# TRICKLE IRRIGATION: EFFECTS ON PAPAYA CROP

**GIAN C. CARVALHO[1], EUGÊNIO F. COELHO[2], AFRÂNIO DOS S. A. M. DA SILVA[3], ARTHUR J. M. PAMPONET[4]**

**ABSTRACT:** The objective of this study was to evaluate growth and yield of papaya cv. Sunrise solo under trickle irrigation system configurations. A random block design was used with six treatments and four replications. Treatments were: T1- a 32 L $h^{-1}$ micro sprinkler; T2 - a 43 L $h^{-1}$ micro sprinkler and T3 - a 60 L $h^{-1}$ micro sprinkler for four plants; T4 – Drip system with four emitters per plant on one lateral line per crop row; T5 - Drip system with eight emitters per plant on two laterals line per crop row; T6 - Drip system with four emitters per plant on one lateral line distributed as pig tail. The dripper flow rate was 4 L $h^{-1}$and they were apart each other 0.50 m. Crop growth variables were measured every two weeks. Production variables were evaluated during harvest. The treatment that presented superiority was irrigated by micro sprinkler system with flow rate of 43 L $h^{-1}$.

**KEYWORDS**: *Carica Papaya L,* yield, trickle irrigation systems.

# IRRIGAÇÃO LOCALIZADA: EFEITOS NA CULTURA DO MAMOEIRO

**RESUMO:** O objetivo deste estudo foi avaliar o crescimento e a produtividade do mamoeiro cv Sunrise Solo submetido a configurações de sistemas de irrigação localizada. O delineamento experimental utilizado foi em blocos ao acaso, com seis tratamentos e quatro repetições. Os tratamentos utilizados foram: T1 – um microaspersor de 32 L $h^{-1}$; T2 – um microaspersor de 43 L $h^{-1}$; T3 – um microaspersor de 60 L $h^{-1}$; T4 – gotejamento com quatro emissores por planta, sendo uma lateral por fileira de plantas; T5 – gotejamento com oito emissores por planta, tendo duas laterais por fileira de plantas; T6 – gotejamento com quatro emissores por planta, em uma lateral em "rabo de porco". Os gotejadores foram de vazão de 4 L $h^{-1}$ e distanciaram-se entre si 0,50 m. Variáveis de crescimento das plantas foram medidas em intervalos quinzenais; na colheita, foram avaliadas variáveis de produção. O tratamento que obteve superioridade aos demais em relação às variáveis observadas foi irrigado por microaspersão, com vazão de 43 L $h^{-1}$.

**PALAVRAS-CHAVE**: *Carica Papaya L*, produtividade, sistemas de irrigação localizada.

## INTRODUCTION

Brazil stands as the second largest producer of papaya in the world, surpassed only by India, with an area of 34,213 ha and a production of 1.87 million ton of papaya in the agricultural year 2010, corresponding to 16.67% of world production (FAO, 2012). Papaya is produced in almost all over Brazil, and the State of Bahia and Espírito Santo are top producers, with 910,131 and 613, 734 ton respectively. Papaya ranks fourth on the national scene in output value, behind only oranges, bananas and grapes, generating an output value in the order of 1.5 billion reais (IBGE, 2010).

Works with papaya has shown that culture is highly demanding in water, and the lack of water soil in the period of growth and production as well as excess of water reduces soil aeration also affecting their income SILVA (et al., 2013). The use of irrigation, especially during flowering

[1]Engº Agrícola, Doutorando em Engenharia Agrícola, UFRPE/Recife – PE, Fone: (81) 9717- 0785, giancarvalho@gmail.com.
[2]Engº Agrícola, Pesquisador A da Embrapa Mandioca e Fruticultura, Cruz das Almas – BA, eugenio.coelho@embrapa.br.
[3]Engº Agrônomo. afranioanjos@yahoo.com.br
[4]Engº Agrônomo. arthurpamponet@gmail.com
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favors the processes of growth, flowering and fruiting of the plant, resulting in higher yields, (COELHO et al, 2011).

The research on irrigation of papaya have been directed mainly to define the water needs of the crop and irrigation management, especially as applied to the interaction between water allocation and frequency of application or dosage of nutrients (POSSE et al, 2008; COELHO et al., 2010). The drip irrigation is the practice of applying water directly to the root zone of the plants, in high frequency and low intensity. It has been the most recommended for papaya, due to higher application efficiency (amount of water applied in relation to that used for culture), uniformity emission and water savings. The definition of the drip irrigation system most appropriate to the culture has still been subject to questioning by producers and the possibility of configurations of these systems only increases the doubt of what should be the most appropriate in specific conditions. Few studies have been focused on the adequacy of irrigation systems located on papaya crop.

Thus, the aim of the present study was to evaluate the performance and yield of the papaya *Sunrise Solo* configurations subjected to trickle irrigation systems.

## MATERIALS AND METHODS

The study was conducted in the experimental field of Embrapa Cassava & Fruit, located in the municipality of Cruz das Almas - Bahia (12 ° 48'S, 39 °06'W and 225 m) Brazil. The local climate is of type Am, according to the Köppen climate type (BAPTISTA & OLIVEIRA, 1998). The soil in the area is characterized as distrophic cohesive yellow Oxisol (EMBRAPA, 2009), with average values of 654 g $kg^{-1}$ of total sand, 77 g $kg^{-1}$ of silt, 269 g $kg^{-1}$ of clay, and density of 1.59 kg $dm^{-3}$ in the 0 to 0.70 $m^3$ layer and fertility analysis is shown in Table 1. The moisture field capacity, corresponding to the potential of -10 kPa is 0.1882 $m^3$ $m^{-3}$ and the permanent wilting point, equivalent to -1500 kPa is 0.1271 $m^3$ $m^{-3}$. Soil preparation consists of plowing, harrowing and tillage with dimensions of 0.40 x 0.40 x 0.40 m, with the papaya cultivar *Sunrise Solo* planted in spacing of 3.6 m x 1.8 m x 2.0 m.

TABLE 1. Fertility analysis results in the experimental area.

| ph | P | K | Ca | Mg | Na | H+Al | CTC | V |
|---|---|---|---|---|---|---|---|---|
| In water | mg $dm^{-3}$ | $cmol_c$ $dm^{-3}$ | | | | | | % |
| 5.7 | 10 | 0.26 | 1.90 | 1.10 | 0.35 | 3.6 | 4.81 | 75 |

The experimental design was randomized blocks with six treatments: three constituting of irrigation systems with a micro sprinkler for four plants (T1 - 32 L $h^{-1}$ micro sprinkler, T2 - 43 L $h^{-1}$ micro sprinkler, T3 - 60 L $h^{-1}$ micro sprinkler) and three constituting of drip irrigation systems with a flow rate of 4 L $h^{-1}$ by emitter, spaced 0.50 m (T4 - four emitters per plant on one side of the plant row, T5- eight emitters per plant on two laterals line per crop row , T6 - four emitters per plant on one lateral line distributed as "pigtail") with four replicates per treatment. The irrigated plots by micro sprinkler consisted of two rows with six useful plants each, while drip irrigated plots were composed of a row of six useful plants. Among the plots were installed a row of plants in order to avoid interference between a treatment and the other (border).

The water allocations were similar for all treatments, and calculated based on the simplified water balance, where the blade was applied from the difference between the crop evapotranspiration (ALLEN et al., 1998) and effective rainfall (MAROUELLI et al. 2011), considering the efficiency of the irrigation system based on the results by COELHO et al (2010). The drip irrigation were performed following the recommendations by COELHO et al (2011) and calculations of the amounts of nitrogen and potassium fertilizers applied in each drip irrigation followed the recommendations by COELHO et al (2008).

The values of precipitation, evapotranspiration and water appropriation applied, respectively, 1,207.4 mm, 1,553.23 mm and 527.40 mm are shown in Figure 1, where irrigation prevailed in the period from November 2009 to March 2010.

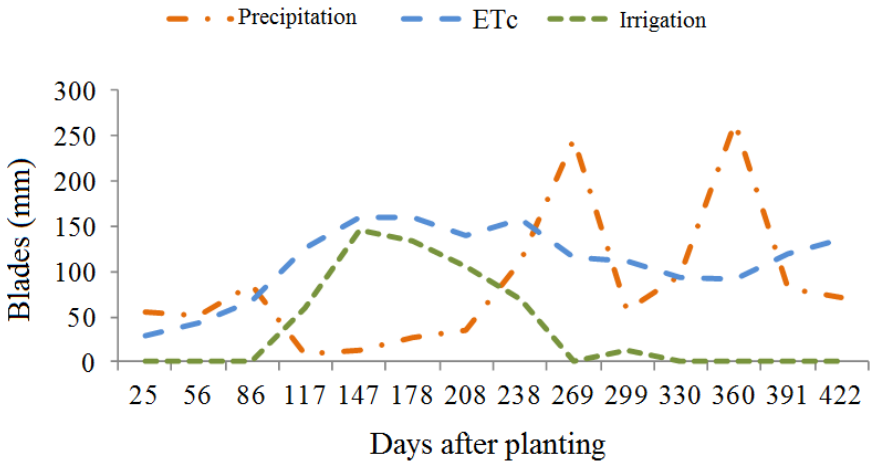



FIGURE 1. Precipitation, evapotranspiration and water allocation applied to the period of development and production of *Sunrise Solo* papaya.

The plant growth variables were determined in all experimental plots at fortnightly intervals. Stem diameter was obtained by measuring the circumference of the stem at height of 0.20 m above the ground with the aid of a graduated tape at 0.001 m. Plant height was measured from the base of the plant to the insertion of the leaves at the start of formation. To obtain the areas of the leaves surface (ALS) was measured the length of the central lobe (L) of each leaf and using the $ALS = 0.0947\ L^{2,\ 7352}$ model, according to ALVES & SANTOS (2002), to determine the total leaf area of each plant was added to the individual areas of each leaf.

The fruit harvest was performed at the time the peel went from dark green to light green to light yellow, or when the color of the fruit apex went from green to yellow (FREIRE, 2008). Individual fruit were weighed on an electronic scale and classified as commercial (weight between 280 and 890 g) and noncommercial (weighing less than 280g and deformed fruit) as MARIN et al. (1995) and for this study was considered only the commercial fruits. The average fruit weight was calculated by dividing the total weight of fruits per plot by the total number of fruits per plot.

The results were subjected to analysis of variance using SAS app and when significant the averages generated for each treatment were subjected to SASM – AGRI app, which by inserting the values of the residue degrees of freedom, mean square of the residue, number of treatments and replicates, provided the comparison Tukey's test at 5% level.

## RESULTS AND DISCUSSION

Among the variables analyzed, the stem diameter showed the greatest sensitivity to the effect of treatments corroborating with described by COELHO et al. (2011).

The plants presented bigger stem diameter under micro sprinkle irrigation especially on treatment T2 which reached higher values 211 days after planting (DAP), significantly changing on 320(DAP) when the rainfall increased and the irrigation shall only be the supplement for water demand of the culture, showing better values for drip irrigation treatments (Table 2).

In the last evaluation of the papaya stem diameters (350 DAP) the average values ranged from 11.61 cm (T1) to 14.88 cm (T6). COELHO FILHO & COELHO (2007) observed this same phonological stage ranging from 10 to 13 cm in 324 DAP for *Sunrise Solo* papaya with different drip irrigation systems, which did not differ from those obtained by ESPINDULA NETO

(2007)who observed greater growth for the irrigation system by micro sprinkler and drip with two lateral lines per row of plants.

TABLE 2. Average values of stem diameter (cm) during the growing season of papaya.

| Treatment | Days After Planting | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 93 | 107 | 135 | 155 | 198 | 211 | 320 | 350 |
| 1 | 3.84 b | 4.66 b | 5.51 ab | 5.80 ab | 7.09 ab | 7.55 ab | 10.32 b | 11.61 b |
| 2 | 5.06 a | 6.09 a | 6.80 a | 7.02 a | 7.99 a | 8.83 a | 11.97 ab | 12.77 ab |
| 3 | 3.8 b | 4.55 b | 5.04 b | 5.54 ab | 7.62 ab | 8.08 ab | 11.50 ab | 13.83 ab |
| 4 | 3.86 b | 4.34 b | 4.66 b | 5.21 b | 6.25 b | 6.80 b | 11.77 ab | 12.77 ab |
| 5 | 3.98 b | 4.34 b | 5.01 b | 5.09 b | 6.88 ab | 7.72 ab | 13.04 a | 14.04 a |
| 6 | 3.56 b | 4.33 b | 4.30 b | 5.43 ab | 7.44 ab | 7.92 ab | 13.57 a | 14.88 a |
| CV (%) | 10.80 | 12.42 | 11.06 | 13.23 | 10.03 | 8.93 | 8.07 | 7.58 |

Values followed by the same letter in the column do not differ significantly by the method of Tukey at 5% probability.

By analyzing the data of leaf area (Table 3), significant effect was found in the treatments which irrigations were necessary and the T2 performed better, resulting higher values between 93 and 155 DAP**.** From this period the leaf area begins to have values close to all treatments since it begins the rainy season and irrigation ceases to be the main source of water supply to the soil. Because of this, from the 272 DAP until 320 DAP it is verified an increase of the leaf area in plants irrigated by drip.

After this period begins the sharp fall of the leaf area of plants in all treatments due to abortion of older leaves, which occurs because the final period of the papaya cycle and in function of natural increase of moisture in the region due to seasonal rainfall patterns.

TABLE 1. Average values of leaf area ($m^2$) during the growing season of papaya.

| Treatment | Days After Planting | | | | | | |
|---|---|---|---|---|---|---|---|
| | 93 | 107 | 135 | 155 | 272 | 320 | 350 |
| 1 | 1.34 b | 1.49 ab | 1.71 ab | 2.09 ab | 4.24 b | 5.72 b | 5.11 b |
| 2 | 2.24 a | 2.47 a | 2.87 a | 2.83 a | 6.31 ab | 7.36 ab | 5.76 b |
| 3 | 1.23 b | 1.56 ab | 1.64 b | 2.28 ab | 5.81 ab | 6.75 ab | 7.79 ab |
| 4 | 1.22 b | 1.38 b | 1.48 b | 1.85 ab | 6.28 ab | 7.48 ab | 6.99 ab |
| 5 | 1.39 b | 1.43 b | 1.42 b | 1.87 ab | 7.70 a | 8.90 a | 8.03 ab |
| 6 | 1.19 b | 1.58 ab | 1.59 b | 1.55 b | 7.87 a | 9.88 a | 9.18 a |
| CV (%) | 20.90 | 26.7 | 28.15 | 26.18 | 20.38 | 17.90 | 19.17 |

Values followed by the same letter do not differ significantly by the method of Tukey at 5% probability.

Plant height (Table 4) was the variable less influenced by irrigation systems. At 107 DAP statistical difference was observed in the mean and papaya plants irrigated by micro sprinkler presented the greater heights especially for T2. At 155 DAP was observed different behavior in which T6 showed the highest average height. During the period after that date, the plants had similar growth, being observed statistical difference only at 350 DAP, varying the height of 2.23 for T1 to 2.60 m for T6.

Similar values were found by COELHO FILHO & COELHO (2007) who compared the average growth of *Sunrise Solo* papaya plants under surface drip irrigation along the row of plants and between rows, drip buried next to the plant row and between rows, beyond micro sprinkler , no significant differences was observed in the treatments studied until 324 days after planting and no differences in plant height from 2.28 to 2.48 m, with higher values for surface drip along the row of plants and micro sprinklers.

Plant height is an important point of phytotechnic view and improvement descriptor, depends on the density of planting and crop management, interfering with the production (BELALCÁZAR CARVAJAL, 1991).

TABLE 2. Medium height of plant (m) during the growing season of papaya.

| Treatment | Day After Planting | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 107 | 135 | 155 | 170 | 184 | 211 | 241 | 320 | 350 |
| 1 | 1.02 a | 1.11 a | 1.04 b | 1.08 a | 1.26 a | 1.37 a | 1.59 a | 1.96 a | 2.23 b |
| 2 | 1.07 a | 1.21 a | 1.17 ab | 1.21 a | 1.32 a | 1.57 a | 1.66 a | 2.28 a | 2.46 ab |
| 3 | 0.97 ab | 0.99 a | 1.17 ab | 1.22 a | 1.32 a | 1.40 a | 1.66 a | 2.44 a | 2.41 ab |
| 4 | 0.92 ab | 1.05 a | 1.12 ab | 1.14 a | 1.26 a | 1.35 a | 1.60 a | 2.07 a | 2.27 ab |
| 5 | 0.87 b | 1.00 a | 1.07 ab | 1.85 a | 1.28 a | 1.44 a | 1.67 a | 2.14 a | 2.35 ab |
| 6 | 0.83 b | 1.00 a | 1.22 a | 1.27 a | 1.35 a | 1.45 a | 1.73 a | 2.23 a | 2.60 a |
| CV (%) | 6.98 | 9.72 | 6.39 | 7.10 | 7.44 | 7.97 | 8.16 | 6.75 | 5.79 |

Values followed by the same letter do not differ significantly by the method of Tukey at 5% probability.

Analyzing output variables (Table 5), it was observed that the yield and the number of fruit per treatment are influenced by irrigation systems. The average yield was 47.31 t $ha^{-1}$ of the orchard with the micro-sprinkler irrigation treatment system with a flow rate of 43 L $h^{-1}$ (T2) afforded a yield of 61.99 t $ha^{-1}$that is an average increase of 16.07% when compared to T3, T4 and T5 and 40.32 and 53.52% when compared to T1 and T6, respectively.

The observed differences reflect development of the biometric variables analyzed above, in which, during almost the entire crop cycle, the values for plant height, stem diameter and leaf area of treatment T2 were higher than other treatments. These results, considering the total productivity coincided with the results of EPINDULA NETO (2007), which, however, found lower production losses to drip with two lateral lines per row of plants. COELHO et al. (2010) found no significant difference in average productivity of papaya *Sunrise Solo* working with different water allocations, obtaining maximum yield of 78.28 t $ha^{-1}$ by applying 1,012 mm of water for an irrigation frequency of 3 days.

TABLE 3. Average yield (t $ha^{-1}$), average fruit weight (kg) and number of fruits $ha^{-1}$ for the reviews treatments.

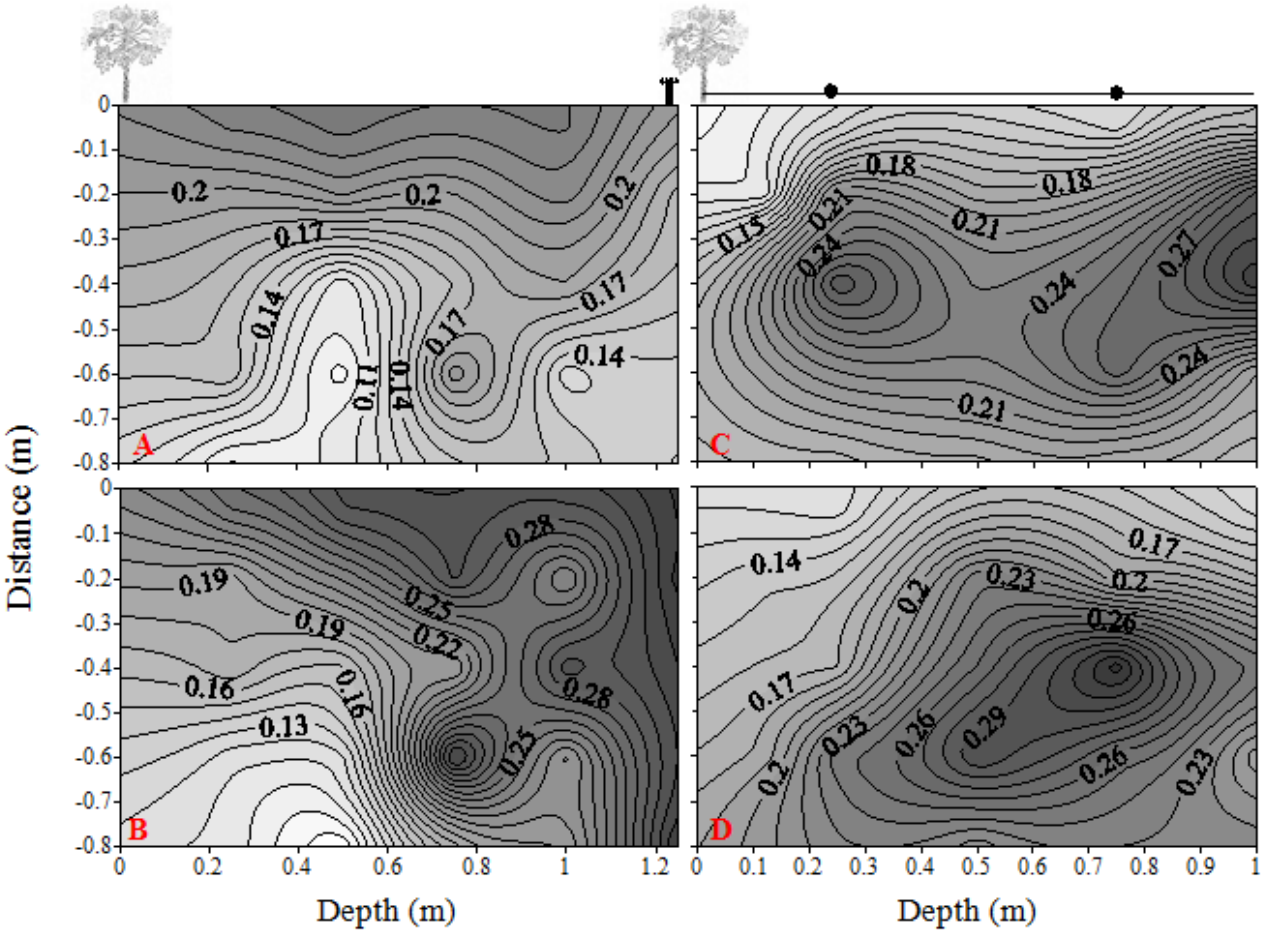
| Treatment | Productivity (t $ha^{-1}$) | Average weight of fruit (kg) | Number of Fruit |
|---|---|---|---|
| 1 | 36.9975 c | 0.5750 a | 65128 cd |
| 2 | 61.9975 a | 0.5575 a | 112612 a |
| 3 | 53.3825 b | 0.6775 a | 79398 bc |
| 4 | 51.2600 b | 0.5725 a | 91423 ab |
| 5 | 51.4400 b | 0.5800 a | 90091 b |
| 6 | 28.8100 d | 0.6400 a | 46326 d |
| Cv (%) | 5.95 | 9.48 | 11.93 |

Values followed by the same letter are not statistically different in the column by the method of Tukey at 5% probability.

The average weight of papaya fruit was not significant, which was caused by the total number of fruit per hectare (Table 5) that varied significantly according to the treatment used. Treatment with the highest number of fruit was the T2. Treatment T3, despite having the second highest productivity obtained only the fourth largest number of fruit, thus indicating that the fruit had higher average weight compared to the other treatments. In general, the treatment for micro sprinkler irrigation with a flow rate 43 L $h^{-1}$ had an increase in number of fruit at the rate of 42, 29, 19, 20 and 59% when compared to treatments irrigated by micro sprinkler of 32 L $h^{-1}$, by micro sprinkler of 60 L $h^{-1}$ for

four drippers in a lateral line, by eight drippers into two lateral lines and four pigtail's drippers, respectively.

The best performance of the irrigation system by micro spray, especially T2, in all variables growth and productivity related to the larger radius of action promoted by micro sprinklers and consequently greater wetted area by this system conditioned better humidity distribution (Figure 2A and B), verifying that the highest values are in the vicinity of the micro sprinklers being near or above field capacity along substantially the whole profile, especially to a depth of 0.40 m. Consequently, due to its greater wetted area, T2 and T3 treatments promote better distribution of water in the soil and increase the wet volume, allowing plant roots explore a greater volume of soil in search of water and nutrients.




FIGUE 2. Moisture distribution in the soil profile six hours after the micro-sprinkler irrigation for 32 h $L^{-1}$ (A), 43 h $L^{-1}$ (B), 4 drip emitters in a lateral line (C) and 8 drip emitters in two lateral lines (D).

The best performance of the treatments T4 and T5 can be explained due to the moisture after irrigation in distances and depths which effectively focuses the root system, even though in smaller amounts than those found for T2, found in general close to the capacity field over the surface and above the field capacity in the layers below 0.2 m deep (Figure 2C and 2D) contributing to the supply of water and nutrients to the plants until subsequent irrigation.

## CONCLUSIONS

The micro sprinkler irrigation with a flow rate of 43 L $h^{-1}$ was the highest averages in most of the cycle for the morphological variables analyzed, as well as productivity.

Irrigated treatments with four drippers per plant in sideline and eight drippers per plant in two lateral lines showed similar results in terms of productivity.

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