relationship of fruit productivity (fruit biomass and water volume) with accumulated evapotranspiration. The dwarf coconut tree presented a total production of 105 and 186 fruits plant^{-1} and 37 and 62 L plant^{-1} of coconut water in the years 2020 and 2021. The largest volumes of water and the highest weights occurred during the wettest season. WP_f was of 1.87 fruits m^{-3} (2020) and 2.94 fruits m^{-3} (2021) and WP_{ca} 0.66 L m^{-3} (2020) and 0.98 L m^{-3} (2021).
Key words: *Cocos nucifera*, WP, evapotranspiration.

Produtividade da água em coqueiro irrigado nas condições de clima tropical úmido na Amazônia Oriental

RESUMO: A crescente demanda por água de coco tem ocasionado a expansão do cultivo de coqueiro-anão-verde irrigado, no entanto, o uso ineficiente da água tem contribuído com a degradação e desperdício dos recursos hídricos, tornando fundamental estudos que visem otimizar o uso da água. Objetivou-se determinar a produtividade física e a produtividade da água do coqueiro-anão-verde, nas condições climáticas de Santa Izabel do Pará, leste da Amazônia, Brasil. O experimento foi realizado no período de 2020 a 2021, em um plantio de coqueiro-anão-verde em espaçamento 7,5 m x 7,5 m em triângulo, na Fazenda Reunidas Sococo, apresentando uma área de aproximadamente 7 ha. A produtividade da água (PA) foi determinada tanto em termos de produção de frutos (PA_f) como de produção de água de coco (PA_{ac}), através da relação da produtividade de frutos (biomassa do fruto e volume de água) com a evapotranspiração acumulada. O coqueiro-anão apresentou uma produção total de 105 e de 186 frutos planta^{-1} e de 37 e de 62 L planta^{-1} de água de coco nos anos de 2020 e 2021. A evapotranspiração total foi de 56,2 m³ (2020) e 53,2 m^{-3} (2021). A PA_f foi de 1,87 frutos m^{-3} (2020) e 2,94 frutos m^{-3} (2021) e a PA_{ac} de 0,66 L m^{-3} (2020) e 0,98 L m^{-3} (2021).
Palavras-chave: *Cocos nucifera* L., PA, evapotranspiração.

INTRODUCTION

The coconut tree (*Cocos nucifera* L.) is a fruit tree with wide commercial exploitation in around 90 countries, mainly at latitudes 20° N and 20° S, because they present edaphoclimatic conditions more favorable to its cultivation (SIVAKUMAR et al., 2021). In Brazil, the Northeast region has the highest coconut production, but with the growing demand for coconut water, its cultivation has expanded to other producing regions, such as the North (FAO, 2022), with the state of Pará as the largest regional producer, reaching a production in 2020 of 189.6 million fruits and an average yield of 9.9 thousand fruits ha^{-1} (IBGE, 2022).

The coconut tree is one of the crops with the highest water requirement, especially during the production phase, since the presence of reproductive organs, such as inflorescence and fruits, tied to high transpiration rates, make the crop more sensitive to water deficit. When subjected to this condition, productive yield, both in terms of fruit and coconut water, tends to be compromised due to miscarriage and poor fruit formation (ARAÚJO et al., 2022; MIRANDA et al., 2007).

The reduction of available water in the soil affects the metabolism of plants, compromising

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their growth and development, since water acts in the processes of cell division and expansion, in the transport of nutrients to the interior of plants and is inevitable to the transpiration and photosynthetic process, since both occur by a common route and by a gradient that favors the flow of water within the plant, which is regulated, in addition to other factors, by the water availability in the soil (SOUZA et al., 2020).

The use of irrigation has been fundamental to avoid water deficit and reduce climate risks, ensuring satisfactory productivity (RADIN et al., 2018). The use of this technology occurs mainly in places where the distribution of rainfall occurs irregularly, mainly in climatic types B and in the climatic subtypes “Am” and “Aw”, which despite presenting high rainfall indices, require water supplementation at some periods of the year (SOUZA et al., 2013).

Water management is part of the targets for sustainable development, as water is a vital asset and the impacts of its use indiscriminately have caused global concerns (FITO & HULE, 2021). Agriculture is one of the activities that most makes use of water resources through irrigation (ANA, 2017). Thus, the efficient use of water, through water supplementation that provides satisfactory productivity and a maximization of the water used in the system, has contributed to the sustainable management of the irrigation system and reduction of environmental problems (VELASCO-MUÑOZ et al., 2019).

The water productivity (WP) corresponds to the relationship between production, both in terms of fruits per plant or in coconut water per plant (MIRANDA et al., 2019), and to a certain volume of water applied to the system, which may be due to evapotranspiration or irrigation (FRIZZONE & MELO, 2021). Knowledge of the WP allows to optimize water use and reduce water deficit, contributing to sustainability in the use of water resources.

Some studies on the efficiency in water use have already been developed for coconut trees in other regions of the country, such as ARAÚJO et al. (2022) and MIRANDA et al. (2019) in Ceará and that of AZEVEDO et al. (2006) in Sergipe. However, climate and soil conditions are intrinsic to each region where the crop is inserted, and studies of this nature are needed in other producing regions, to understand the interactions that occur in the soil-plant-atmosphere system of these localities. In this sense, the objective of this study was to determine the physical productivity and water productivity of green dwarf coconut palms under the climatic conditions of Santa Izabel do Pará, eastern Amazonia, Brazil.

MATERIALS AND METHODS

The experiment was carried out in a commercial plantation of green dwarf coconut palm, located at Fazenda Reunidas Sococo (01º 13’ 40.16” S and 48º 02’ 54.35” W), in the municipality of Santa Izabel do Pará, during the period from August 2020 to December 2021 (Figure 1). The climate of the region is characterized as humid tropical, according to the köppen-geiger climatic classification, presenting climatic subtype “Am”, with moderate dry season and annual rainfall above 2,000 mm, average annual temperature around 26 °C and relative humidity about 80% (ALVARES et al., 2013).

The cultivar used was the green-dwarf-of-brazil-jiqui (AVeBrJ), with seven years of age and in the third (2020) and fourth (2021) year of production, with a planted area of approximately 7 ha, at spacing 7.5 m x 7.5 m in equilateral triangle (205 plants ha^{-1}). Pueraria (*Pueraria phaseoloides*), perennial herbaceous legumes, is the vegetation cover present in the soil, introduced since the beginning of planting. The soil of the area is of sandy-free texture, being classified as Quartzarenic Neosol (EMBRAPA, 2018) and its characteristics are presented in table 1. The critical water soil content was defined based on physical properties of the soil considering an available factor (f) equal to 0.3 (CAMBOIM NETO, 2002)

The plants were fertilized with 3.3kg of the Formulation NPK (10-07-20 + 1.0% magnesium + 5.5% sulfur + 3.5% calcium and 0.10% boron + 0.11% manganese), being performed twice a year. During the experimental period, all management procedures adopted by the company were maintained, such as: weeding, pest control and diseases.

The coconut palm was irrigated by microsprinkler, positioned 1 m from the base of the stipe, being one emitter per plant, self-compensating and with 96 L h^{-1}, with a uniformity coefficient of 96% and an application efficiency of 86%. In the irrigation depth management, a 2-day irrigation shift was used, and the water demand was calculated based on reference evapotranspiration (ET_0) estimated using the Penman-Monteith-FAO-56 method proposed by ALLEN et al. (1998), with data from the company’s meteorological station, installed about 2 km from the experimental area.

In the experimental area an automatic micrometeorological tower (Figure 1) of 12 m high was installed and instrumented with sensors to measure the incident global radiation (CMP6, Campbell Scientifc Instrument, Logan, UT, USA), radiation balance (NR-LITE2, Campbell Scientifc Instrument, Logan, UT,

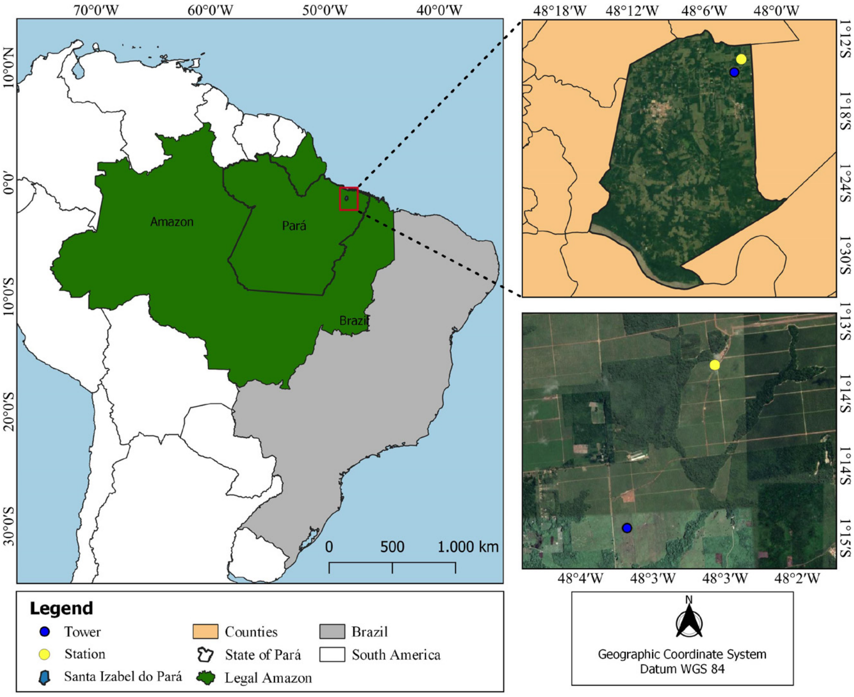

Figure 1 - Location of the experimental area, Santa Izabel do Pará.

USA), temperature and relative humidity (MeteoTemp, Barani Design Technologies, USA) two levels above the coconut tree canopy (0.9 m and 2.1), soil heat flux (HFP01SC, Campbell Scientifc Instrument, Logan, UT, USA) and rainfall (TB4, Campbell Scientifc Instrument, Logan, UT, USA).

These sensors were coupled to two data acquisition and storage systems (Datalloger CR 1000 and CR 10x, Campbell Scientific, Inc., Logan, UT, USA) and a multiplexer (AM416, Campbell Scientific, Inc., Logan, UT, USA) programmed to perform instant readings every 30 seconds and recording averages and totals every 20 minutes.

The maximum evapotranspiration of coconut palm (ET_c) for the period from August/2020 to December/2021, period in which the meteorological instrumentation was installed in the experimental area, was determined using the energy balance method based on the Bowen ratio according to SOUZA et al. (2018).

For the period from January to July 2020, ET_c was estimated by using the reference evapotranspiration, through the Penman-Monteith equation proposed by ALLEN et al. (1998) multiplied by the Kc of 1.1, obtained in the experiment according to CARVALHO (2022).

The estimate by using FAO approach was adopted so that the annual production period was fully utilized and correlated with the total evapotranspiration of the period. The data used to calculate ET_0 were obtained from the automatic weather station located in the company (Figure 1), installed about 2 km from the experimental area.

Twenty-four green dwarf coconut plants were randomly selected and demarcated in a homogeneous orchard. Phenological observations were made every two weeks, from August/2020 to December/2021, counting the number of female flowers (fertilized and unfertilized) from the opening of the spatha. Twenty plants were randomly monitored, with seven years of age and in the year of production. The number of fruits per bunch harvested and the volume of fruit water were evaluated every 21 days for 16 months.

Two fruits of each bunch harvested for biometric evaluations were selected and transported to the laboratory of the company Sococo, according to the methodology adapted by BENASSI et al. (2007), where its stems were removed and the fruits sanitized. After that, the fruit mass was measured on a digital scale with an accuracy of 0.01 gram, and later, these were drilled for removal and quantification of the liquid albumen (coconut water).

Table 1 - Physicochemical and water characterization of the soil of the experimental area.

Characteristics	--------------------------------------Depth (cm) ------------------------------------	
	0-20	20-40
pH ($CaCl_2$)	4.43	4.10
Organic Matter (g dm^3)	8.75	3.25
Organic Carbon (g dm^3)	5.00	2.00
P (mg dm^3)	111.92	7.05
Ca^{+2} ($mmol_c$ dm^3)	10.7	4.00
Mg^{+2} ($mmol_c$ dm^3)	5.50	2.30
K^+ ($mmol_c$ dm^3)	2.10	0.90
$H^+ + Al^{+3}$ ($mmol_c$ dm^3)	33.7	32.7
Cation exchange capability ($mmol_c$ dm^3)	52.5	40.10
Base saturation (%)	34.85	17.95
Al Saturation (%)	6.48	31.76
Sand (%)	70	-
Silt (%)	12	-
Clay (%)	18	-
Field capacity (m^3 m^{-3})	0.195	-
Critical soil humidity (m^3 m^{-3})	0.166	-
Permanent wilting point (m^3 m^{-3})	0.098	-

The use of water expressed in terms of water productivity (WP) was estimated as a function of fruit and coconut water volume production in relation to crop evapotranspiration, using the equations proposed by FRIZZONE & MELO (2021) and adapted by MIRANDA et al. (2019):

$$WP_f = \frac{P_f}{ET_c} \quad (1)$$

$$WP_{ca} = \frac{P_{ca}}{ET_c} \quad (2)$$

In which WP_f is the water productivity in terms of fruit production (fruit m^{-3}); WP_{ca} is the water productivity in terms of coconut water (L m^{-3}); P_f is fruit yield (fruits $plant^{-1}$); P_{ca} is the productivity of coconut water (L $plant^{-1}$) and ETc is the maximum evapotranspiration of the coconut tree over the period considered (m^3 $plant^{-1}$).

RESULTS

The meteorological variables monitored both by the micrometeorological tower present in the experimental area (Tower) and by the meteorological station present in the company (Tower 1), irrigation (I) and total monthly evapotranspiration of coconut palm (ET_c) are presented in figure 2. It is noticed that the average global solar radiation (Rg) of Tower was slightly above (1.49 MJ m^{-2} day^{-1}) the average of Station (Figure 2a).

The total monthly ETc ranged from 71 mm (Feb/2021) to 138 mm (Sep/2020), with an average of 96 and 108 mm for the years 2020 and 2021, respectively (Figure 2c). The highest irrigation depths applied were 61, 77 and 94 mm in October, August and September 2020, respectively (Figure 2c). In both years, in the months of August and September, the values of rainfall were below the water demand of the crop, indicating the need for water supplementation of 145.26 mm (7.0 m^3 $plant^{-1}$ in 2020) e 63,79 mm (3.1 m^3 $plant^{-1}$ in 2021), which were supplied by the applications of irrigation depths of 171.11 mm (8.3 m^3 $plant^{-1}$ in 2020) and 63.52 mm (3.1 m^3 $plant^{-1}$ in 2021), respectively. Soil moisture showed little variation over the months, ranging from 0.164 to 0.247 m^3 m^{-3}, being for most of the period close to or above field capacity (Figure 2c).

As for productivity, during the experimental period, 34 harvests were carried out (17 per year). The number of fruits per harvested bunch ranged from 5 to 8, with an average of 6.2 fruits bunch $^{-1}$ and from 7 to 14, with an average of 10.9 bunch $fruits^{-1}$ for the years 2020 and 2021, respectively (Figure 3a).

The average number of female flowers (fertilized and unfertilized) ranged from 24 to 52, with an average of 34 flowers per inflorescence (Figure 3a). It is observed that in the first year of evaluation, the average number of fruits per harvested bunch was lower than in the second year, around 4.7 fruits $bunch^{-1}$.

An increase in production parameters in 2021 was noted in relation to 2020. The average

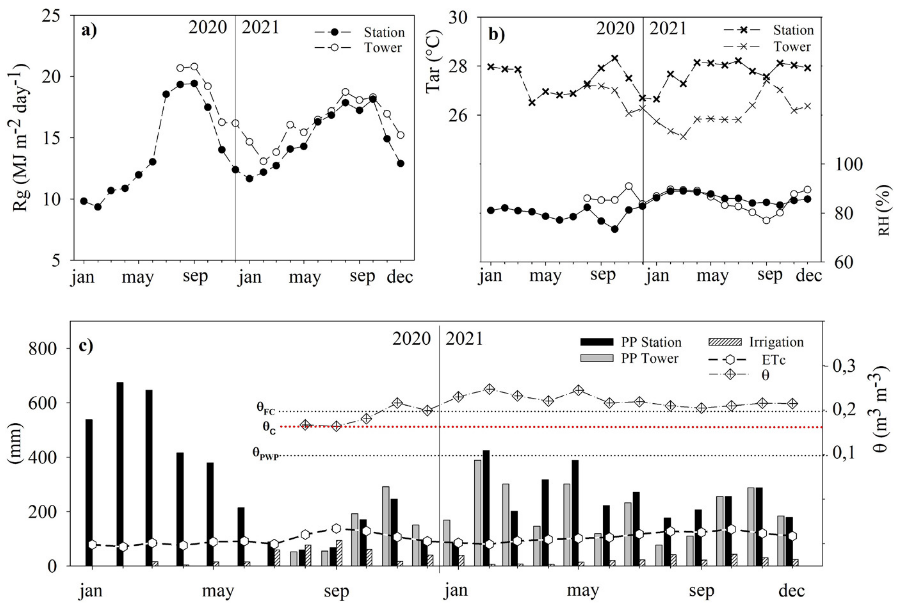

Figure 2 - Variation of (a) incident global radiation (Rg); (b) air temperature (Tar) and relative air humidity (RH); (c) rainfall (PP), irrigation (I), accumulated crop evapotranspiration (ETc) and volumetric soil moisture (θ), for the station and micrometeorological tower, during the years 2020 and 2021.

volume of coconut water (V_{ca}) per fruit was 361 mL (2020) and 337 mL (2021), ranging from 276 to 487 mL and 265 to 419 mL in 2020 and 2021, respectively (Figure 3b). The same pattern was observed for the average fruit weight (PF), which presented an average of 2.03 kg (2020) and 1.95 kg (2021), ranging from 1.69 to 2.51 kg in 2020 and 1 .76 to 2.19 kg in 2021. The dwarf coconut tree presented an average total production of 105 and 186 fruits plant $^{-1}$ and 37 and 62 L plant^{-1} of coconut water in the years 2020 and 2021, respectively (Table 2).

For each one m³ evapotranspired by the coconut tree, 1.87 and 2.94 fruits and 0.66 and 0.98 L of coconut water were produced in 2020 and 2021, respectively (Table 2). Considering the average water productivity values found, the results were similar to those determined by MIRANDA et al. (2019) who obtained by using a different definition, but with similar mathematical description, WP_f and a WP_{ca} of 2.3 and 1.0, respectively, with productivity of 139.5 fruits and 64.0 L of coconut water and an ETc of 60.7 m³.

DISCUSSION

The difference found between the global radiation incident between the station and that in the tower is due to the high volumes of rainfall at Station (3657 mm) compared to tower (3317 mm), which reduce the incidence of solar radiation on the surface, due to its greater scattering (Figure 2c) (ATAIDE et al., 2020).

The highest ETc values occurred in the period of lower rainfall (August to November), probably due to the high atmospheric demand in this period, resulting from the higher temperature and lower relative humidity (Figure 2b). MIRANDA et al. (2019) in studies with coconut trees in the Northeast region found that the highest evapotranspiration values occurred at the time when there were no rain events. ARAÚJO et al. (2022) also showed that in periods with high volumes of rainfall, the accumulated evapotranspiration of coconut trees tends to be limited.

It is noted that the amount of water available for the coconut tree from the rains was higher than the evapotranspiration of the crop in practically every month in the two years evaluated, except in the months of August and September, evidencing that during these months of the second semester there is a need of use of the irrigation technique, combined with proper management, with the objective of increasing the productivity of coconut water fruits in a sustainable way, avoiding the waste of water and financial resources (VELASCO-MUÑOZ et al., 2019).

Despite the reduction in rainfall in the period mentioned, it is noted that the volumetric

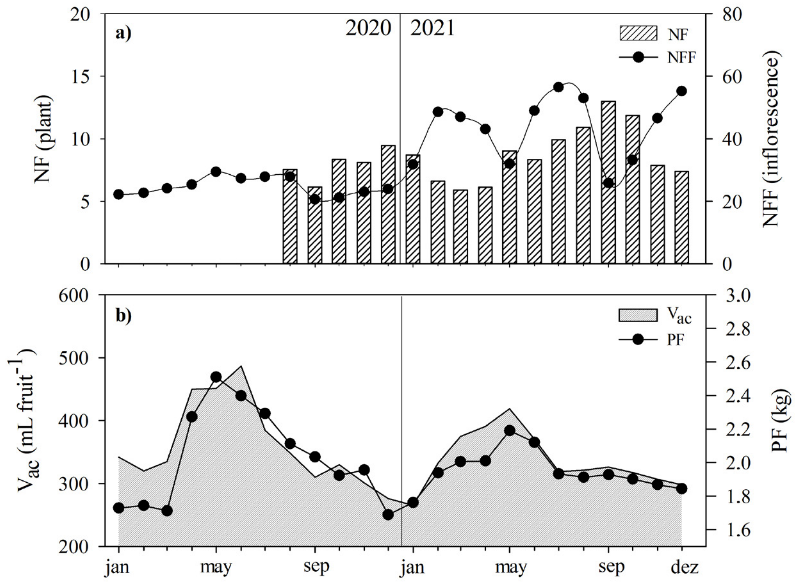

Figure 3 - Temporal variation of (a) number of fruits (NF) per plant and number of female flowers (fertilized and not fertilized) per inflorescence (NFF) and (b) volume of coconut water (V_{ca}) per plant and average fruit weight (PF), during the years 2020 and 2021.

water content always remained above the critical humidity for the coconut tree, ensuring adequate conditions due to irrigation management (Figure 2c). Conversely, the high soil moisture found is due to the large volumes of water, resulting from both rainfall and irrigation, which did not infiltrate the soil causing waterlogging and runoff (not quantified). In such cases, it was observed that soil moisture was higher than field capacity as a result of the excessive rainfall compared to the total ETc, as can be seen in Figure 2c

The frequent occurrence of surface runoff, especially during the rainy season, and the fact that this component has not been monitored is one of the reasons for analyzing water productivity in response to evapotranspiration since we disregard the non-consultative use of water (FRIZZONE & MELO, 2021). Other authors considered water productivity as a function of applied irrigation (MIRANDA et al., 2019) but in cases where irrigation efficiency is not considered, or where other water inputs into the system are disregarded, the use of evapotranspiration becomes a suitable variable to interpret water productivity (FRIZZONE & MELO, 2021).

The productivity values obtained are higher than those found by CÂMARA et al. (2019) in studies with coconut trees in the semiarid region, where the average number of fruits per harvested bunch was 5.2. The production of coconut fruits is more affected by the environmental conditions prior to the harvest period, since the development of the spathe from its opening experiences all the interactions that occur over the seven months, until reaching the ideal point of harvesting the coconut fruit for coconut water (CÂMARA et al., 2019; MIRANDA et al., 2019).

The number of female flowers showed an increase in their production during the less rainy season,

Table 2 - Yield in terms of fruit (P_f) and coconut water (P_{ca}), crop evapotranspiration (ETc) and water productivity of the green dwarf coconut tree in fruit production (WP_f) and coconut water volume (WP_{ca}) in the weather conditions of Santa Izabel do Pará-PA, during the years 2020 and 2021.

Year	P_f (fruits plant^{-1} year^{-1})	P_{ca} (L.plant^{-1} year^{-1})	Etc (m^3)	WP_f (fruits m^{-3})	WP_{ca} (L m^{-3})
2020	105.1	36.9	56.2	1.87	0.66
2021	185.6	62.2	63.2	2.94	0.98
Mean	145.4	49.6	59.7	2.4	0.8

while in the wettest period the production of female flowers decreased. This behavior is similar to that found by LEITE & ENCARNAÇÃO (2002) in studies on the phenology of coconut palms in Pernambuco, where climatic conditions, mainly rainfall, influenced flowering and, consequently, fruit production.

Such an event may be associated with the incidence of pests and diseases observed in the field, linked to the high volumes of rainfall, causing the abortion of female flowers and fruits, resulting in lower production (CASTRO et al., 2009; MIRANDA et al., 2019). It is possible that the excess of rain, mainly during the first semester, also harmed the action of pollinators, inhibiting the number of fertilized flowers, causing a drop in fruit production in the following months (PASSOS et al., 2007).

In 2020, despite conditions of higher water availability, due to rain and irrigation, the incidence of pests and diseases in the area may have favored the drop in the production of coconut fruits, as they cause injuries, rot and even fruit fall. MIRANDA et al. (2019) in studies with dwarf coconut trees in Ceará also found a reduction in fruit production due to the incidence of disease that caused burning of the coconut tree leaves.

Despite the lower fruit production in the first year of the experiment, the average volume of coconut water was higher than in 2021, most likely due to the higher amount of rainfall. It is therefore noted that the highest volumes of water and the highest weights occurred during the wettest season and the lowest in the less rainy season, reaching the maximum values of V_{ca} and PF in May, month with the highest rainfall in both years.

The seasonality in the volume of coconut water per fruit and the average weight of the fruit is more related to the current conditions of the environment, unlike the production of fruits, since the variability in the rainfall regime causes changes in these variables, increasing and decreasing accordingly with the amount of water available in the environment (ARAÚJO et al., 2022). Seasonality in the production of coconut water volume is evident in the presence of water stress even in adequately irrigated plants due to adverse atmospheric conditions as found by MIRANDA et al. (2019) for coconut in Ceará state.

Although, irrigation contributes to the stability of coconut water production and fruit weight in the less rainy season, the average values for this period were lower, around 12%, than for the rainiest season, which may be related not only to by the greater amount of water from the rains as well as by the better distribution of the wetness comprising a superior wet area, reaching the root system of the coconut tree as a whole, unlike the irrigation system, where the water supply is limited, occurring in a localized way (CINTRA et al., 2008; CINTRA et al., 2009).

This low yield may be associated not only with meteorological conditions but also with the age at which the plants were, being only in the third and fourth year of production, respectively, since production stability occurs at 8 years, presenting a production in around 200 fruits plant^{-1} year^{-1} (CÂMARA et al., 2019).

Such results are similar to those found by AZEVEDO et al. (2006) in research with dwarf coconut trees, in the fourth year of production, where the production was 186 fruits plant $^{-1}$. However, they were larger, in terms of fruit, and close or smaller in relation to coconut water yield, than those obtained by MIRANDA et al. (2019) in studies with coconut palms in Ceará that found yields of 139 fruits plant $^{-1}$ and 64 L plant^{-1} of coconut water. Results were also close to those of ARAÚJO et al. (2022) who evaluated fruit production through deficient irrigation, and found a production of 145 fruits plant^{-1} year^{-1} and of 81.4 L plant^{-1} year^{-1} of coconut water.

The year 2021 showed higher evapotranspiration around 13%, as well as the highest production of fruits and coconut water. It is likely that the increase in production in 2021 was favored by the greater amount of water available for the coconut tree. However, possibly the low efficiency observed in the first year may be related to the low fruit production, due to the occurrence of pests and diseases visually perceived in the field.

The greater availability of water in the soil favors plant transpiration and, consequently, the assimilation of CO_2, since both have a diffusional route in common, creating a soil-plant-atmosphere relationship and resulting in greater production (SOUZA et al., 2020). ARAÚJO et al. (2022) found that increasing the amount of water supplied to the coconut tree provided a 33% increase in fruit yield and an 8% increase in coconut water yield. AZEVEDO et al. (2006) reported a 12% increase in fruit production with the addition of water from the irrigation system.

The increase in fruit production identified in thisresearch contributed to a better use of water, both in terms of fruit (WP_f), being higher by 57% and in terms of coconut water (WP_{ca}), with an increase of 49%. compared to the year 2020, since, despite the loss of water by the coconut tree, when kept hydrated, the performance of metabolic and physiological processes is efficient (YADAV et al., 2020). These results reinforce that the coconut tree makes good use of water and that the use of an effective management can promote greater fruit production, resulting in greater productivity, both in terms of biomass as well as water volume.

CONCLUSION

Fruit production was affected by environmental conditions prior to fruit harvest and had the lowest values in 2020, highlighting the effect of water deficit on the volume of coconut water produced;

The volume of coconut water per fruit and the weight of the fruits increased during the wettest period and decreased in the less rainy season, even with the use of the irrigation system;

In 2021 the water productivity was higher in terms of fruit and volume of coconut water than in 2020.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

Data curation, investigation, methodology: EOTC, GSTF, MLR, ACM, JVFS, MLAV, JVNP, PJOPS. Conceptualization, visualization, writing – original draft: EOTC, GSTF, PJOPS. Project administration, resources, supervision: PMPL, PJOPS. Writing – review & editing: EOTC, PMPL, FRM, PJOPS. Funding acquisition: PJOPS. All authors critically revised the manuscript and approved of the final version.

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