

## Soil mulching and deficit irrigation with wastewater in the quality of Italian zucchini

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### ABSTRACT

Conscious agricultural management, which aims to conserve natural resources, has been the target of contemporary agriculture. In this context, the reuse of water in deficit water depth in agricultural irrigation becomes a viable technique, and this work aimed to evaluate the effect of different irrigation depths with wastewater and soil mulching on the microbiological and postharvest characteristics of the Italian zucchini. The experiment was conducted in the field conditions with a randomized block design in a split-plot arrangement. Four irrigation depths (100%, 85%, 70%, and 55% of the estimated ET<sub>c</sub> from the Class A Evaporation Pan) and three types of soil mulching (rice husk, double-sided black and white polyethylene film, and uncovered soil) were analyzed. Texture, titratable acidity (TA), soluble solids content (°Brix), pH, and the °Brix:TA ratio of the Italian zucchini were analyzed, besides the microbiological analysis. The irrigation depth or soil mulching did not influence the pH of the Italian zucchini. The uncovered soil promoted higher titratable acidity to the Italian zucchini. The texture of the fruit, the soluble solids, and the °Brix:TA ratio was influenced by the types of soil mulching and irrigation depths. The use of wastewater for drip irrigation reduces the effects of the microbial load on the crop.

**Keywords:** *Cucurbita pepo*, physical-chemical, microbiological, postharvest.

### Cobertura de solo e irrigação deficitária com água residuária na qualidade de abobrinha italiana

#### RESUMO

O manejo agrícola consciente, que almeja a conservação dos recursos naturais, vem sendo o alvo da agricultura contemporânea. Neste contexto, a reutilização da água em lâminas deficitárias na irrigação agrícola torna-se uma técnica viável e este trabalho teve como objetivo avaliar o efeito de diferentes lâminas de irrigação com água residuária e coberturas do solo na característica microbiológica e de pós-colheita da abobrinha-italiana. O experimento foi conduzido em campo com delineamento experimental em blocos casualizados com parcelas subdivididas. Analisou-se quatro lâminas de irrigação (100%, 85%, 70% e 55% da ET<sub>c</sub> estimada a partir do tanque “Classe A”), e três tipos de coberturas do solo (casca de arroz, filme de polietileno dupla face preto-branco e solo descoberto). As variáveis analisadas foram: textura, acidez titulável, sólidos solúveis, pH, índice de maturação e análise microbiológica da abobrinha-italiana. O pH da abobrinha-italiana não foi influenciado pela lâmina de irrigação, nem pela cobertura do solo. O solo descoberto promoveu maior acidez titulável à abobrinha-italiana. A textura do fruto, os sólidos solúveis e o índice de maturação foram influenciados pelos tipos de cobertura do solo e lâminas de irrigação. O uso de água residuária na irrigação por gotejo reduz os efeitos da carga microbiana da cultura.

**Palavras-chave:** *Cucurbita pepo*, físico-químicas, microbiológicas, pós-colheita.

## 1. Introduction

Italian zucchini (*Cucurbita pepo*) belongs to the class of dicots, which have high morphological variability and include many economically essential vegetables (Martínez-Valdivieso et al., 2015). The genus *Cucurbita* contains 960 species, including cucumber, chayote, watermelon, and melon. In Brazil, three species of zucchini occupy a significant portion of agribusiness: *C. moschata*, *C. maxima*, e *C. pepo* (Stipp et al., 2012; Sim et al., 2015).

The commercial product of the zucchini plant is an immature fruit, with a very tender pulp (Cardoso and Pavan, 2013), and the carbohydrates are the main components that represent between 85-90% of the total dry matter (Oloyede et al., 2012). It is a great option for producers, as it has good acceptance in the market due to its mild flavor, and it can be grown at any time of the year, besides to its medicinal properties, such as its antiviral and antimicrobial capacity (Aliu et al., 2012; Blanco-Díaz et al., 2014). In olericulture, the use of crop management techniques has led to an increase in production, such as the use of soil mulching and the reuse of water, given the influential global appeal for the conservation of water resources.

The use of soil mulching acts as an insulating barrier between soil and atmosphere, providing basic conditions for the production of different vegetable species, and the quality acceptable to the consumer, with profitable levels of yield; and it can be carried out with organic material, in the form of straw, or inert materials, such as plastic films (Lucena et al., 2013; Yaghi et al., 2013). This practice reduces the use of labor for weeding; however, the use of labor is required for the installation of plastic mulch. Thus, the viability of this technique, despite the increase in production costs, is in the increase in income due to the early harvests, in the better quality of the fruits, in the higher yield and the socio-economic development of agriculture for promoting the efficient use of water (Yang et al., 2015).

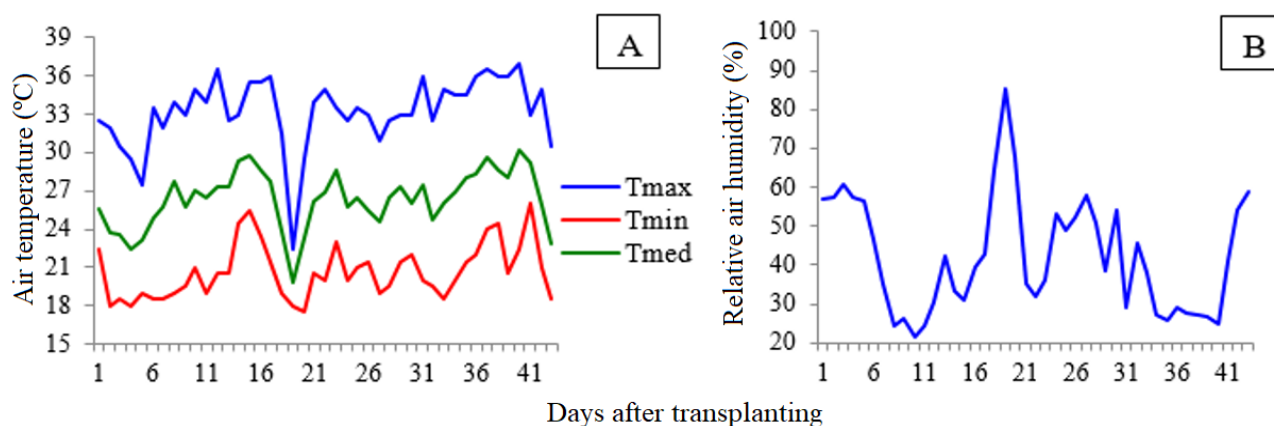
For irrigation with the application of effluents, the most appropriate method is drip, as it provides less chance of contamination by farmers and consumers, by applying water directly to the soil and having a high efficiency of use (Sales and Román, 2019; Gatta et al., 2015), besides providing higher productivity, enabling the method with economic, social and environmental gains (Malafaia et al., 2016). In the Italian zucchini crop, localized irrigation promotes the adequacy of water consumption; therefore, drip irrigation is a viable alternative due to the high potential for minimizing negative impacts caused to the soil (Bernardo et al., 2019).

The main objective of contemporary agriculture is the development of new techniques that increase the productivity and quality of crops with the rational use of resources, especially water resources, is increasingly concerned with investing in technologies and management that lead to increased productivity, reducing production costs, and sustainably improving product quality.

Given this context, the present study aims to evaluate the effect of different irrigation depths with wastewater and soil mulching on the quality of Italian zucchini.

## 2. Material and Methods

The experiment was conducted under field conditions at the State University of Goiás - UEG, Campus of Exact and Technological Sciences - Henrique Santillo, Anápolis-GO (16°20'34" S, 48°52'51" W, and 997 m above sea level), from September to October 2015. According to the Köppen classification, Anápolis has a climate of Aw-type, with warm, from humid to semi-arid climatic characteristics and a seasonal tropical climate, with a well-defined rainfall regime. The maximum, minimum, and average temperature and relative air humidity after transplanting of Italian zucchini seedlings are shown in Figure 1A e 1B, respectively.



**Figure 1.** Daily maximum, minimum, and average air temperature (A), and average relative air humidity (B) after transplanting the Italian zucchini seedlings.

The soil in the experimental area is classified as a Latossolo Vermelho (Oxisol) with a sandy clay loam textural class. The physical-chemical characteristics of the soil in the 0.0-0.40 m layer before the implementation of the experiment were: pH: 5.0, potassium ( $\text{cmol}_c \text{dm}^{-3}$ ): 0.18, calcium ( $\text{cmol}_c \text{dm}^{-3}$ ): 2.4, magnesium ( $\text{cmol}_c \text{dm}^{-3}$ ): 1.0, phosphorus ( $\text{mg dm}^{-3}$ ): 11.0, sodium ( $\text{mg dm}^{-3}$ ): 1.0, iron ( $\text{mg dm}^{-3}$ ): 9.8, sulfur ( $\text{mg dm}^{-3}$ ): 6.0, copper ( $\text{mg dm}^{-3}$ ): 2.3, base saturation (V%): 48.0, clay (%): 31.0, silt (%) 16.0, sand (%): 53.0, organic matter (%): 2.7. The necessary corrections were made according to the soil analysis, and the fertilization was carried out based on the recommendations. The fertilization before the seedling transplanting was carried out following the recommendations of Trani et al. (2014) for the cultivation of Italian zucchini, which is 40 kg ha<sup>-1</sup> of N, 240 kg ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub> and 80 kg ha<sup>-1</sup> of K<sub>2</sub>O.

A randomized block design in a split-plot arrangement with four replications was used. The treatments were four irrigation depths (100%, 85%, 70%, and 55% of the crop evapotranspiration) arranged in the plots and three types of soil mulching (rice husk, black and white double-sided low-density polyethylene film (LDPE), and uncovered soil) in the subplots, totaling 12 treatments.

The experimental plots consisted of two rows, and spacing between rows and plants was 1.0 m and 0.80 m, respectively. Each row had four useful plants, and a row of plants around the entire experiment was considered as a border. The transplanting of seedlings (produced in coconut fiber substrate) of the Italian zucchini (Caserta CAC cultivar) occurred when the seedlings had three fully expanded leaves.

The wastewater used for irrigation came from the domestic sewage of UEG/CCET. The effluent used was stored in a covered reservoir with a lid close to the experimental area, and the analysis of the physical and chemical attributes was performed only once (Table 1). The analyzes follow the recommendations of the AWWA (America Water Works Association).

A drip irrigation system was installed, using tubes with in-line surface drippers, the spacing between emitters of 0.4 m, a flow rate of 3.7 L h<sup>-1</sup>, Drip-plan, Assif model, the working pressure of 10 kPa, installed at 0.05 m from the plant row. The irrigation system was semi-automated with a control panel, containing a HUNTER controller, XC 8 stations 201 IE, four Hunter SRV 6.8 m<sup>3</sup> h<sup>-1</sup> BSP solenoid valves. The motor pump used was Thebe TH 16 AL, 2.0 CV, three-phase; after the pump, a 125-micron disc filter, a pressure regulator, a pressure gauge, and four globe valves (one per experimental plot) were installed. The use of disc filters and their cleaning at each irrigation was responsible for the distribution uniformity values (DU), which were around 95% throughout the experiment.

**Table 1.** Qualitative parameters of wastewater used in irrigation.

Analyzed Parameter	Unit	Wastewater
Total Boron	mg L <sup>-1</sup>	0.4
Calcium	mg L <sup>-1</sup>	2.4
Electrical	dS m <sup>-1</sup>	2.44
B.O.D.	mg L <sup>-1</sup>	74.6
C.O.D.	mg L <sup>-1</sup>	124.1
Total Phosphorus	mg L <sup>-1</sup>	33.9
Magnesium	mg L <sup>-1</sup>	1.0
Nitrate	mg L <sup>-1</sup>	34.90
Nitrite	mg L <sup>-1</sup>	19.1
Dissolved oxygen	mg L <sup>-1</sup> de O <sub>2</sub>	1.40
pH	-	6.4
Potassium	mg L <sup>-1</sup>	1.02
Total Sodium	mg L <sup>-1</sup>	66.0
Turbidity	N.T.U	31.5
Total Coliforms	M.P.N. 100	7.76 10 <sup>5</sup>
<i>Escherichia Coli</i>	M.P.N. 100	5.69 10 <sup>5</sup>
S.A.R.	(mmolc L <sup>-1</sup> ) <sup>1/2</sup>	9.66

B.O.D.: Biochemical Oxygen Demand, C.O.D.: Chemical Oxygen Demand, M.P.N.: Most Probable Number, N.T.U.: Nephelometric Turbidity Unit, S.A.R.: Sodium Adsorption Ratio.

The differentiation of the irrigation depths, according to the treatments, occurred on the seventh day after transplanting (DAT), so that there was a high survival rate. Irrigation management was carried out based on the Class A Tank method (Bernardo et al., 2019), with a fixed irrigation frequency, once every three days. The application of 55%, 70%, 85%, and 100% of the crop evapotranspiration (ET<sub>c</sub>) was equivalent to the following irrigation depths: 156.9 mm, 199.3 mm, 242.2 mm, and 285.3 mm.

The fruits were harvested every two days after the beginning of production. A cut was made on the fruit stalk with a knife to remove the fruit. After harvest, the fruits were taken to the Agricultural Products Post-Harvest Drying and Storage Laboratory (UEG/CCET) for physical-chemical analysis. The titratable acidity (g of ascorbic acid 100g<sup>-1</sup> of pulp) was determined by titrating five grams of homogenized pulp and diluted to 100 ml of distilled water, with standardized 0.1 mol L<sup>-1</sup> sodium hydroxide (NaOH) solution, using phenolphthalein as an indicator. The soluble solids (°Brix) was determined using an Abbe digital benchtop refractometer. The texture (cN) was determined using the Brookfield CT3 50K texture analyzer, and the pH was measured by direct reading in homogenized pulp solutions, using the Digimed pH meter DMPH-2 model. The °Brix/TA ratio was determined by the relationship between the soluble solids content (°Brix) and the titratable acidity (TA) (AOAC, 2012).

For microbiological analysis, one sample per subplot was placed in sterile plastic bags, and 150 ml of peptone water were added and stirred for two minutes. After this procedure, the samples were sonicated for five minutes at 25 kHz in an ultrasonic bath in a UNIQUE brand

sonicator. Then, 100 mL of the sonicated peptone water was distributed in multiple tubes, following the recommended methodology for water analysis, and the most probable number (MPN mL<sup>-1</sup>) of coliforms in solution was determined (Franco and Landgraf, 1996).

The data were submitted to analysis of variance ( $P < 0.05$  and  $P < 0.01$ ). The variables with significant effect were submitted to regression analysis (quantitative) and Tukey-test (qualitative) at 5% probability, using the SISVAR 5.3 Software (Ferreira, 2019).

### 3. Results and Discussion

The summary of the analysis of variance of the postharvest variables of the Italian zucchini related to the fruit texture (FT), the potential of hydrogen (pH), soluble solids content (SS), titratable acidity (TA), and the soluble solids content:titratable acidity ratio ( $^{\circ}$ Brix:TA) is shown in Table 2. There was an influence of significant interaction between the types of soil mulching and irrigation depths on FT, SS, and  $^{\circ}$ Brix:TA. The evaluated factors did not influence the pH, and the soil mulching influenced the titratable acidity.

The treatment with uncovered soil had the highest average fruit texture (445.0 cN) when subjected to the irrigation depth of 100% ETc was applied. The lowest average fruit texture (355.0 cN) was observed in the treatment with rice straw and the irrigation depth of 55% ETc (Figure 2A). The lowest values of fruit texture were observed when the irrigation depth of 55% ETc was applied, with values of 365 cN and 368.5 cN in the soil mulching with polyethylene film and uncovered soil, respectively.

The highest averages of fruit texture were found in the irrigation depth of 85% ETc, with the soil mulching with polyethylene film (426.25 cN) and with rice straw (435.00 cN). Fruits harvested with greater firmness of the pulp generally have greater conservation and postharvest shelf life, because the firmer fruits are more resistant to mechanical injuries during transport and commercialization (Medeiros et al., 2012; Martínez-Valdivieso et al., 2015).

Medeiros et al. (2012) observed that pulp firmness of melon decreased with the increase in irrigation. Araújo and Botrel (2010), studying the effect of the irrigation depth on melon, concluded that the different irrigation depths applied to the melon culture did not significantly influence the pulp firmness. Also, pH was not influenced by the irrigation depth, with an average of 6.74, a result that was also observed in this study. The pH values were not influenced by the irrigation depths and type of soil mulching, with an average value of 6.61. However, Faria et al. (2015) found that the pH was influenced by the irrigation depth, with an average of 7.32 in melon fruits.

According to Medeiros et al. (2012), the pH tends to increase due to an increase of the irrigation depth, since it exerts a dilutive factor in the components of the fruits. This variation in the results is mainly due to differences in the morphology of the vegetables and mainly to each morphotype characteristic of the Italian zucchini (Martínez-Valdivieso et al., 2015).

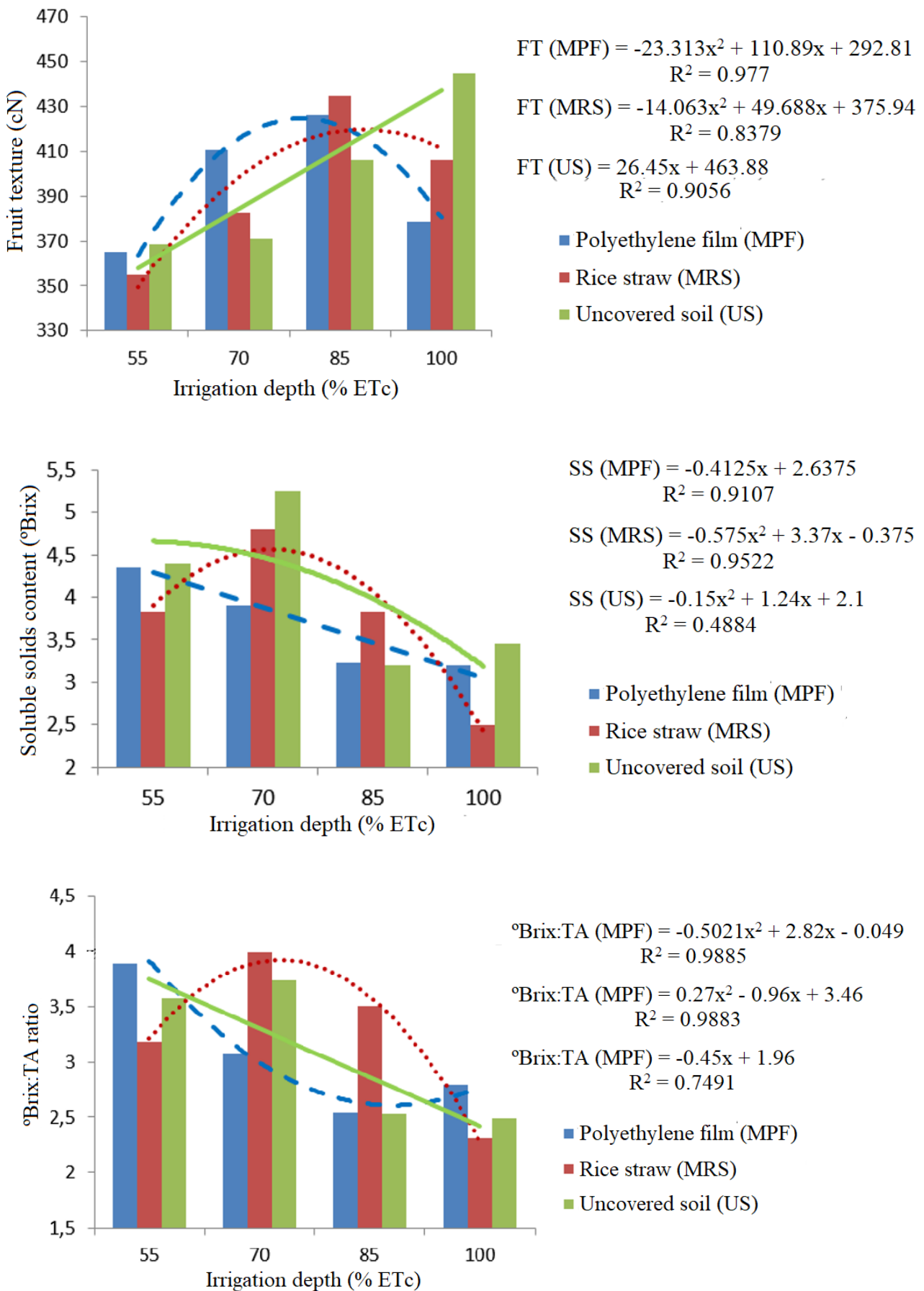
The average value of the soluble solids content (SS) was 3.82  $^{\circ}$ Brix, and the maximum SS value was 5.25  $^{\circ}$ Brix in fruits grown on uncovered soil and with an irrigation depth of 70% ETc. The lowest SS value was 2.82  $^{\circ}$ Brix, in the treatment with irrigation depth of 100% ETc and soil mulching with rice straw. The decrease in the SS content according to the increase of irrigation depth may be related to the reduction in the concentration of the elements that originate mainly sugars, due to the higher availability of water in the plant and, therefore, in the fruits (Araújo and Botrel, 2010).

Medeiros et al. (2012) did not observe a significant change in the soluble solids content in melon fruits due to the irrigation depths. Dantas et al. (2011) evaluated the effect of irrigation depths and soil mulching with different types of polyethylene films and uncovered soil in melon crop and observed that the higher irrigation depth, the higher SS values. The same authors, when analyzing the types of plastic film, did not observe a significant effect on soluble solids content, confirming the importance of water management in standardizing the soluble solids content.

**Table 2.** Summary of analysis of variance expressed by the mean square of the variables: fruit texture (FT - cN), pH, soluble solids content (SS -  $^{\circ}$ Brix), titratable acidity (TA - g ascorbic acid 100g<sup>-1</sup> pulp) and the soluble solids content:titratable acidity ratio ( $^{\circ}$ Brix:TA).

Source of Variation	DF	FT	pH	SS	TA	$^{\circ}$ Brix:TA
Block	3	1,913.42	0.027	0.16	0.0097	0.059
Irrigation depth (D)	3	8,238.31**	0.250 <sup>ns</sup>	7.61**	0.0402 <sup>ns</sup>	3.318**
Error 1	9	1,384.60	0.194	0.37	0.0161	0.198
Soil Mulching (M)	2	43.19 <sup>ns</sup>	0.646 <sup>ns</sup>	0.64*	0.1546*	0.147 <sup>ns</sup>
D*M	6	2,369.91*	0.062 <sup>ns</sup>	1.01*	0.0220 <sup>ns</sup>	0.915*
Error 2	24	897.12	0.236	0.19	0.0295	0.271
C.V. 1 (%)		9.40	6.49	15.88	10.24	14.23
C.V. 2 (%)		7.57	7.15	11.50	13.82	16.62
Average		395.87	6.80	3.83	1.238	3.13

<sup>ns</sup> not significant ( $P > 0.05$ ), \* significant at 5% probability ( $P < 0.05$ ), \*\* significant at 1% probability ( $P < 0.01$ ). C.V.1 and C.V.2: Coefficient of variation of the plot and subplot, respectively.



**Figure 2.** Fruit texture (FT, cN), soluble solids content (SS, °Brix), and the soluble solids content:titratable acidity ratio (°Brix:TA) of Italian zucchini with different types of soil mulching and irrigation depths according to the ETC.

**Table 3.** Fruit texture (FT, cN), soluble solids content (SS, °Brix), and the soluble solids content:titratable acidity ratio (°Brix:TA) of Italian zucchini with different types of soil mulching and irrigation depths according to the ETc.

Soil mulching	Irrigation depth (% ETc)			
	55	70	85	100
FT (cN)				
Polyethylene film	Aa	Aa	Aa	Ab
Rice straw	Ba	ABa	Ba	ABab
Uncovered soil	Ba	Ba	ABa	Ab
SS (°Brix)				
Polyethylene film	Aa	Ab	Aa	Aa
Rice straw	ABa	Aa	Ba	Cb
Uncovered soil	Aa	Aa	Ba	Ba
°Brix:TA				
Polyethylene film	Ba	ABa	Ba	ABa
Rice straw	ABa	Aa	Aa	Ba
Uncovered soil	ABa	Aa	Ba	Ba

Means followed by the same lowercase letter do not differ concerning the different types of soil mulching, and means followed by the same uppercase letter do not differ concerning the irrigation depths, both by the Tukey test ( $P>0.05$ ).

There was no influence of irrigation depths on the titratable acidity of fruits, and the fruits had average values of 1.238 g ascorbic acid 100g<sup>-1</sup> pulp. However, even though there was no significant difference among the irrigation depths, the Italian zucchini fruits had higher values of titratable acidity (1.322 g ascorbic acid 100g<sup>-1</sup> pulp) when applied the irrigation depth of 70% ETc, and lower values (1.195 g ascorbic acid 100g<sup>-1</sup> pulp) when the irrigation depth of 55% ETc was applied.

Salata and Stepaniuk (2013), working with zucchini, cultivar Soraya, and the influence of drip irrigation on different variables, concluded that there was a lower concentration of ascorbic acid in fruits that were grown in the best humidity conditions.

The soil mulching influenced the titratable acidity (Table 4), the soil mulching with rice straw differed statistically ( $P<0.05$ ) from the uncovered soil, and the polyethylene film did not differ from the uncovered soil. Titratable acidity decreased 4.8%, from treatment with polyethylene film to treatment with rice straw, and increased 11.05%, from treatment with polyethylene film to uncovered soil.

In the treatment with uncovered soil, there were different values of °Brix:TA ratio concerning the different irrigation depths. The highest value of 3.57 was observed in the irrigation depth of 70% ETc, and the lowest value, 1.32, was found in the irrigation depth of 100% ETc. In the soil mulching with rice straw, the lowest average of °Brix:TA ratio was observed in the irrigation depth of 85% ETc, with a value of 1.09, and the highest average was found in the irrigation depth of 100% ETc, with the value of 2.30.

With the progressive ripening, there is a tendency to increase the sugar content in the watermelon and melon

fruits, increasing the titratable acidity; however, as the Italian zucchini is harvested immature, its values are lower than that of the melon and watermelon. Since patterns of this relationship for Italian zucchini are unknown, it is not possible to state that there was an improvement or worsening in the taste of the fruits, only that there was a change. However, in a study by Medeiros et al. (2012), no significant difference was found for the °Brix:TA ratio, indicative of fruit ripeness, concerning the irrigation depths for the melon crop.

Microbiological analyzes of Italian zucchini are shown in Table 5. The presence of Escherichia Coli was observed only with the use of irrigation depth of 85% ETc and in uncovered soil, which is probably due to contamination of the sample during fruit harvesting. In the other treatments, the presence of this microorganism was not found. The treatments with irrigation depth of 85% ETc and soil mulching with rice straw and polyethylene film had no presence of thermotolerant coliforms.

The use of drip irrigation may have contributed to reducing the effects of treated wastewater on the microbial load of the crop, a fact also described by Lonigro et al. (2016), which indicates the use of drip irrigation when wastewater is used in the irrigation of vegetables.

**Table 4.** 1 Titratable acidity (TA) of Italian zucchini grown with different types of soil mulching.

Soil covering	TA (g ascorbic acid 100g <sup>-1</sup> pulp)
Polyethylene film	1.212 ab
Rice straw	1.154 b
Uncovered soil	1.346 a

Means followed by the same letter do not differ by the Tukey test ( $P>0.05$ ).

**Table 5.** Most probable number (MPN) of fecal and total coliforms in the different treatments analyzed on Italian zucchini fruits.

Treatment	Thermotolerant Coliforms (MPN ml)	<i>Escherichia Coli</i>
100% ETc + MPF	16	Absent
100% ETc + MRS	<2	Absent
100% ETc + US	16	Absent
85% ETc + MPF	Absent	Absent
85% ETc + MRS	Absent	Absent
85% ETc + US	3	100
70% ETc + MPF	7	Absent
70% ETc + MRS	< 2	Absent
70% ETc + US	18	Absent
55% ETc + MPF	< 2	Absent
55% ETc + MRS	< 2	Absent
55% ETc + US	16	Absent

MPN: Most probable number, ETc: Crop evapotranspiration, MPF: Soil mulching with black and white double-sided low-density polyethylene film (LDPE), MRS: Soil mulching with rice straw, and US: Uncovered soil.

One of the limitations for the use of wastewater for irrigation is the potential for microbiological contamination of the producer, the soil and the food produced, due to the possibility of the presence of a wide spectrum of pathogenic agents, such as coliforms (Lonigro et al., 2016). In this sense, Brazilian legislation, through resolution n° 12, of January 2, 2001, establishes microbiological sanitary standards for food. In the case of fresh vegetables, they can present up to 102 MPN g<sup>-1</sup> of thermotolerant coliforms after sample incubation at 45°C (ANVISA, 2001).

Although there are no limits for total coliforms in Brazilian legislation, such analyzes were performed considering that the positive results (presence of total coliforms) indicate inadequate hygiene conditions of the place, the product, and the risk of the presence of pathogens in these foods. According to the legislation, the treatment with the irrigation depth of 85% ETc in uncovered soil was the only one that presented coliform count; however, this value is within the acceptable limit for consumption. The other treatments were considered adequate for consumption, according to the current legislation.

The absence of microbial contamination, likewise, was observed by Gatta et al. (2015) for the tomato crop irrigated with agro-industrial wastewater. These authors justified the good microbiological quality of tomato fruits due to the drip irrigation system.

Other research also found values within the standards established by the ANVISA Resolution when vegetables were irrigated with wastewater. This occurred in radishes irrigated with domestic wastewater (Dantas et al., 2014) and in bell pepper irrigated with swine wastewater (Souza et al., 2013).

Pereira et al. (2012), analyzing the sanitary quality of lettuce fertilized with septic tank effluent, observed that about 100% of the lettuce harvested in the experiment would not be accepted for human consumption. However, the microbiological analysis confirmed the

non-contamination by fecal coliforms. Carvalho et al. (2013) found results from thermotolerant coliforms lower than 3.0 MPN g<sup>-1</sup> when they evaluated the influence of wastewater reuse on the microbiological quality of sunflower.

#### 4. Conclusions

The irrigation depth did not influence the pH of the Italian zucchini with wastewater or soil mulching. The uncovered soil promotes higher titratable acidity to the Italian zucchini. Fruit texture, soluble solids contents, and the °Brix:TA ratio was influenced both by the types of soil mulching and by the irrigation depths with wastewater.

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