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Bell pepper cultivation under different irrigation strategies in soil with and without mulching

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ABSTRACT

This study aimed to evaluate productive, physiological and phytotechnical characteristics of bell pepper under different irrigation strategies, in soil with mulch (polyethylene film, black on bottom, white on top) and without mulching. The experimental design was of randomized blocks with four replicates, arranged in split plot scheme; plots consisted of treatments with and without mulching, and in the subplots ten irrigation strategies = 1) 125% of crop evapotranspiration (ETc); 2) 100% of ETc; 3) 75% of ETc; 4) 50% of ETc, both in vegetative phase (FI) and production phase (FII); 5) regulated deficit irrigation (RDI); with 50% of ETc in FI and 100% of ETc in FII; 6) RDI with 100% of ETc in FI and 50% of ETc in FII; 7) RDI with 75% of ETc in FI and 100% of ETc in FII; 8) RDI with 100% of ETc in FI and 75% of ETc in FII; 9) RDI with 125% of ETc in FI and 75% of ETc in FII; 10) RDI with 75% of ETc in FI and 125% of ETc in FII. Two phytotechnical and one physiological evaluations were done during the phases of development and production. Moreover, we determined productivity and water-use efficiency 90 days after seedling transplanting. Plants maintained quantum efficiency and chlorophyll *a* content close to the ideal. Mulching provided higher number of fruits in comparison to plants grown in bare soil. Diameter, mass and length of the fruits as well as peel thickness were higher at the first two harvests. Irrigation at 50% of ETc in mulched soil provided higher productivity using less water, increasing water-use efficiency.

Keywords: *Capsicum annuum*, water deficit, mulching, water-use efficiency.

RESUMO

Cultivo do pimentão sob diferentes estratégias de irrigação em solo com e sem cobertura

Objetivou-se avaliar o uso de diferentes estratégias de irrigação nas características produtivas, fisiológicas e fitotécnicas de plantas de pimentão, em solo com e sem cobertura (filme de polietileno, preto na parte inferior e branco na parte superior). O experimento foi conduzido em blocos casualizados, com quatro repetições, em esquema de parcelas subdivididas. Nas parcelas os tratamentos foram cobertura do solo e nas subparcelas dez estratégias de irrigação = 1) 125% da evapotranspiração da cultura (ETc); 2) 100% da ETc; 3) 75% da ETc; 4) 50% da ETc, tanto na fase vegetativa (FI) e de produção (FII); 5) irrigação com déficit controlado (RDI) com 50% da ETc na FI e 100% da ETc na FII; 6) RDI com 100% da ETc na FI e 50% da ETc na FII; 7) RDI 75% da ETc na FI e 100% da ETc na FII; 8) RDI 100% da ETc na FI e 75% da ETc na FII; 9) RDI 125% da ETc na FI e 75% da ETc na FII; 10) RDI 75% da ETc na FI e 125% da ETc na FII. Foram realizadas duas avaliações fitotécnicas e uma fisiológica durante as fases de desenvolvimento e produção da cultura. Além disso, determinou-se produtividade e eficiência do uso da água após 90 dias das mudas transplantadas. Verificou-se que as plantas mantiveram a eficiência quântica e os valores de clorofila *a* próximos ao ideal. O uso do *mulching* proporciona maior quantidade de frutos, comparado ao solo descoberto. O diâmetro, massa e comprimento dos frutos e a espessura da casca foram maiores nas duas primeiras colheitas. Por fim, a irrigação com 50% da ETc em solo com *mulching*, proporcionou maior produtividade com a utilização de menos água, ou seja, com maior eficiência de uso da água.

Palavras-chave: *Capsicum annuum*, irrigação com déficit, cobertura do solo, eficiência do uso da água.

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Bell pepper is a vegetable of great economic importance in Brazil. This vegetable has been grown and consumed throughout the country; the planting area is estimated on 19 thousand hectares and production over 420 thousand tons (FAO, 2017). The crop shows good adaptation to Semiarid conditions. States such as Pernambuco, Paraíba, Ceará and Bahia are considered the main producers in the Northeast region of the Country (Nascimento, 2014).

Bahia has vegetable crops in Chapada Diamantina, Irecê, Vitória da Conquista, Juazeiro and Jaguaquara. In Vitória da Conquista, bell pepper is grown in urban and periurban areas, with planting areas in the municipalities of Barra do Choça and Poções. In these locations, bell pepper is produced in open field during dry season or in plastic-covered greenhouses, where the irrigation is an essential practice in order to supply the water demand of the plants.

In this context, further studies on availability and use of water in the Northeast Region of Brazil, especially in semiarid region, considering irrigation water use efficiency, are still necessary.

The use of deficit irrigation strategies has contributed to maintain productivity and increase water use efficiency. Among these strategies, partial rootzone drying (PRD) and regulated deficit irrigation (RDI) stand out (Santos *et al*, 2014, Chai *et al*., 2016; Santos & Brito, 2016), being used to control water use during irrigation in important development phases of the crop, favoring the reduction of the water applied to crop and to maintain productivity.

RDI consists of applying deficit irrigation during phases of plant development which the growing and quality of fruit show low sensitivity, being possible to reduce water and energy consumption without losing fruit quality and harming the plant (Santos *et al*., 2014; Chai *et al*., 2016).

Besides these irrigation strategies which aim to increase water use efficiency, the use of plastic mulching on bell pepper crops have been adopted by producers worldwide due to higher soil water conservation, resulting in lower soil moisture variability on the superficial soil layer, with higher root concentration and less irrigation need (Marouelli, 2016).

The combination of factors such as irrigation strategies and mulching may result in significant increases in production system and this fact is relevantly important in Semiarid Region, where availability of water resources is limited. Thus, the aim of this study was to evaluate various irrigation strategies on bell pepper productivity and physiological growth characteristics and fruit quality of plants cultivated with and without mulching.

MATERIAL AND METHODS

The experiment was carried out in an experimental area in Estiva, municipality of Vitória da Conquista, Southwest of Bahia State (14º52'06"S, 40º44'55"W, 917 m altitude), from March to December, 2016. The local climate was classified as Cwa, according to Köppen. Annual average temperature of 20.2ºC and 733.9 mm average annual rainfall, registering the rainy season, from November to January. In the experimental period, a rainfall accumulation of 87 mm, average maximum and minimum temperatures of 27.4 and 16.3°C, respectively, and average relative humidity of 74% (Figure 1A) were verified.

The experiment was conducted in randomized blocks, with four replicates, in a split plot scheme, consisting of two treatments in the plots, with and without mulching, and ten treatments in the split plots, consisting of water depths and regulated deficit irrigation (RDI) in vegetative (FI) and production phase (FII) = 1) 125% of crop evapotranspiration (ETc); 2), 100% of ETc; 3) 75% of ETc; 4) 50% of ETc, both in vegetative (FI) and production phase (FII); 5) regulated deficit irrigation (RDI) with 50% of ETc in FI and 100% of ETc in FII; 6) RDI with 100% of ETc in FI and 50% of ETc in FII; 7) RDI 75% of ETc in FI and 100% of ETc in FII; 8) RDI 100% of ETc in FI and 75% of ETc in FII; 9) RDI 125% of ETc in FI and 75% of ETc in FII; 10) RDI 75% of ETc in FI and 125% of ETc in FII. Accumulated irrigation in vegetative and production phase are shown in Figure 1B.

The experimental unit consisted of four rows with seven plants, in which the useful plants were the ones in the center rows and the five center plants, totalizing ten useful plants in the split plot, considering that each plot consisted of ten split plots. For vegetative and productive characteristics, the seasons of evaluation were considered, in which the authors used plots subdivided in time, 30, 60, 90 and 120 days after planting (DAP) at the subsplit plots.

The planting of Mayara hybrid bell pepper seedlings (Hortec; Bragança Paulista-SP) was performed on May 11, 2016. This cultivar shows a cone-shaped fruit (conic group), green color, 275 g average weight, 120-day cycle and meet supermarket demand since it presents big and heavier fruits, besides being the most cultivated by the producers from the Region of Planalto da Conquista, in Bahia.

The crop was installed in simple rows at 0.40 m spacing between plants and 1.0 m between rows with a population of 25,000 plants ha^{-1}. The rows were arranged in seedbeds, 0.15 m high and 0.50 m wide. In the plots with mulching, the seedbeds were covered with polyethylene film (black on bottom, white on top), 1.6 m wide and 50 microns thick.

During the experiment, cultural and phytosanitary practices were carried out according to the recommendations for the crop: control of invasive plants; elimination of the first flower/fruit on the first fork of the plant, woody stakes to support the plant, in a mattress system, using plastic ribbons placed horizontally, spaced 20 cm in the cultivation line direction; and sprout thinning, removing the excess of shoots and branches. In the crop phenological cycle, the authors verified low incidence of pests and diseases.

Soil chemical and physical characteristics, 0-0.2 m deep, before the installation of the experiment were: pH (H_2O)= 5.1; P= 145 mg dm^{-3}, K= 0.49 cmolc dm^{-3}, Ca= 3.00 cmolc dm^{-3}; Mg= 0.74 cmolc dm^{-3}, Al= 0.30 cmolc dm^{-3}, Na= 0.06 cmolc dm^{-3}, H+Al= 7.26 cmolc dm^{-3}, SB= 4.28 cmolc dm^{-3}, CTC= 11.54 cmolc dm^{-3}, V= 37%, M.O.= 37 g kg^{-1}, Cu= 1.27 mg dm^{-3}, Fe= 98.91 mg dm^{-3}, Zn= 4.22 mg dm^{-3}, Mn= 6.51 mg dm^{-3} and sandy clay loam texture. Soil correction and top-dressing fertilizations via fertigation were done according to the analysis result.

Fertilization via fertigation was done every 15 days, according to each crop stage. To perform fertigation, the authors used a reservoir in which fertilizer was diluted in water and then injected into submain lines. The experimental area was managed using soil conservation practices, with history of previous land-use: pasture, black mucuna, corn, cucumber and bell peppers.

A dripping irrigation system was used, with self-compensating drippers "online", nominal flow rate of 2.39 L h^{-1}, operating pressure of 0.8 to 3.0 bar. Spacing among drippers was 0.50 m along the lateral rows, spaced 1.0 m, placed near the plants, forming a continuous wet track. Before seedling planting and during the experiment, the authors determined average flow, Christiansen Uniformity Coefficient (CUC), Distribution Uniformity

Coefficient (DUC), Statistical Uniformity Coefficient (SUC) and Application Efficiency (AE) (Keller & Karmeli, 1975) in order to calculate irrigation time.

Every day, on the first 15 days, all plots were irrigated equally, in order to uniform the soil water content and favor seedling initial growing and crop establishment. After the 15th day of the seedling transplant, the authors began to apply different irrigation water depths, calculating irrigation time using crop evapotranspiration (ETc) based on reference evapotranspiration (ETo) and crop coefficient (Kc) (Allen *et al*., 1998), using data obtained at the weather station Nexus (14º52'S, 40º56'W), 200 m away from the experimental unit. Throughout the cycle, three values for the crop coefficient (Kc) were used, considering 0.4 in the initial phase, 0.8 in the development phase and 1.0 in the production phase (Marouelli, 2016).

For irrigation management, irrigation time was calculated daily (Santos & Brito, 2016). Due to rain, the quantity of irrigation water was subtracted from the ETc to obtain the irrigation time and when the quantity of rainwater was larger than ETc, the irrigation was suspended and restarted when actual soil water storage was exhausted.

In one extreme of the submainlines, the authors installed a fixed manometer Bourdon type with a reading range from 0 to 10 bar, so that the pressure established of 1.2 bar on the research was maintained constant during the daily irrigation management, as well as during uniformity test.

After 90 days of seedling transplanting, three harvests were performed [90, 120 and 150 days after transplanting (DAT)] to evaluate productivity and quality of fruits. The harvested fruits from the plants of the useful area were weighed using a digital scale. Three fruits were randomly obtained for measuring length, diameter and pulp thickness, using a caliper. In order to quantify productivity, the authors obtained fruit production of the sum of harvests of the useful area.

Water use efficiency was calculated for all treatments and the authors considered productivity and water depth applied to the treatment, according to Silva *et al*. (2009) and Santos *et al*. (2014; 2015) (Equation 1).

$$WUE = Pr/WDA \qquad (1)$$

in which WUE= water use efficiency (kg ha^{-1} mm^{-1}); Pr= productivity (kg ha^{-1}); WDA= water depth applied during the crop cycle (mm).

During the crop cycle, vegetative characteristics were evaluated: plant height, quantity of leaves and fruits, in two seasons of each crop stage, in vegetative and production phase. Ten plants of the useful area were evaluated, measuring height (using a measuring tape adapted to a board), quantity of leaves (through counting total leaves) and quantity of fruits (counting total fruits of the plants).

Physiological characteristics such as chlorophyll index *a* and *b* and chlorophyll fluorescence were determined in two readings: one reading in vegetative phase and one reading in the production phase, in July and September, 2016, respectively.

To evaluate chlorophyll index *a* and *b*, the authors always used the middle third of the plant, using a chlorophyll meter (CLOROFILOG model CFL 1030; Falker Automação Agrícola, Porto Alegre-RS).

Chlorophyll fluorescence readings were taken using a modulation fluorometer (model OS1-FL; OPTI-Sciences, Hudson, NH) in the morning, from three plants of the useful plot. Tweezers for measuring chlorophyll *a* fluorescence were placed in the middle third of the plant and the measurement was done after five minutes of dark adaptation, with emission of saturating light pulse of 0.3 s, under frequency of 0.6 KHz, when the photochemical efficiency (Fv/Fm) was determined. During measurements, tweezers were used to adapt chloroplasts to the dark, so that all reaction centers of photosystem II (PSII) acquired the condition of "open" and the heat loss was minimal (Strauss *et al*., 2006).

Plant growing, Fv/Fm, chlorophyll index, production and WUE data were submitted to variance analysis and afterwards the authors verified interactions between the factors for the variables submitted to more than one factor, according to their significance. The averages were compared by F, Tukey ($p<0.05$) tests for mulching and grouped by the Scott-Knott grouping test ($p<0.05$) for irrigation strategies (physiological and productive characteristics). To evaluate quantitative factors, the authors used regression analysis.

RESULTS AND DISCUSSION

For productivity and water use efficiency, the effects were significant in the interaction between irrigation strategies and treatments with and without mulching. Bell pepper production accumulated in three harvests ranged from 24 to 42.15 t ha^{-1} in mulched plot and from 17.72 to 24.58 t ha^{-1} in nonmulched plot (Table 1). This average productivity is consistent with the national average value of 22.3 t ha^{-1} (Goto *et al*., 2016).

In relation to soil cover factor, the authors verified that in 50% of ETc treatments and in all RDI treatments, mulching provided higher productivities, when comparing with treatments without mulching. These results are consistent with the comparison with bell pepper cultivation with and without mulching (Rasal *et al*., 2017; Paul *et al*., 2013). These obtained results are also related to the beneficial effects of mulching which result in a better weed control, lesser amounts of nutrient leached from the soil, favorable soil temperature, an increase in microorganism activities and improvement in physiological activities, as well as the results observed for Fv/Fm.

In mulching treatments, irrigation strategies with application of water depths of 50% and 75% of ETc and RDI conditions provided higher productivities, whereas water depths of 125 and 100% of ETc showed lower productivities. In the treatments without mulching, the authors verified no differences in relation to productivities.

Bell pepper plants prioritize biomass accumulation in the shoot area to detriment of the root system,

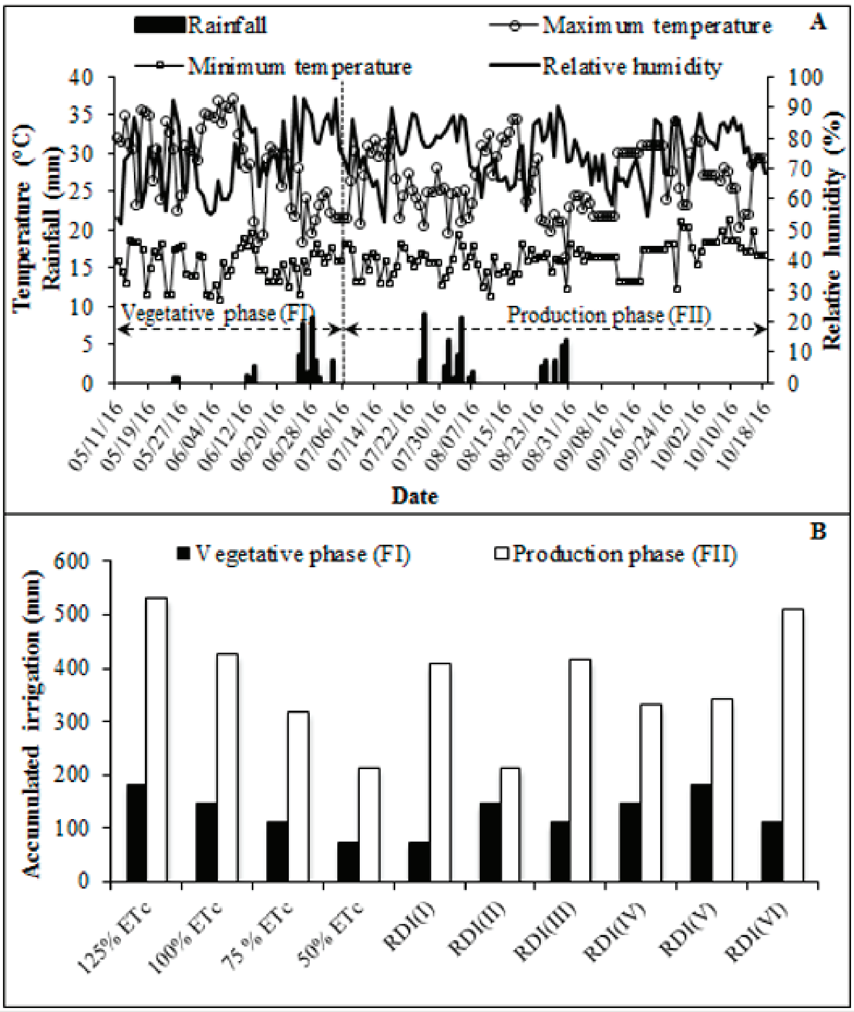

Figure 1. Temperature (maximum and minimum), relative humidity and rainfall (A) and accumulated irrigation (B) during the experiment. Regulated deficit irrigation (RDI) (I) – 50% ETc in vegetative phase (FI) and 100% ETc in production phase (FII); RDI (II)- 100% ETc in FI and 50% ETc in FII; RDI (III)-75% ETc in FI and 100% ETc in FII; RDI (IV)- 100% ETc in FI and 75% ETc in FII; RDI (V)- 125% ETc in FI and 75% ETc in FII; RDI(VI)- 75% ETc in FI and 125% ETc in FII. FI: 0-60 days after transplanting; FII: 61-170 days after transplanting. Vitória da Conquista, IF Baiano, 2016.

so considering this aspect in relation to irrigation management, due to small soil volume exploited by the roots (Oliveira *et al*., 2015). In this sense, water depths of 125% and 100% of ETc under mulching condition provided excess of water for the crop and, probably, leached essential nutrients out of the reach of plant roots (Aragão *et al*., 2013; Rasal *et al*., 2017) reducing productivities. Besides these factors, excess of irrigation water in bell pepper cultivation provides the development of anaerobic conditions which reduce the efficiency of the rhizosphere in the absorption of water and nutrients (Rasal *et al*., 2017).

The results found in this study suggest that for bell pepper irrigation under mulching conditions, water depths of 50% of ETc and RDI (II) should be applied in order to obtain high productivities and greater water savings. This fact is reported in other studies on dripping irrigation system under mulching conditions, showing that greater bell pepper yields were obtained under water supply of 60% ETc (Paul *et al*., 2013; Rasal *et al*., 2017).

Using mulching, treatment 50% ETc provided the best water use efficiency (WUE) followed by RDI (II) which presented the second best value. In the plots without mulching no differences were noticed among irrigation strategies (Table 1).

The increase of water use efficiency is obtained keeping productivity and lower use of water (Santos *et al*., 2016), which explains the results in this study, since treatment with 50% ETc is among the most productive treatments using the lowest quantity of water during the bell pepper crop cycle (282.93 mm) (Figure 1B). The authors verified that treatment 50% of ETc showed satisfactory results, both in water savings and in maximizing productivity.

Comparing soil cover factor, the authors verified that in 50% of ETc treatments and RDI treatments (II, III and V), the use of mulching provided the highest WUE in comparison to the treatments without mulching. This tendency is also verified in other studies and shows that irrigation water was well distributed without causing damage to bell pepper roots (Paul *et al*., 2013), and also promoted lower soil water evaporation and consequently improve use efficiency.

The quantity of bell pepper fruits was always higher in the presence of mulching (Table 2), which can be related to the advantages of this soil cover, such as lower water evaporation, higher efficiency in nutrient use and lower root stress (Rodrigues & Goto, 2016). Moreover, higher quantity of leaves in the presence of mulching (Figure 2B), possibly promoted higher light uptake and, consequently, higher photoassimilate production which was reversed in a greater amount of fruits (Araújo *et al*., 2009).

Mass, diameter and length of fruits as well as the bell pepper peel thickness in relation to different harvest seasons (90, 120 and 150 DAT) presented higher average values in the first and second harvests, differing from the third harvest (Table 3). This analysis of fruit quality per harvest is important, since these are determinant characteristics for classification and commercialization of bell pepper and, since Brazilian market appreciates big fruits (Santos *et al*., 2017). Therewith, the producer can manage the supply of bell pepper available to the market and that way it is possible to obtain better prices considering the characteristics of harvested fruits.

In the three harvests performed in this study, fruits were classified into class 12 (12 to 15 cm in length) and subclass 6 (6 to 8 cm in diameter) (Carvalho Filho *et al*., 2016). Overall, several bell pepper hybrids show medium to big fruits, ranging from 12 to 16 cm (Blat *et al*., 2007). Therefore, the classification done in this study is consistent with the average productive characteristics of the crop.

Table 1. Productivity and water use efficiency (WUE), Mayara hybrid bell pepper grown under different irrigation strategies, with and without mulching. Vitória da Conquista, IF Baiano, 2016.

Water depths	Productivity (t ha^{-1})		WUE (kg ha^{-1} mm^{-1})	
	With mulching	Without mulching	With mulching	Without mulching
125% ETc	27.72 Ba	20.70 Aa	42.92 Ca	29.26 Aa
100% ETc	24.00 Ba	19.87 Aa	54.94 Ca	35.13 Aa
75% ETc	33.01 Aa	27.18 Aa	77.78 Ca	55.70 Aa
50% ETc	42.15 Aa	17.72 Ab	148.99 Aa	62.65 Ab
RDI (I)	33.55 Aa	24.58 Ab	70.35 Ca	51.54 Aa
RDI (II)	36.61 Aa	24.88 Ab	103.23 Ba	70.14 Ab
RDI (III)	34.39 Aa	18.88 Ab	66.13 Ca	33.12 Ab
RDI (IV)	33.67 Aa	23.76 Ab	71.44 Ca	50.40 Aa
RDI (V)	35.18 Aa	20.82 Ab	68.01 Ca	40.24 Ab
RDI (VI)	37.93 Aa	20.11 Ab	54.43 Ca	37.10 Aa

Averages followed by same uppercase letters, in columns, for irrigation strategies, belong to the same group by Scott-Knott criteria and, averages followed by the same lowercase letters in lines, for soil cover, did not differ significantly by F test, at 5% probability. Regulated deficit irrigation (RDI) (I) - 50% ETc in vegetative phase (FI) and 100% ETc in production phase (FII); RDI (II)- 100% ETc in FI and 50% ETc in FII; RDI (III)-75% ETc FI and 100% ETc in FII; RDI (IV)- 100% ETc in FI and 75% ETc in FII; RDI (V) - 125% ETc in FI and 75% ETc in FII; RDI (VI) - 75% ETc in FI and 125% ETc in FII. FI: 0-6 days after transplanting; FII: 61-170 days after transplanting.

Table 2. Quantity of Mayara hybrid bell pepper fruits in different harvest seasons. Vitória da Conquista, IF Baiano, 2016.

Season	Number of fruits	
	With mulching	Without mulching
Development	4.57 Ac	3.5 Bc
Flowering/fructification	7.70 Ab	4.6 Bb
Full Production	11.07 Aa	9.05 Ba
CV (%)	24.7	

Averages followed by same uppercase letters in lines for soil cover, did not differ significantly by using the F test at 5% probability, and lowercase letter in columns, for seasons, did not differ by Tukey test at 5% probalility.

Table 3. Fruit mass (FM), fruit diameter (FD), fruit length (FL) and peel thickness (PT) of Mayara hybrid bell pepper in different harvest seasons. Vitória da Conquista, IF Baiano, 2016.

Harvest	FM (g)	FD (cm)	FL (cm)	PT (cm)
90 DAT	219.86 a	7.52 a	14.23 a	0.60 a
120 DAT	227.97 a	7.47 a	13.77 a	0.59 a
150 DAT	144.73 b	6.65 b	12.06 b	0.51 b
CV (%)	21.41	8.44	9.65	13.14

Averages followed by same letters in column did not differ by using Tukey test at 5% probability.

Another important characteristic of bell pepper is peel thickness, since fruits which present thicker peel are more resistant to transport, show longer post-harvest lifespan and higher mass yield, and it is also a greater consumer preference (Charlo *et al*., 2009). Thus, the values found in two initial harvests are satisfactory for commercialization of bell pepper and contributed to the fruits presenting greater mass and, consequently, allow the producer to market the fruits using mass and not volume.

Chlorophyll index *a* and *b* did not show any differences in July considering the factors in this study (soil cover and irrigation strategies) (Table 4). Chlorophyll is strongly influenced by environmental factors such as availability of light, water and mineral nutrients and when the plants are submitted to stress (Kaya *et al*., 2013). Thus, in this study, these indexes did not show any stress condition for plants under different strategies of water application.

In September, the authors verified higher values for chlorophyll *b*, without mulching, in 100% of ETc, RDI, I, II, IV, V and VI treatments. This increase in chlorophyll *b* values can be considered as an important characteristic for vegetative adaptability, since chlorophyll *b* absorbs energy at wavelengths different from chlorophyll *a* and transfers this energy to reaction center, thus maximizing the energy capture that effectively acts on the photochemical reactions (Taiz & Zeiger, 2013).

Quantum efficiency (Fv/Fm) was influenced by soil cover, in evaluations done during July, when the plants under mulching showed higher average values in relation to plants without mulching for 100% and 125% of ETc and RDI V treatments (Table 4). In the evaluation done in September, no significant difference among irrigation strategies was noticed; but in water depth of 125 and 50% of ETc, the authors verified higher value for Fv/Fm under mulching

Table 4. Chlorophyll *a* and *b* and quantum efficiency (Fv/Fm), evaluated in July and September 2016, in Mayara hybrid bell pepper plants submitted to different irrigation strategies with and without mulching. Vitória da Conquista, IF Baiano, 2016.

Water depths	Chlorophyll *a*		Chlorophyll *b*		Fv/Fm	
	With mulching	Without mulching	With mulching	Without mulching	With mulching	Without mulching
July						
125%ETc	40.9	41.3	22.4	22.8	0.70 Ba	0.67 Ab
100%ETc	40.2	41.8	21.6	22.6	0.72 Aa	0.69 Ab
75% ETc	40.8	41.1	22.8	21.4	0.69 Ba	0.70 Aa
50% ETc	41.0	40.2	22.3	21.6	0.70 Ba	0.69 Aa
RDI (I)	41.1	40.1	23.8	21.6	0.70 Ba	0.69 Aa
RDI (II)	40.9	41.8	22.0	23.5	0.70 Ba	0.69 Aa
RDI (III)	38.2	40.8	19.2	21.8	0.68 Ba	0.69 Aa
RDI (IV)	40.7	41.3	20.8	23.6	0.70 Ba	0.69 Aa
RDI (V)	39.8	40.4	21.4	20.7	0.73 Aa	0.70 Ab
RDI (VI)	41.5	41.4	23.9	23.1	0.69 Ba	0.70 Aa
CV(%)	3.05		9.74		2.90	
September						
125%ETc	42.8 Aa	43.7 Aa	25.1 Aa	28.4 Aa	0.74 Aa	0.70 Ab
100%ETc	41.2 Aa	42.8 Aa	24.4 Ab	28.5 Aa	0.72 Aa	0.72 Aa
75% ETc	44.0 Aa	42.1 Aa	26.8 Aa	22.0 Bb	0.74 Aa	0.73 Aa
50% ETc	41.0 Aa	41.4 Aa	26.2 Aa	26.2 Ba	0.73 Aa	0.69 Ab
RDI (I)	42.8 Aa	44.0 Aa	24.9 Ab	29.9 Aa	0.72 Aa	0.72 Aa
RDI (II)	40.6 Ab	44.3 Aa	24.1 Ab	30.3 Aa	0.72 Aa	0.72 Aa
RDI (III)	41.8 Aa	41.3 Aa	24.8 Aa	24.6 Ba	0.73 Aa	0.71 Aa
RDI (IV)	41.9 Ab	45.7 Aa	23.4 Ab	30.3 Aa	0.73 Aa	0.71 Aa
RDI (V)	41.3 Ab	45.1 Aa	21.4 Ab	28.5 Aa	0.72 Aa	0.72 Aa
RDI (VI)	40.3 Ab	43.6 Aa	19.7 Ab	28.7 Aa	0.74 Aa	0.70 Aa
CV(%)	7.36		16.02		3.40	

Averages followed by same uppercase letters in columns, for irrigation strategies, belong to the same group by Scott-Knott criteria and, averages followed by same lowercase letters, for soil cover, did not differ significantly by F test at 5% probability. Regulated deficit irrigation (RDI) (I) - 50% ETc in vegetative phase (FI) and 100% ETc in production phase (FII); RDI (II)- 100% ETc in FI and 50% ETc in FII; RDI (III)-75% ETc in FI and 100% ETc in FII; RDI (IV)- 100% ETc in FI and 75% ETc in FII; RDI (V) - 125% ETc in FI and 75% ETc in FII; RDI(VI)- 125% ETc in FI and 75% ETc in FII; RDI(VI)- 75% ETc in FI and 125% ETc in FII. FI: 0-6 days after transplanting; FII: 61-170 days after transplanting.

treatment.

Fv/Fm indicates the functional photosystem II (PSII), and consequently, photochemical radiation use efficiency in carbon assimilation by plants and under water stress condition hinders mainly electron transfer and so it limits the assimilation of carbon in bell pepper plants (Campos *et al*., 2014).

The authors highlight that irrigation strategy consisting of 50% ETc, without mulching, resulted in moderate water deficit stress for bell pepper plants, when the value of Fv/Fm, equal to 0.69, is below the range considered optimal for most crops (Fv/Fm of 0.800 ± 0.5) (Bolhàr-Nordenkampf *et al*., 1989). However, the stress suffered was not enough to cause severe damage to the functional photosystem II (PSII) and drastically reduce Fv/Fm.

The change in quantum efficiency occurs when the amount of photochemical energy introduced into the leaves is greater than the capacity of the photochemical process, resulting in decreases in Fv/Fm, which characterizes a greater non-photochemical dissipation. Therefore, under the conditions of the present study, the applied water depths, even the small ones, did not cause stress in bell pepper plants.

Plant height and quantity of bell pepper leaves increased in the growing season, both with or without mulching (Figures 2A and 2B). This result is expected since growing is undetermined and bell pepper plants show continuous growth over time.

With mulching, the crop shows higher number of leaves after 30 DAT, however, at 120 DAT, the authors verified similar quantity of leaves, both with and without mulching. For plant height, with mulching, the authors observed

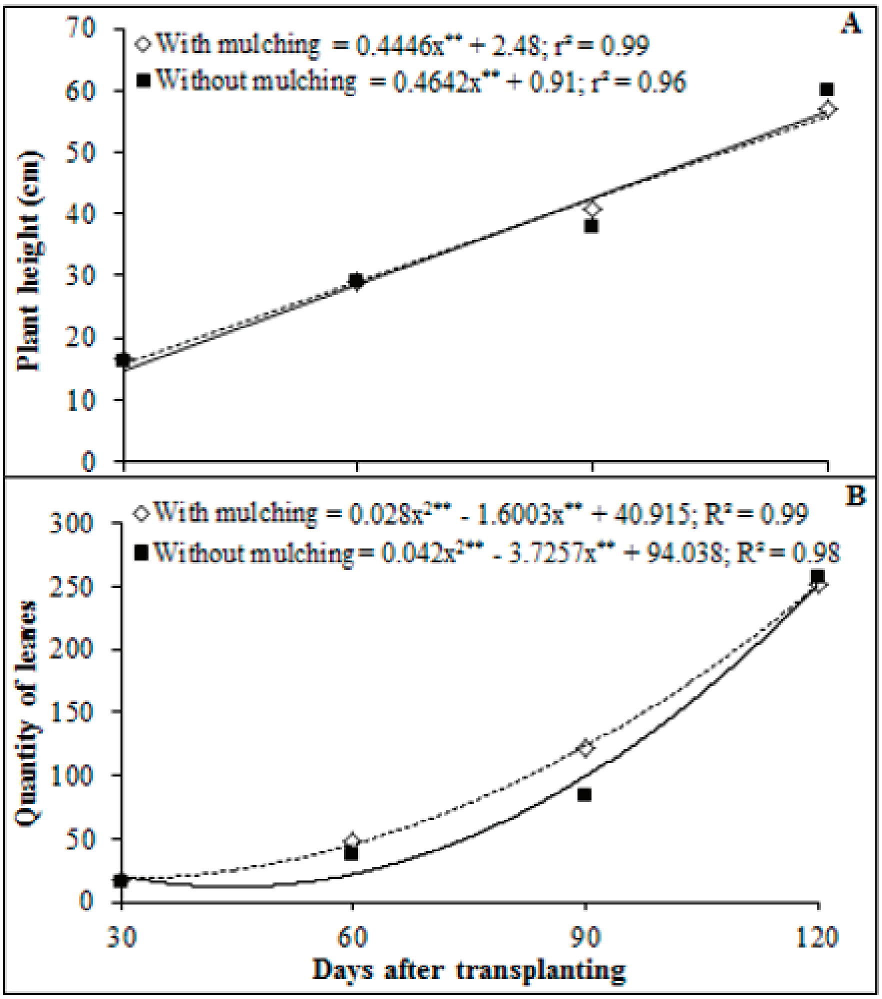

Figure 2. Plant height (A) and quantity of leaves (B) of Mayara hybrid bell pepper under different seasons of evaluation with or without mulching. Vitória da Conquista, IF Baiano, 2016.

the highest value in the third season of evaluation, and in the fourth season of evaluation, the authors observed the opposite, though. These results may have been influenced by temperature, since the three evaluation seasons were done in Autumn and Winter, seasons with the lowest temperatures. The last evaluation was done in Spring, when it is warmer (Figure 1A).

The authors concluded that mulching provides higher quantity of fruits, when compared to crops in treatments without mulching; diameter, mass and length of fruits as well as peel thickness are higher in the first two harvests; chlorophyll index was not changed in relation to plots with or without mulching under different irrigation strategies. Applying water depths of 50% ETc, higher water use efficiency with superior productivity for plants under mulching conditions was obtained.

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