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Response of the cherry tomato to watering and ground cover under organic cultivation

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Abstract

Studies on production factors of the irrigated organic cherry tomato in the Brazilian semi-arid region are just at the beginning phase. It mainly focuses on adequate irrigation management. Therefore, the aim of the present study was the technical and economic evaluation of some production factors like water and ground cover on cherry tomato. The climate of the region is of the BSw'h type, hot and semi-arid, with irregular rains distributed from February to May. The ground has fairly flat relief. The soil presents a sandy loam texture, well-drained, without risk of salinity and sodicity problems. The experimental design was of randomised blocks with three replications and subdivided plots, comprising five primary treatments in the plots and three secondary treatments arranged in the subplots. The primary treatments consisted of five levels of irrigation with 50, 75, 100, 125 and 150% of crop evapotranspiration, and three secondary treatments were assigned with ground covers of carnauba straw (CS), elephant grass (EG), plus a control treatment with no ground cover. The crop was irrigated by a system of drip irrigation. The results showed estimated slides equivalent to 454 mm (107% ETc loc), 461 mm (109% ETc loc) and 592 mm (140% ETc loc) can contribute to the highest commercial yield, corresponding to 11401, 10466 and 7802 kg ha^{-1} of cherry tomatoes for carnauba bagana, elephant grass and uncovered soil, respectively. Carnauba straw presented potential as a vegetative cover, being economically feasible as it allowed a reduction in water consumption and yield of cereal tomato under poor irrigation strategy.

Keywords: Economic analysis. Ground cover. Production function. *Solanum lycopersicum* var. cerasiforme.

Introduction

In recent years, there is increasing concern about the environmental impact of conventional farming practices. This has been coupled with increased consumer demand for sustainable agricultural products, pushing producers to take up more organic farming (Prince et al., 2016).
Organic farming in Brazil is growing at a rate of 30% per year, gaining more and more ground in the agricultural chain, around BRL 2.5 billion in 2015. Between 2014 and 2015, the number of production units and the number of producers were increased by 32 and 52% respectively, (MAPA, 2016).
Among the organic products being grown, the cherry tomato (*S. lycopersicum* var. Cerasiforme) has become an option for farmers, since it has good rusticity, high market value and greater productivity. It is also well accepted by consumers (Maia et al., 2013).
However, excessive or deficient irrigation can negatively affect the quality of the tomato (Santana et al., 2010), making irrigation at the optimal level vital to increasing production and water use efficiency (Martin et al., 2012; Costa et al., 2011).
The water situation is very critical in the Curu River Basin, located in the north-central part of the State of Ceará. In September 2017, it was at 11.66% of its storage capacity (CEARÁ, 2017). The Pereira de Miranda reservoir, the main reservoir of the basin, is at 1.72% capacity, and since 2013, the release of water to supply the Curu Pentecoste and Curu Paraipaba Irrigated Perimeters for use in irrigated agriculture has been suspended.
Irrigation farmers have had to resort the alternative sources of water, such as that from shallow or deep wells, and to choose between reducing the irrigated area and allocating enough water to meet the need of the crop, or using deficient irrigation and irrigating a larger area, and/or investing in a localised irrigation system.
In this scenario, reducing water loss from evaporation is also a basic activity in irrigation management. Within this context, the use of mulch is a suitable technique for semi-arid regions, presenting several advantages, such as greater water retention in the soil, control of invasive plants (Araújo et al., 2012), less variation in soil temperature and moisture, and the formation of an environment favourable to plant development (Ferreira et al., 2013, Carvalho et al., 2011).
Considering the above mentioned factors, studies on production of the irrigated organic cherry tomato in the Brazilian semi-arid region are just at the beginning phase, regarding adequate irrigation management, i.e. the best time to irrigate and the amount of water to apply. This is relevant as the rainfall has been below the historical average

in recent years and the depletion of water reserves has caused water crisis.

Accordingly, the aim of the present research was the technical and economic evaluation of the effect of the production factors such as water and ground cover on productivity of cherry tomato.

Results and Discussion

Air temperature

We found that the mean and maximum temperatures were above the range considered optimal for development and fruiting of the crop, which is between 18.5 and 26.5ºC (Keillor, 2008), despite the statement by Alvarenga (2013), that the tomato can tolerate temperature variations in the range of 10 to 34ºC. When the temperature departs from the optimum, it causes stress to the plant, resulting in flower abortion and commercial yield losses (Candian et al., 2017).

Water slides associated with replacement rates

During the crop cycle, the accumulated irrigation depths were 211, 316.5, 422, 527.5 and 633.0 mm, corresponding to a recovery rate of 50, 75, 100, 125 and 150% of ETc, respectively. These values correspond to the total water applied after starting the different irrigation levels. A total wtater of 24.1mm was applied before this differentiation.

Productivity

Fig. 1 shows the factors of irrigation depth and the soil cover, in addition to their respective interaction. It can be observed that the data related to crop productivity were adjusted to a quadratic regression model for irrigation level with significance of 1%. Also they are shown like equations for the adjustment of the product that show very strong correlations, which is translated to the coefficient of determination superior to 0.8.

Santana et al. (2010) obtained the same quadratic behaviour, when studying the effect of the rate of soil water recovery on productivity of tomato.

Although the curves adjust to a quadratic model, similar behaviour can be seen for the curves associated with the ground cover, with higher yields for the treatment including ground cover based on carnauba straw, either under water deficit or water excess conditions.

The factor-product relationship estimated that irrigation depths equal to 454 mm (107% ETc), 461 mm (109% ETc) and 592 mm (140% ETc) gave the greatest commercial yields, corresponding to 11,401, 10,466 and 7,802 kg ha^{-1} of cherry tomatoes for the ground covers carnauba straw, elephant grass and control (with no cover), respectively.

Albuquerque Neto and Peil (2012) obtained a value for commercial productivity greater than that found in this study when evaluating the yield of genotypes of the mini-tomato group Red cherry, Yubi Cherry and Flavour Top under hydroponic cultivation, with yields of 14,900, 30,500 and 15,900 kg ha^{-1}, respectively.

The occurrence of temperatures above the optimal range for crop development was observed during the experiment. It may have had a negative influence on the productivity of the cherry tomato.

Cultivation in soil covered with carnauba straw or elephant grass gave increases of 3,599 and 2,664 kg ha^{-1} of cherry tomatoes in relation to the crop grown with no ground cover. Similar results have been obtained by several authors analysing productivity in the papaya, tomato, lettuce and cabbage grown in soil with and without ground cover (Sousa et al., 2017; Campagnol et al., 2014; Ferreira et al., 2013; Carvalho et al., 2011).

To obtain such results, several factors must have come together, among which, less variation and greater retention of soil moisture; the formation of an environment favourable to plant development; and less heating of the soil with a smaller thermal range (Ferreira et al., 2013; Carvalho et al., 2011; Marouelli, et al., 2010).

Similarly, Mukherjee et al. (2010) point out that ground cover reduces the weed population, causing a reduction in competition for water and nutrients. Orrillo et al. (2016) pointed out that ground cover creates a physical barrier, reducing water loss from the soil to the atmosphere and promoting thermal changes in the soil (Rossi et al., 2013).

According to the adjusted regression equation, maximum productivity for the tomato grown in the soil with no ground cover was obtained with an irrigation depth of 592 mm. The same productivity was also obtained in soils covered with straw or elephant grass corresponded to irrigation depths of 252 and 297 mm, respectively, resulting in a water saving of 57.4 and 49.8%, respectively.

A similar response was reported by Oliveira Neto et al. (2011), growing beetroot in soil covered with Uganda grass or gliricidia, who obtained a reduction of 53% in evapotranspiration compared to crops with no ground cover.

The optimal irrigation depths from an economic point of view were calculated by equating the expression for the Marginal Physical Product (MPP) of Water (Figure 2) to the relationship between the price of the variable factor water (Pw) and the production of cherry tomato.

It can be seen that the MPP is initially positive and decreases with increased water depth, when the value for MPP reaches zero, corresponding to water depths of 454, 461 and 592 mm, in soil covered with straw or elephant grass, or with no cover. It shows that the applied depths resulted in maximum physical productivity. From the point where the MPP takes on a negative value, a decrease in productivity can be seen for an increase in water depth, showing the further application of water to be uneconomic.

The optimal irrigation depth for soil covered with straw was 453 mm (107% of ETc), generating a productivity of 11,400 kg ha^{-1}. For the soil covered with elephant grass, the depth was 460 mm (92.3% of ETc), resulting in a productivity of 10,465 kg ha^{-1}whereas for the soil with no cover, the depth was 589 mm (140% of ETc), generating a productivity of 7,801 kg ha^{-1}.

Comparing the optimal economic irrigation depth with the maximum physical irrigation depth, very close production

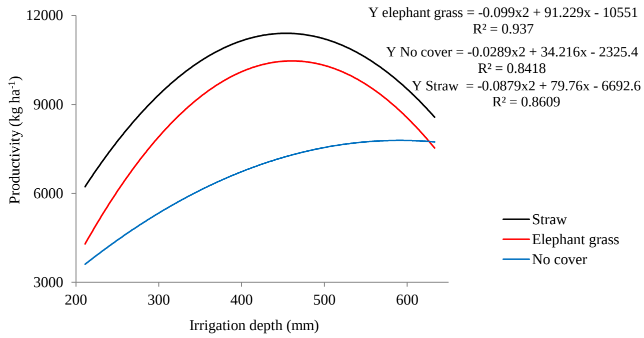

Fig 1. Productivity of cherry red tomato grown in soil covered with straw and elephant grass and in the soil with no ground cover, submitted to different levels of irrigation. Pentecost, CE. UFC, 2017.

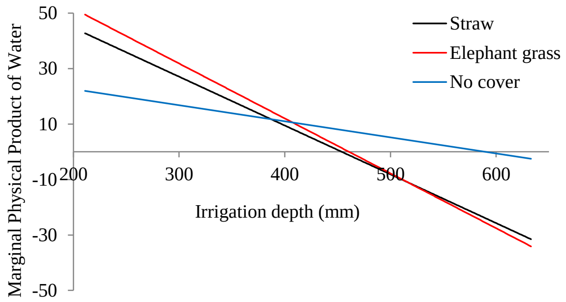

Fig 2. Marginal physical product of water (MPP) for different applied irrigation depths in soils covered with Carnaúba straw and elephant grass, and with no ground cover. Pentecost, CE. UFC, 2017.

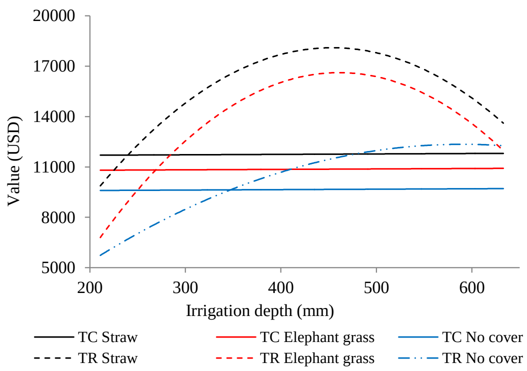

Fig 3. Production costs and value of the cherry tomato for irrigation depth, in January 2017. Pentecoste, CE. UFC, 2017.

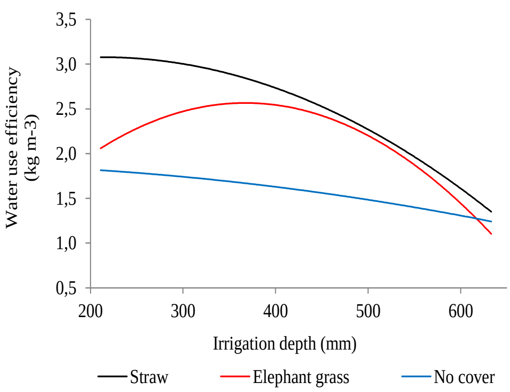

Fig 4. Water use efficiency in the cherry tomato for different water levels and ground cover. Pentecoste, CE. UFC, 2017.

values are seen, and it can be said that the depth which maximizes production is the same that provides the maximum economic return. Therefore, when applying the water depth that maximizes physical production, it may be sufficient to achieve economically viable production, showing that irrigation management should be handled in a way that guarantees the water needs of the crop under optimal conditions (Oliveira et al., 2011).

Similar behaviour was seen by several authors, who analysed the production function when cultivating roses, eggplants, Japanese cucumbers and beans (Oliveira et al*.,* 2016; Bilibio et al., 2010; Santana et al., 2009).

The proximity of the optimal economic irrigation depth and the maximum physical irrigation depth was influenced by the high economic value of the crop, the low cost of the water, and the efficiency of the local irrigation system.

Using the optimal economic depth, the profit for each crop was obtained as per equation 7, considering the price of tomatoes per kg (Py) to be USD 1.59, the costs of the fixed and variable factors in the experiment (C) to be USD 11,763.38, 10,871.54 and 9,699.05 ha^{-1}, respectively for a ground cover of straw or elephant grass and with no cover, and the price of water (Pw) to be USD 0.258 mm^{-1} (Fig. 3).

The differences between total production costs are in descending order of CS > EG > NC, this result being influenced by increases in the ground cover inputs of carnauba straw and elephant grass used in growing the cherry tomato. Another interesting factor is the small variation in the total cost curve for increases in applied water depth. This is due to the price of water being much lower when compared to the other production costs.

The production profits for the different crops, estimated as a function of the optimal economic irrigation depth for January 2017, were USD 6,214.79; 5,620.70 and 2,531,29 ha^{-1} for the soil covered with straw, elephant grass and no cover (control), respectively.

Productivity of culture water (PA)

The analysis of variance shows that for the variable, water use efficiency of the cherry tomato, and the factors irrigation depth and ground cover, in addition to the interaction of these factors, significant results were obtained at 1% probability. Furthermore, the factor irrigation depth showed a significant fit to the quadratic regression model at 1% probability.

Water use efficiency as a function of the different totals for applied water depth fitted the second degree polynomial regression. It can be seen that the soil with carnauba straw gave the best results, corresponding to 3.06 kg m^{-3} for a water depth of 205 mm, followed by the elephant grass and no cover, corresponding to 2.66 and 1.8 kg m^{-3} for water depths of 380 and 200 mm, respectively (Fig. 4).

The results demonstrate that crops with a ground cover of straw and elephant grass were 41 and 32% more efficient in their use of water in relation to those with no cover, giving higher fruit productivity for less applied water, in agreement with a report by Marouelli et al. (2006), who studied the effect of the use of water on the production of processed tomatoes in the soils covered with sorghum and with no cover.

Teófilo et al. (2012) reported that PA is the relationship between production and water consumption. It can be improved by procedures, such as an improvement in cropping practices, fertiliser management and especially the adoption of efficient irrigation systems. Thess practices may minimise water loss using the techniques that favour the storage and infiltration of water in the soil reducing the rate of evaporation. This was discernable in the present work, where higher PA values can be seen for those treatments where the soil was covered with carnauba straw and elephant grass.

The ground cover reduces water loss through evaporation, which promotes an increase in water use efficiency in the crops (Teófilo et al., 2012).

An economic water or irrigation usually means a water depth that maximises productivity of tomato. In this study the costs were 25.16, 22.75 and 13.24 Brazilian Rials (BRL) per m^{-3} under carnauba straw, elephant grass and with no cover, respectively. It can be seen that growing the crop with carnauba straw and elephant grass showed 47% and 42% increase in economic water productivity (EWP) for the cherry tomato, compared to no ground cover.

Researchers working with banana and watermelon crops obtained lower values of BRL 2.65 and 11.48 m^{-3} for economic water productivity than those of this study, (Barbosa et al., 2016; Oliveira et al., 2012).

Faced with a water crisis, these results demonstrate that the tomato proved to be efficient in economic water productivity, confirming it as a crop of high added value.

Materials and Methods

Characterization of the experimental area

The research was carried out from July 2016 to January 2017 in an area belonging to Prece (Cooperative Cell Educational Program), located in the town of Pentecoste, CE. According to the Köppen classification, the climate in the region is BSw'h' type, characterised as hot semi-arid, with irregular rainfall distributed from February to May. The average air temperature during the experiment varied between 23.5ºC and 38.4ºC.

The physical and chemical attributes of the soil in the 0-0.20 m layer had the following values: pH in water 5.9; 6 mg kg^{-1} assimilable phosphorus; 0.29 $cmol_c$ kg^{-1} potassium; 3.00 $cmol_c$ kg^{-1} calcium; 1.50 $cmol_c$ kg^{-1} magnesium; 0.05 $cmol_c$ kg^{-1} sodium; 0.15 $cmol_c$ kg^{-1} aluminum; 9.62 g kg^{-1} organic matter; electrical conductivity 0.16 dS m^{-1}; bulk density 1490 kg m^{-3}; particle density 2770 kg m^{-3}; available water 4.1 g $100g^{-1}$; with a sandy-loam texture.

Experimental design and characterization of treatments

The experimental design was randomised blocks, in a scheme of subdivided plots, comprising five primary treatments in the plots and three secondary treatments arranged in the subplots. The primary treatments consisted of five irrigation levels with 50, 75, 100, 125 and 150% of crop evapotranspiration and two secondary treatments comprising two types of ground cover (carnauba straw - CS and elephant grass - EG) and a control treatment, with no ground cover. Each plot comprised an area of 28.0 m^2 (1.0 m x 28.00 m) and each subplot of 7.0 m^2 (1.0 m x 7.0 m), composed of 12 plants, with the three central plants considered as working plants. Spacing was 0.5 m between plants and 1.0 m between rows.

Setting up and conduction of the experiment

Preparation of the area consisted of cleaning followed by the distribution of 20 kg of cattle manure per m². The secondary treatments of crushed elephant grass and carnauba straw were then applied in the amounts of 19,000 and 27,000 kg ha^{-1}, respectively, to guarantee a ground cover of approximately 0.03 m in thickness.

Seedlings of cherry red tomatoes were produced in polyethylene trays with 162 cells, filled with a substrate containing 90% humus and 10% vermiculite. Transplanting was carried out 27 days after sowing (DAS) when the seedlings presented between four and six true leaves.

The plants were grown in a system of vertical training using polyethylene ribbon. Top dressing was applied 20, 40 and 60 days after transplanting, with doses of 500 g $plant^{-1}$ organic compound with a pH of 6.9, containing 314.7 mg dm^{-3} assimilable phosphorus, 1690 mg dm^{-3} potassium, 14.00 $cmol_c$ dm^{-3} calcium, 9.2 $cmol_c$ kg^{-1} magnesium, base saturation 97%, 0.0 $cmol_c$ kg^{-1} aluminum, 14.3 dag kg^{-1} organic matter, 26.9 mg dm^{-3} iron, 0.4 mg dm^{-3} copper, 20.4 mg dm^{-3} zinc, and 100.3 mg dm^{-3} manganese.

The tomatoes were thinned weekly and all lateral shoots were removed, leaving two main stems. Apical pruning was carried out from the eighth cluster on each stem.

Irrigation system and water supply to the crop

The water used for irrigation came from a shallow well located on the left bank of the Canindé River in the town of Pentecoste, and was classified as C_3S_1 with an EC of 1.46 dSm^{-1}. A drip irrigation system was used, with self-compensating button emitters spaced 0.50 m apart, at a flow rate of 3.8 L h^{-1} and operating at a working pressure of 2 kgf cm^{-2}. Water was applied twice a day. The data used to estimate the reference evapotranspiration (ETo) were collected daily from a Class A tank located five metres from the experimental area. The reference evapotranspiration (ETo) was estimated from the product of the evaporation measured in the tank (ECA) and the tank coefficient (Kt). The value for crop evapotranspiration (ETc) was obtained from the product of the ETo value and the crop coefficient (Kc) of the tomato for the initial, vegetative, flowering, fruiting and maturation stages, whose reference values were 0.5, 0.8, 1.25, 0.9, 0.65, respectively (Doorenbos and Kassan, 1994). In the first 11 days after transplanting, all treatments received the same irrigation at 100% of the daily ETc in order to guarantee uniform plant development. After defining treatments, irrigation was carried out daily according to the ETc of the previous day and adjusted for the respective treatment. The crop productivity was based on the fresh weight of the cherry tomatoes measured on a commercial scale and related to the area of the subplot. The harvesting was carried out when the fruits were showing a light-green colouration.

Production function

To obtain the production function a regression analysis was fitted to a polynomial model. It was used between crop productivity and the applied levels of water.

The net income or production profit was obtained from the difference between the total monetary value of production and the costs of water application and the fixed cost of the production system, including the irrigation system and types of ground cover (Frizzone, 2007).

The product price (Py) was the average price obtained by the rural producers of Serra da Ibiapaba CE, from November 2016 to January 2017. Considering that application costs are included in the costs of crop production, the cost of irrigation was considered equal to the value of the electricity tariff, and estimated according to equation 1 (Frizzone et al., 1994).

$$EC = 0.7457 \times Pot \times To \times Pkwh \quad (1)$$

Where:
EC - cost of electricity during the crop cycle, in Brazilian Rials (BRL); 0.7457 - conversion factor from hp to kw;
Pot - engine power, in hp;
To - system operating time required to restore the ETc, in hours, considering an irrigated area of 1.0 ha;
Pkwh - price per kwh, in Brazilian Rials (BRL).

The price per kwh was obtained from Enel (Energy Company of Ceará), considering that the system operated during peak hours. The price for one millimetre of applied water (Pw) ($BRL.mm^{-1}$) was obtained by dividing the cost of the electricity in Brazilain Rials (BRL) by the water depth applied during the period (mm) and adding the price of the K_2 water tariff (practised in the Lower Acaraú Irrigation Perimeter in 2016).

The marginal physical productivity (MPP) of a variable factor comprises the increase in the physical product resulting from the use of an additional unit of the variable factor, and is expressed by the first derivative of the Y response function.

Efficiency in water use

Water use efficiency was evaluated from crop water productivity (WP), estimated by the relationship between the total value for productivity (kg ha^{-1}) and the respective amounts of water applied in each treatment. Economic water productivity (EWP) was estimated by the relationship between the monetary values for total production (BRL) and the respective amounts of water applied (m³) in each treatment. To determine production values ($Y_{USD\$}$), the unit price of the product was obtained from the wholesale price history at the Centre for Supply (Ceasa) in Maracanaú for 2016.

Statistical analysis

Once the results were obtained, statistical analysis was carried out employing analysis of variance using the Sisvar software (Ferreira, 2010). When the values were significant by F-test, the Scott Knot test was applied to compare the mean values for the treatments with the types of ground cover, and regression analysis for the treatments and levels of irrigation, both at a significance level of 5%.

Conclusion

The maximum productivity of the cherry tomato was 11,401.00 kg ha^{-1} obtained with an ideal water blade of 454 mm. The carnauba straw presented potential as a vegetative cover, being economically feasible, as it allowed a reduction in water consumption and increase in the yield of cherry tomato under a poor irrigation strategy.

References

Albuquerque Neto AAR, Peil RMN (2012) Produtividade biológica de genótipos de tomateiro em sistema hidropônico no outono/inverno. Hortic Bras. 30(4): 613-619.

Alvarenga MAR (2013) Origem, botânica e descrição da planta. In: TOMATE. Produção em campo, casa de vegetação e hidroponia. 2. ed. Lavras: UFLA, 455p.

Araújo TVO, Lima, AD, Marinho, AB, Duarte, JML; Azevedo, BM, Costa, Solerne Caminha. Lâminas de irrigação e coberturas do solo na cultura do girassol, sob condições semiáridas (2012) Irrig.17 (2):126-136.

Barbosa FEL, Lacerda CF, Amorim AV, Costa RNT, Silva JA, Hernandez FFF (2016) Production and economic viability of banana managed with cover crops. Rev. Bras de Eng Agríc e Amb. 20 (12): 1078-1082.

Bilibio C, Carvalho JÁ, Martins M, Rezende FC, Freitas WA, Gomes LAA (2010) Função de produção da berinjela irrigada em ambiente protegido. Irrig. 15 (1): 10-22.

Campagnol R, Abrahão C, Mello SC, Oviedo VRS, Minami K (2014) Impactos do nível de irrigação e da cobertura do solo na cultura do tomateiro. Irrig. 19 (3): 345-357.

Candian JS, Martins BNM, Cardoso AII, Evangelist ARM, Fujita E (2017) Stem conduction systems effect on the production and quality of mini tomato under organic management. Brag.76 (2): 238-245.

Carvalho JF, Montenegro AAA, Soares TM, Silva EFF, Montenegro SMGL (2011) Produtividade do repolho utilizando cobertura morta e diferentes intervalos de irrigação com água moderadamente salina. Rev Bras de Eng Agri Amb. 15 (3): 256–263.

CEARÁ (2017) Portal Hidrológico do Ceará - Volume armazenado dos reservatórios. Disponível em: <http://www.hidro.ce.gov.br/ >. Acesso em:10 julho 2017.

Costa RNT, Araújo DF, Araújo HF, Moreira OC (2012) Alternativas para uso racional da água em perímetros irrigados por superfície. In: Gheyl, H. R.; Paz, VPS, Medeiros, SS, Galvão, CO (2012) 1 Ed. Recursos hídricos em regiões semiáridas. Campina Grande: INSA. p. 117 – 128.

Doorenbos J, Kassam AH (1994) Efeito da irrigação no rendimento das culturas. FAO 33: irrigação e drenagem, Tradução: Gheyi, HR, Souza, AA, Medeiros, JF (1994) Campina Grande: Universidade Federal de Paraíba. 306p.

Ferreira DF (2010) SISVAR - Sistemas de análises estatísticas. Versão 5.3. Lavras: Departamento de Ciências Exatas, UFLA.

Ferreira ICPV, Araujo AV, Nascimento AL, Cavalcante TFM, Santos LDT (2013) Cobertura morta e adubação orgânica na produção de alface e supressão de plantas daninhas. Rev Ceres. 60 (4): 582-588.

Frizzone JA, Botrel TA, Freitas HAC (1994) Análise comparativa dos custos de irrigação por pivô-central, em cultura de feijão, utilizando energia elétrica e óleo diesel. Eng Rural. 5 (1): 34-53.

Frizzone JA (2007) Planejamento da Irrigação com Uso de Técnicas de Otimização. Rev Bras de Agric Irrig. 1 (1): 24–49.

Keillor G (2018) Plant characteristics and physiology (2008) In: JONES, J. B. Tomato plant culture: in the field, greenhouse, and home garden. Boca Raton: CRC Press, p. 55- 78.

Maia JTLS, Maia JTLS, Clemente JM, Souza NH, Silva JO, Martinez HEP (2013) Adubação orgânica em tomateiros do grupo cereja. Biotem. 26 (1):37 – 44.

MAPA (2016) Ministério da Agricultura, Pecuária e Abastecimento. Disponível em: <http://www.agricultura.gov.br/comunicacao/noticias/2015/09/mercado-brasileiro-de-organicos-deve-movimentar-rs-2-bi-em-2016 > Acesso em: 28 julho 2016.

Marouelli WA, Silva HR, Madeira NR (2006) Uso de água e produção de tomateiro para processamento em sistema de plantio direto com palhada. Pesq Agropec Bras. 41 (9): 1399-1404.

Marouelli WA, Abdalla RP, Madeira NR, Oliveira AS, Souza RF (2010) Eficiência de uso da água e produção de repolho sobre diferentes quantidades de palhada em plantio direto. Pesq Agropec Bras. 45(4):369-375.

Martin JD, Carlesso R, Aires NP (2012) Irrigação deficitária para aumentar a produtividade da água na produção de silagem de milho. Irrig. Special Edition (1):192-205.

Mukherjee A, Kundu M, Sarkar S (2010) Role of irrigation and mulch on yield, evapotranspiration rate and water use pattern of tomato (*Lycopersicon esculentum* L.). Agric Wat Manag. 98 (1): 182–189.

Oliveira Neto DH, Carvalho DF, Silva LDB, Guerra JGM, Ceddia MB (2011) Evapotranspiração e coeficientes de cultivo da beterraba orgânica sob cobertura morta de leguminosa e gramínea. Hortic Bras. 29 (1): 330-334.

Oliveira EC (2016) Função de produção para a roseira cultivada em sistema de produção integrada. Eng. na Agric. 24 (6): 473-483.

Oliveira, EC, Carvalho, JA, Silva, WD, Rezende, FC, Gomes, LAA, Jesus, MCN (2011) Análise produtiva e econômica do pepino japonês submetido a diferentes lâminas de irrigação. Rev. Bras. de Eng. Agríc e Amb. 15 (7): 702-708.

Oliveira PGF, Moreira OC, Branco LMC, Costa RNT, Dias CN (2012) Eficiência de uso dos fatores de produção água e potássio na cultura da melancia irrigada com água de reuso. Rev Bras de Eng Agríc e Amb.16(2): 153–158.

Orrillo HM, Araujo WF, Rodriguez CA, Lozano RMB, Sakazaki, RT, Vargas ARP (2016) Influência da cobertura morta na evapotranspiração, coeficiente de cultivo e eficiência de uso de água do milho cultivado em cerrado. Irrig. 21 (2): 352-364.

Price AJ, Duzy LM, Balkcom KS, Kelton JA, Kornecki TS, Sarunaite L (2016) Organic Weed Control and Cover Crop Residue Integration Impacts on Weed Control, Quality, Yield and Economics in Conservation Tillage Tomato-A

Case Study, Organic Farming - A Promising Way of Food Production, Dr. Petr Konvalina (Ed.), InTech.

Rossi CQ, Pereira MG, Giácomo SG, Betta M, Polidoro JC (2013) Decomposição e liberação de nutrientes da palhada de braquiária, sorgo e soja em áreas de plantio direto no cerrado goiano. Sem Ciên Agrá. 34 (4): 1523-1534.

Santana MJ, Vieira TA (2010) Resposta do tomateiro irrigado a níveis de reposição de água no solo. Irrig. 15(3): 443-454.

Santana MJ, Carvalho JA, Andrade MJB, Gervásio GG, Braga JC, Lepri EB (2009) Viabilidade técnica e econômica da aplicação de água na cultura do feijoeiro comum (*Phaseolus vulgaris* L.). Cien e Agrotec. 33(2): 532-538.

Sousa PR, Sousa JPF, Sousa AM, Costa RNT (2017) Produtividade do mamoeiro cultivado sob aplicação de cinzas vegetais e bagana de carnaúba. Rev Bras de Agric Irrig. 11(1): 1201-1212.

Teofilo TMS, Freitas FCL, Medeiros JF, Fernandes D, Grangeiro LC, Tomaz HVQ, Rodrigues APMS (2012) Eficiência no uso da água e interferência de plantas daninhas no meloeiro cultivado nos sistemas de plantio direto e convencional. Plan Dan. 30 (3): 547-556.