Revista Brasileira de Agricultura Irrigada
Brazilian Journal of Irrigated Agriculture
ISSN: 1982-7679 (on-line)
v.16, p. 12-20, 2022
Fortaleza, CE - www.inovagri.org.br

DOI: 10.7127/rbai.v1601241

PRODUCTIVITY AND QUALITY OF TOMATO SUBMITTED TO IRRIGATION LEVELS USING MULCHING IN ECONOMIC BEDS

PARÂMETROS PRODUTIVOS DO TOMATE SUBMETIDO A LÂMINAS DE IRRIGAÇÃO UTILIZANDO MULCHING EM CANTEIROS ECONÔMICOS

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ABSTRACT: The objective of this study was to evaluate irrigation levels in tomato crops, using economical beds with mulch. A randomized block design within a split-plot had run in a 2 x 5 factorial treatment scheme structure, with four replications. The plots were the five irrigation levels (50, 75, 100, 125, and 150%) of crop Evapotranspiration (ETc), and subplots were two tomato varieties RASTEIRO RIO GRANDE (RR) (Lycopersicon lycopersicum) and CALINE IPA- 7 (IPA) (Lycopersicon esculentum Mill.). In the end, 40 experimental units consisting of five plants each were evaluated. The variables assessed were tomato productivity (PROD), fruit mass (FM), volume (VOL), fruit diameter (DIA), titratable acidity (TA), hydrogen potential (pH), soluble solids (° Brix), and soluble solids/titratable acidity ratio (SS/AT). The results showed that the irrigation level of 117.85% of ETc provide greater productivity for a cultivar RASTEIRO RIO GRANDE, while for CALINE IPA-7, it was 150% of ETc. The variety CALINE IPA-7 had higher acidity content and lower soluble solids/titratable acidity ratio. The addition of irrigation levels influenced a decrease in acidity content by applying levels of up to 125% of ETc.

Keywords: Evapotranspiration, Lycopersicon esculentum L., Northeastern semiarid.

RESUMO: Objetivou-se com esse trabalho avaliar lâminas de irrigação na cultura do tomateiro, utilizando canteiros econômicos com mulching. A pesquisa foi conduzida na Universidade Federal Rural de Pernambuco em Serra Talhada – Pernambuco. Utilizou-se delineamento em blocos casualizados sob parcelas subdivididas, em esquema fatorial (5 x 2), no qual, avaliou-se como parcelas 5 lâminas de irrigação (50, 75, 100, 125 e 150% da Evapotranspiração da Cultura - ETc), e subparcelas duas variedades de tomateiro RASTEIRO RIO GRANDE (RR) (Lycopersicon lycopersicum) e CALINE IPA- 7 (IPA) (Lycopersicon esculentum Mill.), com quatro repetições, totalizando 40 unidades experimentais. Foram avaliadas a produtividade do tomateiro (PROD), a massa dos frutos (MF), o volume (VOL), o diâmetro dos frutos (DIA), acidez titulável (AT), potencial hidrogeniônico (pH), sólidos solúveis (°Brix), e a relação dos sólidos solúveis com acidez titulável (SS/AT). Constatou-se que a lâmina de irrigação de 117,85% da ETc proporciona uma produtividade de 4,68 kg. planta-1 para a cultivar RASTEIRO RIO GRANDE, enquanto para a CALINE IPA-7 foi a de 150% da ETc. A variedade CALINE IPA-7 apresentou maior acidez e menor relação sólidos solúveis e acidez titulável. O acréscimo da lâmina de irrigação proporciona diminuição nos níveis de acidez ao se aplicar uma lâmina de até 125% da ETc.

Palavras-chave: Evapotranspiração, Lycopersicon esculentum L., Semiárido nordestino.

Protocolo 1241.22 - 2021-05-07- Aprovado em 27-12-2021
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Editor de área: Geocleber Sousa

INTRODUCTION

Irregularities in rainfall behavior and distribution across the semi-arid region of the Northeast of Brazil lead to severe drought periods, compromising agricultural food production when carried out in a rainfed system, especially for crops with high water demand (CASSIMIRO et al., 2019). According to Bispo et al. (2017) and Valeriano et al. (2016), irrigation is an important technique for water supply and optimizing the productivity of various crops, nevertheless, inadequate management of the irrigation system and culture can make the production process impracticable. Thus, the use of technologies and management to save water is needed.

According to Cassimiro (2019), the economic beds constitute a social technology that aims to mitigate the inefficient use of water for vegetables production. These types of beds prevent outflow by conditioning a waterproofing the planted land, in addition to subsurface irrigation that reduces evaporation losses. Baumgartner et al. (2007) affirm that the use of economic beds contributes to an increase in the quantity and quality of harvested products; another advantage is the low cost of these systems. Furthermore, if the economic beds are associated with the use of mulching (plastic covering), whose purpose is to maintain moisture when on the ground, it will be possible to promote water savings without losses in plant yield and food quality (YURI et al., 2012). Among the most cultivated crops in economic beds, tomato plant has great water demand. Thus, the correct use of water can promote better productivity. In this sense, studies are testing different irrigation levels in tomato plants (SANTIAGO et al., 2018; SILVA et al., 2020 & SOARES et al., 2013); however, studies on economic beds using mulching were not found in the available scientific literature.

It is believed that with the reduction of evapotranspiration, lower irrigation levels can provide similar productivity and fruit quality.

Hence, the objective of this study was to evaluate different irrigation levels in the tomato crop, using the economic beds with mulching in order to find the irrigation levels that provide the highest productivity and fruit quality under these conditions.

MATERIAL AND METHODS

The experiment was conducted from August 2018 to March 2019, at the Federal Rural University of Pernambuco, at the Serra Talhada Academic Unit (UFRPE/UAST), in the municipality of Serra Talhada, located at the geographic coordinates of 7°57'10" S and 38°17'43" W, at an altitude of 429 meters (SIRGAS 2000), in Mesoregion of Sertão Pernambucano, Brazil. According to the classification of Köppen, the climate type in the region is BSw'h'. The average annual rainfall is 639 mm, with an average annual temperature of around 25.2ºC (LAMEPE/ITEP, 2017).

A randomized block design within a split-plot had run in a 2 x 5 factorial treatment scheme structure, with four replications. The plots were the five irrigation levels (50, 75, 100, 125, and 150%) of crop Evapotranspiration (ETc), and subplots were two tomato varieties RASTEIRO RIO GRANDE' (Lycopersicon lycopersicum) and ''CALINE IPA- 7' (Lycopersicon esculentum Mill.). In the end, 40 experimental units consisting of five plants each were evaluated.

Twenty beds of 3m² (3m x 1m), 0.20 m deep were built, leveled in transverse and longitudinal directions, to keep each layer level, favoring a uniform distribution of water (WIN, 2007). Subsequently, they were filled with substrate prepared in the proportion of 2:3:4, of sand, soil, and cattle manure, respectively, mixed until homogenized. The coverage with mulching was carried out after the beds' installation.

The seedlings were produced in plastic trays, cultivated in sand and humus substrate (2:1), keeping it always moist, in a protected environment, and covered by shading at 50% for 15 days after germination and then 25% for another 12 days. The seedlings of the two varieties were distributed equidistantly in the

beds every 0.3 m, totaling ten plants per bed, with five plants for each cultivar.

Irrigation levels were calculated based on the crop evapotranspiration (ETc) according to the equation proposed by Allen et al. (1998). The reference evapotranspiration was determined by the Class A Tank methodology.

At harvest time, the tomato productivity was evaluated, according to Alvarenga (2004), obtaining the commercial fruits in each treatment. The fruits mass (FM) was determined using a semi-analytical balance. The volume (VOL) was determined with the aid of a cup of water, in which the fruits were immersed.

For the VOL calculation, the initial level of the water was subtracted from the final level of the immersion. Fruit diameter (DIA) was obtained using a caliper. From the fruit mass, it was possible to determine the productivity of fruit per plant (PROD). Additionally, the quality parameters of tomato fruits were obtained, such as titratable acidity (TA), Hydrogen Potential (HP), soluble solids (°Brix), and soluble solids/titratable acidity ratio (SS/TA), according to Adolfo Luts Institute's methodology for food analysis (2008).

The results were submitted to analysis of variance to evaluate the effects of different irrigation levels and cultivars. When significant, the effects of irrigation regimes were assessed by regression analysis using the SIGMA PLOT 12.0 software. For the effect of the cultivars, the Tukey test was adopted, at 5% probability, using the statistical program Sisvar 5.6 (FERREIRA, 2019).

RESULTS AND DISCUSSION

The results from the analysis of variance demonstrated that the variables FM, VOL, and PROD had a significant effect ($P<0.01$). There was an interaction between irrigation levels and cultivars only for variable productivity ($P<0.01$) (Table 1)

Table 1. Analysis of variance table of the variables: Fruit mass (FM), fruit diameter (DIA), fruit volume (VOL), and productivity (PROD) of tomato under different irrigation levels.

SV	DF	FM (g)	DIA (cm)	VOL (cm^3)	PROD (kg $plant^{-1}$)
		MS			
Block	3	149.8323^{ns}	0.4270^{ns}	164.1358^{ns}	1.5582^{ns}
Levels (L)	4	427.4545**	0.9781^{ns}	476.0267**	17.5440**
Error 1	12	59.3241	0.3334	61.2758	1.6076
Cultivar (C)	1	188.4428^{ns}	0.0001^{ns}	202.9502^{ns}	2.7984^{ns}
C * L	4	24.6096^{ns}	0.2751^{ns}	22.1052^{ns}	5.9712**
Error 2	15	44.16	0.2551	49.6761	0.7609
CV 1 (%)	-	17.45	14.39	17.76	44.41
CV 2 (%)	-	15.06	12.41	15.99	30.55

** significant at 1% probability; ns - not significant, by the F test; SV – Source of Variation; DF – Degree of freedom; CV – Coefficient of variation; MS - Mean square.

According to Figure 1, there was a linear increase for both volume (A) and fruit mass (B) of tomato on irrigation levels used in the experiment.

Although the irrigation levels are greater than 100% of the recommended ETc, the increase in water availability can provide a higher volume to the fruits due to the source and drain relation in the water movement in the plant, also providing greater weight. Furthermore, the level corresponding to 150% of ETc provided increases in the variables VOL (A) and FM (B), of 20.5 and 18.5%, in relation to the level of 100%.

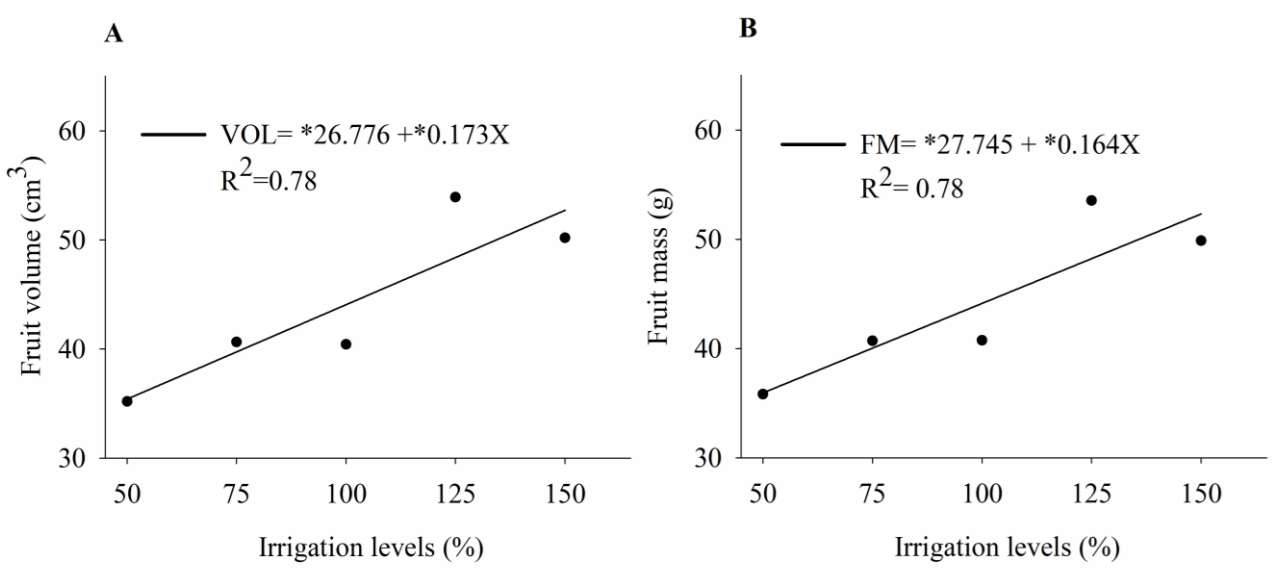

Figure 1. Volume (A) and mass (B) of Tomato fruit on different irrigation levels.
* Significant coefficient at 5% probability.

Ansary et al. (2017) affirm that the increase in the weight of fruits per plant could be related to an improved microclimate, below and above the soil surface, using plastic coverings. In this investigation, economical beds and plastic cover were used, which probably have led to a lower water loss from the soil to the atmosphere, granting the proper crop supply and favoring higher yields. A similar effect was observed by Bin et al. (2021) when testing different water replacements with and without the use of plastic cover in tomato plants. These authors noted that the increased water availability expanded the tomatoes' productivity, and the use of plastic covering provided greater results. Figure 2 shows the tomato productivity under different irrigation levels. It was observed a linear increase of the variety CALINE IPA-7 (IPA) cultivated with a maximum yield of 4.44 kg plant-1, using the 150% ETc level. Silva et al. (2014), who worked with the same cultivar, found a lower productivity than observed in this study. The referred authors obtained a value of 1.94 kg plant-1 for an irrigation level of 150% of the ETc, with a productive increment of 110% in relation to the depth of 50 %. Whereas, in this study, a productivity had an increment of 590% compared to the same level.

For the variety RASTEIRO RIO GRANDE (RR) (Figure 2), a quadratic behavior was observed, maximum productivity (4.68 kg plant-1) with estimated irrigation levels, corresponding to 117.85% of the ETc was obtained. According to Silva et al. (2020), who studied the development of industrial tomato under different irrigation levels using the BRS Sena hybrid, the excess and deficit of water affect the development of the tomato, including flowering and fruiting of the crop, directly affecting its productivity.

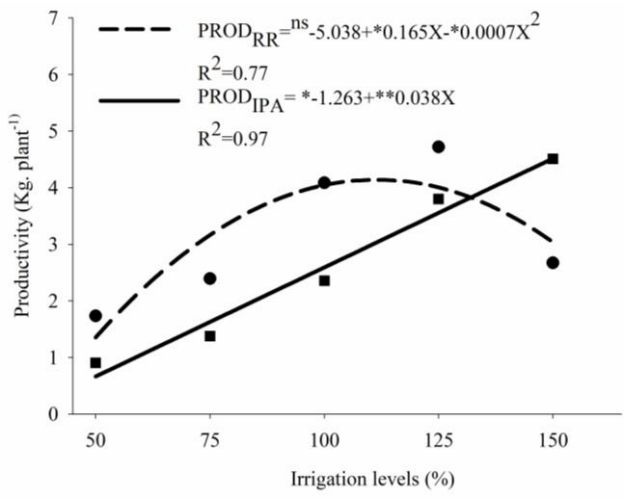

Figure 2. Productivity of tomato cultivars under different irrigation levels.
* Significant coefficient at 5% probability; and ** 1% probability.

Table 2 shows the analysis of variance of qualitative parameters of tomato. The results indicated a significant effect just for titratable acidity (TA) on level (L). About the factor cultivar (C), only the variables titratable acidity (TA) and soluble solids/titratable acidity ratio (SS/TA) differed significantly (P<0.01).

Table 2. Analysis of variance table of the variables: titratable acidity (TA), soluble solids (SS), pH and soluble solids/titratable acidity ratio (SS/TA) of tomato plants submitted to different irrigation levels.

SV	DF	pH	SS	TA	SS/AT
		MS			
Block	3	0.03347^{ns}	0.3752^{ns}	0.0402^{ns}	5.2906^{ns}
Level (L)	4	0.0244^{ns}	1.3856^{ns}	0.0857*	4.0513^{ns}
Error 1	12	0.0158	0.4483	0.0229	1.8015
Cultivar (C)	1	0.0164^{ns}	0.4622^{ns}	0.4553**	69.1926**
C * L	4	0.0099^{ns}	0.0460^{ns}	0.0203^{ns}	2.5300^{ns}
Error 2	15	0.0171	0.3592	0.0224	2.6156
CV 1 (%)	-	2.98	7.44	17.30	12.55
CV 2 (%)	-	3.10	6.66	17.09	15.12

* Significant coefficient at 5% probability; ** significant at 1% probability; ns - not significant, by the F test; SV – Source of Variation; DF – Degree of freedom; CV – Coefficient of variation. MS - Mean square

When analyzing the factor Cultivar (C), it was noticed that the variety CALINE IPA-7 presented a higher acidity content (Figure 3A), which probably led to a lower soluble solids/titratable acidity ratio (Figure 3B). According to Vieira et al. (2014), tomato fruits could be considered mild flavor when they have a SS/TA ratio greater than ten due to the excellent combination of sugar and acid, as observed in the fruits of the cv. RR. On the other hand, values lower than ten could lead to fruit with an unpleasant or astringent taste, as the fruits of the cv. IPA.

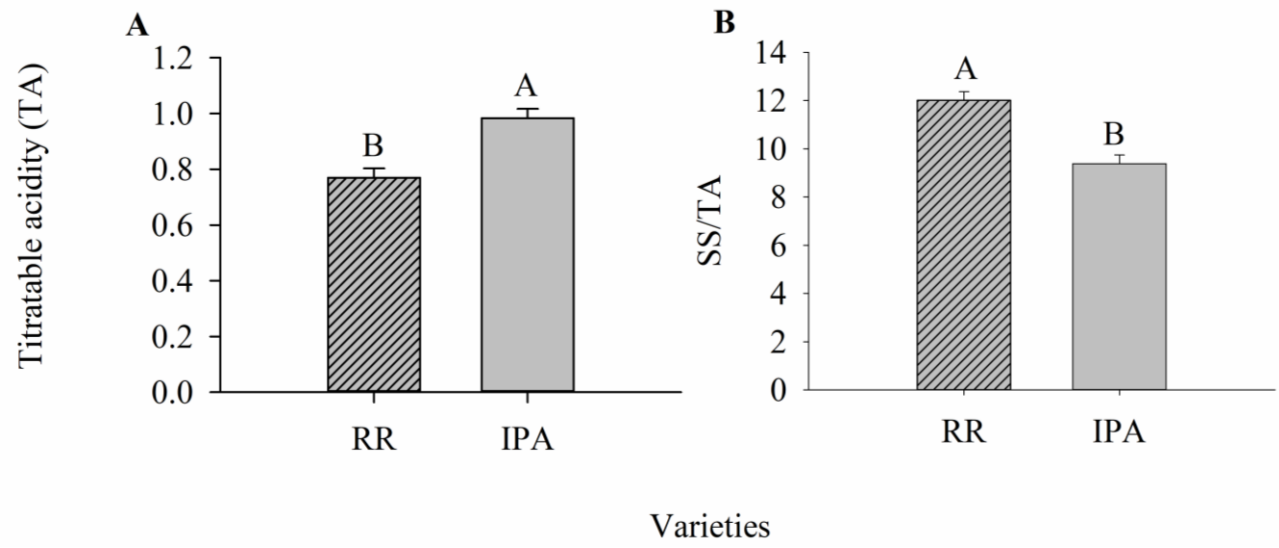

Figure 3. Titratable acidity (TA) and soluble solids/titratable acidity ratio (SS/TA) for tomato under different irrigation levels. (Different letters indicate statistical difference by Tukey test, $p<0.05$).

Regarding the acidity of tomato fruits, it was noticed (Figure 4) that the increase in the irrigation levels provided a quadratic decrease in the titratable acidity levels, obtaining the lowest result when applying 125% of ETc. Likewise, Santiago et al. (2018), when testing irrigation levels in tomato plants in a protected environment and open field, observed a reduction in titratable acidity with increasing levels, indicating that the higher the level of water replacement, the lower the content of soluble acids in the tomato fruits.

Furthermore, Marquelli & Silva (2008) noted that higher soil water tensions provided linear growth in titratable acidity.

Portes et al. (2006) point out that under conditions of low water availability in the soil, various metabolic processes of plants are affected, leading to reductions of stomatal conductance, photosynthesis, and transpiration, and stomatal closure. As consequence, it can reduce the fruit quality, producing, for example, fruits with high acidity.

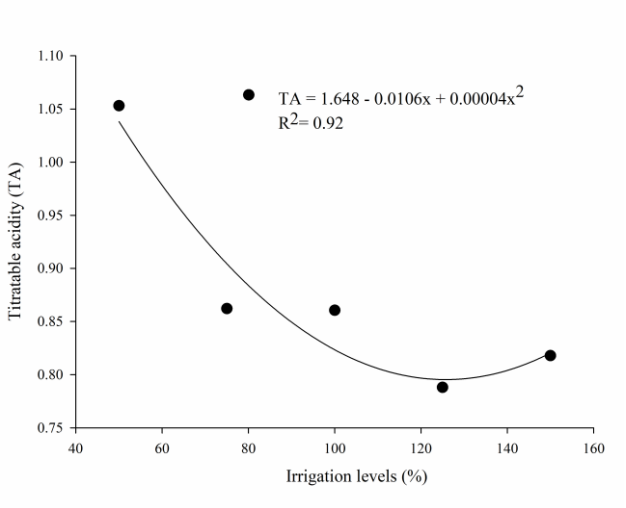

Figure 4. Titratable acidity depending on the different irrigation levels.
* significant at 5% probability; ns not significant.

CONCLUSION

The irrigation levels of 117.85% of ETc provide the yield of 4.68 kg. Plant-1 for the cultivar 'RASTEIRO RIO GRANDE' while for the 'CALINE IPA-7', it was 150% of Etc. The variety CALINE IPA-7 exhibited higher acidity 18ontente and lower soluble solids/titratable acidity ratio. The addition of irrigation levels influenced a decrease in acidity 18ontente by applying levels of up to 125% of Etc.

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