



## PRODUCTION AND POST HARVEST OF 'KENT' MANGO UNDER DIFFERENT IRRIGATION SYSTEMS

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### Keywords:

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### ABSTRACT

Facing the fruit market's search for more efficient production systems, this research aimed to identify an arrangement of efficient irrigation systems for the productive and postharvest characteristics of 'Kent' mango fruits, under the conditions of the Brazilian semiárido. The research was performed in an agricultural property in the municipality of Petrolina-PE, with the soil classified in Quartzarenic Neosol. Four irrigation system arrangements were tested: a micro sprinkler below the canopy; a micro sprinkler between plants; two lateral dripper lines per row of plant; and a ring-shaped drip strip around the plant in a randomized block design with five repetitions. The productive characteristics were evaluated, such as number and average weight of fruits and productivity; and qualitative parameters (evaluated by plant quadrant): volume, density, firmness, soluble solids content and titratable acidity. A micro sprinkler between plants provided a greater number of fruits and productivity, as well as greater firmness and titratable acidity for mangoes of the South and West quadrants; these characteristics associated with the lowest soluble solids content of the pulp, at the time of harvest, was also obtained with a micro sprinkler between plants and induce a longer post harvest time to the fruits.

### Palavras-chave:

manejo da irrigação

*Mangifera indica* L.

semiárido

### PRODUÇÃO E PÓS COLHEITA DA MANGUEIRA 'KENT' SOB DIFERENTES SISTEMAS DE IRRIGAÇÃO

#### RESUMO

Diante da busca no mercado frutícola por sistemas de produção mais eficientes, objetivou-se com esta pesquisa identificar uma disposição eficiente dos sistemas de irrigação para as características produtivas e de pós-colheita dos frutos da mangueira 'Kent', nas condições do Semiárido brasileiro. A pesquisa foi realizada numa propriedade agrícola no município de Petrolina-PE, com o solo classificado em Neossolo Quartzarênico. Foram testadas quatro disposições do sistema de irrigação: um microaspersor abaixo da copa; um microaspersor entre plantas; duas linhas laterais de gotejadores por fileira de planta; e uma faixa de gotejo em formato de círculo ao redor da planta, em delineamento com blocos aleatorizados e cinco repetições. Foram avaliadas as características produtivas: número e peso médio de frutos e produtividade; e parâmetros qualitativos do fruto (avaliados por quadrante da planta): volume, densidade, firmeza, teor de sólidos solúveis e acidez titulável. O tratamento com um microaspersor entre plantas proporcionou maior número de frutos e produtividade que os demais, como também maior firmeza e acidez titulável para as mangas dos quadrantes Sul e Oeste da copa; estas características associadas com o menor teor de sólidos solúveis da polpa, no momento da colheita, obtido também no manejo com um microaspersor entre plantas, induz um maior tempo de pós colheita aos frutos.

## INTRODUCTION

Mango production (*Mangifera indica* L.) has represented great economic expression for Brazilian agriculture, with an average productivity of 16.2 tonnes per hectare. The largest production is located in the Northeast, with the states of Bahia and Pernambuco being the largest producers (KIST *et al.*, 2018).

'Kent' mango is cultivated in Brazil to produce between the months of November and December. Despite the characteristic of difficult handling for floral induction, it has been well cultivated due to the lack of fibers and the better taste of its fruits, which places it among the most appreciated fruits in some European countries and in Japan (SILVA *et al.*, 2010). Thus, the 'Kent' mango cultivation provides a good return to producers.

The northeastern semi-arid region has scarce and irregular rainfall, which results in a major limiting factor in agricultural production (SOARES *et al.*, 2013). Thus, the rational use of water is required in order to increase the efficiency of irrigation.

Although the mango tree is considered a drought-tolerant plant, studies have shown that the low water availability in the soil, due to the incorrect irrigation management system, can affect physiological characteristics, the growth of the aerial part and the root system, productivity and fruit quality (PRAKASH *et al.*, 2015).

Under low water availability, plants tend to decrease water loss by partially closing stomata, thus avoiding a reduction in water potential. However, this response negatively affects several physiological processes important for plant growth and development, such as transpiration, stomatal conductance, photosynthesis and sugar synthesis, causing a reduction in productivity (OTTO *et al.*, 2013).

Many factors are considered to choose the irrigation system and management, such as the available technologies and their cost, the type and depth of the soil, the quantity and distribution of rainfall, the fertilization practices and the production objective. In turn, the productive and qualitative response of plants to irrigation depends mainly on the frequency, the method and form of installation, the cultivation stage, the edaphoclimatic conditions

and the type of cultivar (COELHO *et al.*, 2015; LÉCHAUDEL; JOAS, 2007). In the localized irrigation, emitters can be arranged in different positions, and their efficiency will depend on their characteristics, handling, environmental attributes and the culture itself (BOMAN, 2007).

Thus, the objective of this study was to identify an efficient arrangement of the localized irrigation systems for the productive and post-harvest characteristics of the fruits of the 'Kent' mango tree, in the conditions of the Brazilian Semi-Arid.

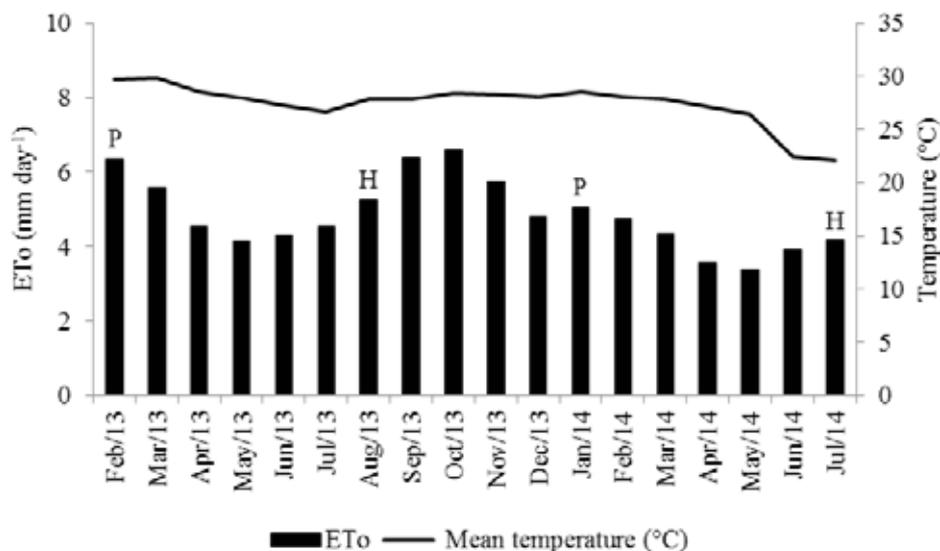
## MATERIAL AND METHODS

The research was performed on the Agravil agricultural property, in the municipality of Petrolina-PE, in the Vale do Submédio São Francisco region, at geographical coordinates 09° 24 'S and 40° 20' O and an average altitude of 370 m. According to the Köppen classification, the climate of the region is of the BSh' type, very hot dry steppe (MEDEIROS *et al.*, 2013), which can be observed in Figure 1 with the climatic data. The soil of the experimental area was classified as Quartzarenic Neosol (EMBRAPA, 2013).

The experimentation took place over two productive cycles, in a 'Kent' mango orchard, with 8 x 5 m spacing, with 9 years of age. The productive management of pruning, fertilization, plant health and floral induction was performed as described by Mouco (2015).

The experiment was conducted in a randomized block design, in subdivided plots, with the plots being four irrigation system arrangements, and the subplots two cultivation cycles, with five blocks, totaling 20 experimental plots. Each plot consisted of 4 plants, being the two central plants useful. The tested treatments were: a drip line in a circle shape (DLC) around the plant; two drip lines per plant line (2DP); a micro sprinkler below the canopy (MSC), located 0.3 m from the plant's trunk; and a micro sprinkler between plants (MBP). All treatments provided a flow of 56 L h<sup>-1</sup> plant<sup>-1</sup>. The 2DP and DLC treatments had 14 drippers with a spacing of 0.5 m and generated wet strips of 0.55 m in width. The wet radius of the micro sprinklers from MSC and MBP treatments was 2.3 m.

Irrigation management was performed using



**Figure 1.** Reference evapotranspiration (ETo) and mean monthly temperatures, from a Weather station close to Agranvil farm, Petrolina-PE. 2012/2013 and 2013/2014 vintages. P: pruning; H: harvest

reference evapotranspiration (ETo) data calculated using the Penman-Monteith method equation. Data were collected daily by a meteorological station installed close to the experimental area. The cultivation coefficients (Kc) used to calculate crop evapotranspiration (ETc) were those proposed by Teixeira *et al.* (2008), as described in Table 1.

**Table 1.** Culture coefficients (Kc) recommended in different phenological phases for the cultivation of mango trees in Petrolina-PE (Teixeira *et al.*, 2008)

Phenological phase	Kc
Rest	0.7
Vegetative growth	0.8
Branch maturation	1.0
Beginning of flowering	1.0
Fruit growth	0.9
Fruit maturation	0.8
Harvest	0.6

At the end of each production cycle, all fruits were harvested at the initial stage of maturation (E2), in two useful plants from each plot, being counted and weighed. The E2 maturation stage is adopted as a standard for export, characterized by a light green color of the peel, which corresponds, in the pulp, to yellowing limited to the surrounding of the seed (BRECHT; YAHIA, 2017).

Thus, the number of fruits, average fruit weight and productivity were determined. For post-harvest, three fruits were harvested in each of the different quadrants of the plants (North, South, East and West), in rows arranged in the North-South direction, constituting an arrangement in subdivided plots. The arrangements of the irrigation were the plots, the quadrants the subplots and the productive cycles the subsubplots. The post-harvest analyzes of fruits were performed in the post-harvest physiology laboratory of Embrapa Semiárido.

The fruits were analyzed for pulp firmness, determined using a manual penetrometer (Effegi, model FT 327). The measurements were taken after the peel was removed, at two opposite points, in the equatorial region of the fruits. The pulp of the fruit was homogenized in a domestic juice processor, after peeling it, for analysis of the content of total soluble solids (SST) and of the titratable acidity (ATT). The SST was determined using a manual refractometer (Pocket pal-1 model). ATT was determined by titrating 1 g of homogenized pulp and diluted in 50 mL of distilled water, in which three drops of the 1% phenolphthalein indicator were added, proceeding to titration using a digital burette, under constant agitation, with 0.1N NaOH solution. The results were expressed in grams of citric acid per 100 g of pulp.

During the conduction of the experiment in both

cycles, data regarding the production and post-harvest of the fruits were obtained, being evaluated as plots subdivided over time.

The data were submitted to analysis of variance ( $P < 0.05$ ) and the means, when significant, were compared using the Tukey test at 5% probability.

## RESULTS AND DISCUSSION

The data referring to the number of fruits per plant, average fruit weight and productivity are shown in Table 2. There was an interaction between the different provisions of irrigation systems and the two production cycles for these variables. No difference was observed in relation to the different quadrants where the fruits were located.

The disposition of the irrigation systems that provided the largest number of fruits per plant was the MBP, in the two productive cycles. The MBP treatment was statistically similar to the 2DP treatment in the first cycle and similar to the MSC treatment in the second cycle. Kent mango is a vigorous cultivar, presenting difficult flowering management (SILVA *et al.*, 2010). Thus, considering that the MBP treatment had an emitter located between the plants, in a little shaded area, the exposure of the wet bulb to the sun was greater (on average 7.16 m<sup>2</sup> between plants), increasing evaporation and reducing water availability for plants. This exposure may have contributed to the break in the vigor of the plants, favoring flowering, as described by Sandip *et al.* (2015) and consequently providing the highest number of fruits per plant. The 2DP treatment also had part of the wet strip exposed to the sun (on

average 2.38 m<sup>2</sup> between plants). The temperature and evapotranspiration were higher in the first cycle than in the second cycle, accentuating the degree of water stress in the plants, which possibly contributed to greater flowering and consequent greater number of fruits and productivity in this treatment.

In addition to the aforementioned factors, what confirms the difference in the number of fruits between the cycles is the alternation of production, a characteristic present in the mango culture (OLIVEIRA *et al.*, 2015). Thus, the MSC treatment also provided a greater number of fruits in the second cycle, in contrast to the first cycle of low fruit production.

The highest average fruit weight was obtained in the second production cycle, for all irrigation system provisions, except for MSC. This result was possibly due to the lower number of fruits per plant, resulting in fewer drains for the photosynthetic production of the plants. Another factor that may have contributed to this difference between cycles is the alternation of production, a characteristic present in the mango culture (DAVENPORT, 2007). As a result of the greater number of fruits, without reducing their average weight, the MBP treatment also provided the highest productivity in the two production cycles, being statistically equal to the 2DP in the first cycle.

The treatments that provided the highest fruit production (MBP and 2DP) were those that had part of the wet soil strip exposed to the sun, with greater losses by evaporation and less efficiency in water application. According to the Teixeira *et al.* (2008), the results show that possibly the Kc's used

**Table 2.** Number of fruits per plant, average fruit weight and productivity of the 'Kent' mango tree, in two cultivation cycles, in plants subjected to different provisions of the irrigation systems

Treatment	Fruits per plant		Average weight (kg)		Productivity (t ha <sup>-1</sup> )	
	1° cycle	2° cycle	1° cycle	2° cycle	1° cycle	2° cycle
DLC	66.83 aB	57.42 aB	0.578 bA	0.693 aAB	7.636 aB	8.13 aB
2DP	103.73 aA	59.47 bB	0.594 bA	0.706 aAB	12.138 aA	9.019 bB
MSC	58.62 aB	66.96 aAB	0.629 aA	0.673 aB	7.342 aB	9.21 aB
MBP	105.90 aA	76.50 bA	0.596 bA	0.729 aA	12.616 aA	11.17 aA
CV (%)	22.57	15.30	6.22	4.15	19.41	14.65

DLC: a drip line in a circle shape around the plant; 2DP: two drip lines per plant line; MSC: a micro sprinkler below the canopy; MBP: a micro sprinkler between plants. Different lowercase letters indicate difference between cycles. Different capital letters indicate a difference between the arrangements of irrigation systems.

were overestimated for this cultivar, mainly during the floral induction phase, as previously described, which suggests the need for research on the water demand of the mango Kent, in the conditions of the region.

The data regarding the volume, density and titratable acidity of fruits are shown in Table 3. It was observed that there was an interaction between the different provisions in the irrigation system and the different quadrants where the fruits were located for these variables.

The lowest volume of fruits was obtained with the MBP treatment in the south quadrant, which can be justified by the fact that it was the treatment with the highest density of fruits, thus having a greater ratio between fruits per leaf area. Due to the arrangement of the rows, the fruits located in the south quadrant received direct solar radiation throughout the day, which may have contributed to the stomatal closure of the leaves of these branches. According to Vasconcelos *et al.* (2010), the canopy quadrant most exposed to the sun has its water potential reduced. Insufficient water supply induces stomatal closure of the plant, thus preventing the reduction of water potential. However, this response negatively affects several physiological processes such as sweating and photosynthesis,

causing reduced productivity (OTTO, 2013).

The highest titratable acidity was observed in fruits harvested in the South and West quadrants for the MSC (Table 4). In view of the geographic location and the time of year, these were the quadrants with the greatest exposure to sunlight. The greater solar incidence in the western quadrant results in a higher production of hexoses in the fruit (ROSALES *et al.*, 2009). These monosaccharides can favor the antioxidant defense mechanisms by providing precursors of antioxidant compounds, such as acid ascorbic and carotenoids (COUÉ *et al.*, 2006).

The fruits of the plants submitted to the MBP treatment showed greater firmness in the first productive cycle, not differing statistically from the DLC treatment (Table 4). This greater firmness observed for the MBP treatment corroborates with Sams (1999), who states that smaller fruits, in general, present greater firmness of the pulp because they have a higher percentage of their volume occupied with cell wall materials. This characteristic provides to the fruits greater density and resistance to penetration of the penetrometer plunger. No difference was observed between treatments in the second cycle.

**Table 3.** Volume, density and titratable acidity of fruits of the 'Kent' mango tree, in two cultivation cycles, in plants submitted to different provisions of the irrigation systems

Variable	Treatment	Quadrant			
		North	South	East	West
Volume	2DP	634.66 aA	657.16 aAB	652.33 aA	675.00 aA
	DLC	615.66 aA	599.83 aBC	660.00 aA	631.33 aA
	MBP	556.16 aA	569.00 aC	620.83 aA	607.83 aA
	MSC	595.10 aA	685.42 aA	606.33 aA	595.96 aA
CV (%)		12.32	13.47	12.68	15.04
Density	2DP	1.009 aB	1.014 aB	1.023 aA	1.023 aA
	DLC	1.055 aAB	1.021 aB	1.014 aA	1.053 aA
	MBP	1.105 aA	1.11 aA	1.051 abA	1.025 bA
	MSC	1.046 aAB	1.008 aB	1.061 aA	1.045 aA
CV (%)		4.55	5.02	4.91	3.22
Titratable acidity	2DP	0.705 aA	0.774 aA	0.725 aA	0.712 aB
	DLC	0.789 aA	0.755 aA	0.696 aA	0.689 aB
	MBP	0.696 aA	0.741 aA	0.652 aA	0.645 aB
	MSC	0.682 bA	0.833 aA	0.713 bA	0.896 aA
CV (%)		11.43	9.81	12.55	14.84

DLC: a drip line in a circle shape around the plant; 2DP: two drip lines per plant line; MSC: a micro sprinkler below the canopy; MBP: a micro sprinkler between plants. Different lowercase letters indicate difference between cycles. Different capital letters indicate a difference between the irrigation provisions.

**Table 4.** Firmness, volume, soluble solids (SS) and titratable acidity of ‘Kent’ mango fruits, in two cultivation cycles, in plants submitted to different irrigation systems

Treatment	Firmness		Volume		SS		Titratable acidity	
	1° cycle	2° cycle	1° cycle	2° cycle	1° cycle	2° cycle	1° cycle	2° cycle
DLC	97.93 aB	95.75 aA	664.5 aA	645.5 aA	6.80 bC	8.51 aAB	0.685 bB	0.773 aA
2DP	104.97 aAB	93.62 bA	637.2 aA	616.2 aA	7.07 bBC	8.92 aA	0.683 bB	0.781 aA
MSC	113.68 aA	90.44 bA	545.9 bB	631.0 aA	8.29 aA	7.91 aB	0.615 bB	0.751 aA
MBP	99.82 aB	89.38 bA	603.6 aAB	653.9 aA	7.84 aAB	7.97 aB	0.826 aA	0.736 bA
CV (%)	16.40	11.35	13.24	14.45	7.45	9.77	9.15	6.76

DLC: a drip line in a circle shape around the plant; 2DP: two drip lines per plant line; MSC: a micro sprinkler below the canopy; MBP: a micro sprinkler between plants. Different lowercase letters indicate difference between cycles. Different capital letters indicate a difference between the irrigation provisions.

The highest TSS content was obtained by the MBP treatment in the first cycle, which did not differ statistically from the MSC treatment and by the DLC in the second cycle, which did not differ statistically from the 2DP treatment. The number of fruits was a determining factor for the SST content, as it directly influences the source-drain relationship. In the second cycle, the lower number of fruits in the DLC and 2DP treatments contributed to the increase in the concentration of solutes, considering the smaller number of drains for the production of photoassimilates such as sugars and organic acids, as was observed in the ‘Palmer’ mango tree (OLIVEIRA *et al.*, 2019; SIMÕES *et al.*, 2020), melon (DALASTRA *et al.*, 2016) and watermelon (LINS *et al.*, 2013). In the first cycle, possibly, the higher temperature and the exposure of the wet bulb of the MBP treatment to the sun caused a water deficit in the maturation phase, and consequently an increase in the concentration of soluble solids, as was also observed by Andrade *et al.* (2019) in the ‘Kent’ mango tree and by Reis *et al.* (2013) in the ‘Haden’ mango.

The lowest titratable acidity (Table 4) was observed in the fruits harvested in the first cycle, which had a higher temperature during the maturation period, except for the MSC treatment. According to Chitarra and Chitarra (2005), the increase in temperature increases the respiration rate of the fruits, causing the consumption of organic acids. In the MSC treatment, the smaller number of fruits in the first cycle was possibly a more prevalent factor than the climate for the accumulation of organic acids, due to the greater source-drain ratio.

## CONCLUSION

- The use of micro sprinkler between plants is an efficient form of cultivation for ‘Kent’ mango tree irrigated in the Brazilian semiarid region, providing a greater number of fruits and productivity;
- The greater firmness and titratable acidity, associated with the lower content of soluble solids in the fruits at the time of harvest, characteristics that induce longer shelf life in mangoes, are obtained with the handling of a micro sprinkler between plants.

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