

EFFECT OF SEWAGE SLUDGE ON ITALIAN ZUCCHINI PLANTATION

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ABSTRACT

Italian zucchini is a very important crop due to its short cycle, high productivity and great market acceptance. Standing out as alternative to the increase in income of small farmers. The objective of this study was to evaluate the emergence and growth of Italian zucchini plants in substrates enriched with sewage sludge. The study was conducted in a greenhouse using Italian zucchini seeds, cv. Caserta purchased at a local commerce. The substrates were composed of dystrophic Yellow Red Latosol; sand and sewage sludge corrected with calcario in the proportions of 0; 40; 80; 120 and 240 t ha⁻¹, in a randomized block design. Each experimental plot was composed of six replicates. The following variables were analyzed: emergence, emergence velocity index, first leaf length, stem length, number of leaves, fresh and dry aerial plant part, volume and root dry mass. According to the results with the increase in the concentration of sewage sludge in the substrates, lower percentage values of emergence and emergence speed index were observed however favors the initial growth of Italian zucchini plants. It was verified that the post-seminal growth of Italian zucchini is viable in maximum concentration of up to 398.56 t ha⁻¹ of sewage sludge.

Keywords: Biosolids; *Cucurbita pepo* L.; Growth.

EFEITO DO LODO DE ESGOTO NA PLANTAÇÃO DE ABOBRINHA ITALIANA

RESUMO:

A abobrinha italiana é uma cultura muito importante devido ao seu ciclo curto, alta produtividade e ótima aceitação no mercado. Destacando-se como alternativa para aumento de renda de pequenos produtores. O objetivo deste trabalho foi avaliar a emergência e o crescimento de mudas de abobrinha italiana em substratos enriquecidos com lodo de esgoto. O estudo foi conduzido em casa de vegetação com sementes de abobrinha italiana, cv. Caserta comprada em um comércio local. Os substratos foram compostos por Latossolo Vermelho Amarelo distrófico; areia e lodo de esgoto corrigido com calcario nas proporções de 0; 40; 80; 120 e 240 t ha⁻¹, em delineamento de blocos ao acaso. Cada parcela experimental foi composta por seis repetições. Foram analisadas as seguintes variáveis: emergência, índice de velocidade de emergência, comprimento da primeira folha, comprimento do caule, número de folhas, parte aérea fresca e seca da planta, volume e massa seca da raiz. De acordo com os resultados obtidos com o aumento da concentração de lodo de esgoto nos substratos, menores valores

percentuais de emergência e índice de velocidade de emergência foram observados, porém favorece o crescimento inicial das abobrinhas italianas. Verificou-se que o crescimento pós-seminal da abobrinha italiana é viável na concentração máxima de até 398,56 t ha⁻¹ de lodo de esgoto.

Palavras-chave: Biossólidos; *Cucurbita pepo* L.; Crescimento.

1 INTRODUÇÃO

The *Cucurbitaceae* family, in the plant kingdom, stands out as one of the plant group that presents wide genetic diversity, comprising about 120 genera and more than 800 species (Teppner, 2004), with a worldwide production in 2018 of 27 millions of tons of pumpkins, grown in an area of 2 million hectares (IBGE, 2019).

In this family stands out the the Italian zucchini (*Cucurbita pepo* L.), cv. Caserta, popularly know as clotter zucchini, as a vegetable that has great acceptance in the Brazilian market, being a vegetable of great economic value, whose national production is approximately 228.500 tons, cultivated in more than 100.000 agricultural establishments. The species has develops well in autumn and spring and in mild winters in warmer regions, preferably under temperatures between 18 and 35 °C, in which it has higher productivity, which is 10 to 20 thousand tons per hectare. Its fruits are harvested immature, when the length is approximately 20 cm and mass between 200 and 250 g (FILGUEIRA, 2013; IBGE, 2019), mostly from small farms and from family labor.

Generally, the smaller fruits are soft tendered and with a softer and sweet flavor in relation to the larger ones, being among the ten most consumed vegetables, with high nutritional value and culinary versatility low caloric density vegetable, fiber source and excellent source of vitamin A. Pumpkin seed has distinct nutritional properties, energy source as a function of carbohydrate, protein and lipidcontent, being an alternative in the supply of nutrients in the diet of vegetarians and vegans (SOUZA et al., 2017; IBGE, 2019). However, in the southeast, it is recommended to plant between August to May (EMBRAPA HORTALIÇAS, 2010). Zucchini is between the ten vegetables with higher economic value, and is cultivated in the North, Northeast and most of the Southeast and Center-West regions of Brazil (CARPES et al., 2008).

To cultivate this species, high agronomic technology is not necessary, which makes it feasible as an alternative to increase financial income in small farms where it is predominantly cultivated. Although the cultivation of zucchini easily adapts to any type of soil, it develops better in arenaceous soils, with pH of 6 to 6.5 and with good drainage (FILGUEIRA, 2013; MAROUELLI et al., 2017).

Among the main factors for agricultural production, soil fertility stands out. Macro and micronutrients have specific and essential functions in plant metabolism. However, low agricultural production cannot be attributed only to the low levels of nutrients present in the soils, but also the inadequate use of fertilizers, especially those with N and K (MALAVOLTA, 2006; VALDERRAMA et al., 2011). Although phosphate fertilization is necessary, N is one of most required nutrients in crops, and in larger quantities for high yields in order to ensure maximum crop productivity (MALAVOLTA, 2006).

In farms, farmers have been emphasizing agriculture based on the management of materials already existing in rural properties, and for the cultivation of pumpkin, organic inputs such as cattle and poultry manure (ARMOND et al., 2016) are used in their availability. However, other organic wastes of plant and animal origin are used, as well as recycling products, such as biosolids. This alters soil organic matter, influencing their physical and biological properties depending on soil conditions, climate, pH, microorganisms present and cultural practices adopted, whose decomposition results in mineralization of the nutrients and their release to the plants (CARIDE et al., 2012; GROTTTO et al., 2013; OLIVEIRA et al., 2014; FREITAS et al., 2015).

Sewage sludge is a solid waste from the treatment of sanitary effluents, which presents diversity in its chemical and biological composition, with variations depending on the stabilization method and the treatments used. The use of these compounds as fertilizers is important because of their composition, diversity of chemical elements and high content of organic matter, which potentiates their use in agriculture (GROTTTO et al., 2013; FREITAS et al., 2015).

The objective of this work was to study the growth of Italian zucchini (*Cucurbita pepo* L.) plants grown in substrates enriched with sewage sludge.

2 METHOD

The study was conducted in the Laboratory of Seed Analysis and in a greenhouse on the campus of the Center of Agricultural Sciences of the Federal University of Espírito Santo (CCAUE-UFES), located in the municipality of Alegre-ES, geographic coordinates 20 ° 45'48 'S and 41 ° 31'57' 'O, with an altitude of 250 meters. The climate of the region is hot and humid in the summer, with dry winter, and with an average annual precipitation of 1,200 mm. The annual average temperature oscillates around 27 °C (INMET, 2017).

Italian zucchini (*Cucurbita pepo* L.) seeds, cv. Caserta used in this work were acquired in local commerce. The soil used was the Dystrophic Yellow Red Latosol, collected in the 15-60 cm layer, air dried, grounded and passed through a 4 mm sieve to obtain fine air-dried soil. The soil physical and chemical analyzes were done according to Embrapa (1997). The sewage sludge used was from the Sewage Treatment Plant (ETE) of Companhia Espírito Santense de Saneamento (CESAN) of Joana Dark, municipality of Vitória-ES, whose physicochemical and heavy metal analysis had: pH (H₂O) : 6.32; natural moisture: 98.12%; P: 856.24 mg dm⁻³; Ca: 62756 mg dm⁻³; Mg: 291.6 mg dm⁻³; Cu: 571.5 mg dm⁻³; Cr: 568.7 mg dm⁻³; Zn: 1010.9 mg dm⁻³; Co = 8 mg dm⁻³; Ni = 25 mg dm⁻³; Cd = 3 mg dm⁻³; Pb = 80 mg dm⁻³; Hg = 1.5 mg dm⁻³; Mn = 118 mg dm⁻³; Fe = 34 g dm⁻³.

The treatments were composed of substrates composed of 30% by Dystrophic Yellow Red Latosol, 10% sand, and sewage sludge in proportions of 0; 40; 80; 120 and 240 t ha⁻¹, based on the recommendations of Rolas (1994), totaling five substrates, which were sieved in 4-millimeter meshes. They were packed in plastic containers with a capacity of five dm³ and incubated for 20 days. After the substrate incubation period, sowing was carried out with five seeds per pot at a depth of approximately 20 mm, which were kept in a greenhouse covered with black polyolefin screens with 50% light retention. Plants were thinned 20 days after sowing, remaining the most vigorous in each pot.

Soil moisture during the experiment was maintained around 70% of the field capacity, considering that the plant presents a superficial root system, requiring frequent irrigations (FILGUEIRA, 2013). Field capacity (WC) was determined using Richards Extractor at ten kPa voltage (EMBRAPA, 1997). The experimental units were saturated to determine the irrigation depth and, after 24 hours, weight quantification was performed. The water retained in the vessel after this time interval was determined by weighing, and the weight found was considered as the soil weight in field capacity.

The experiment was a randomized complete block design (RCBD), composed of five treatments and six replicates. The variables analyzed were: emergence (%) - The count of the number of emergence seeds was performed daily until germination was constant, and was characterized by the protrusion of the primary root with a dimension ≥ 2.0 mm. The results were expressed as the emergence percentage; emergence speed index (ESI) - Determined along with the germination test by daily registering the number of seeds that presented primary root protrusion equal to or above two millimeters (MAGUIRE, 1962); length of the first leaf (cm); stem length (cm); number of leaves; Volume of leaves (mL plant⁻¹) -

Determined using the test tube method and fresh and dry aerial plant part (g). Fresh and dry matter of seedlings - Determined at 90 days after sowing with an analytical balance (0.0001 g). After the obtainment of the dry matter, the seedlings were stored in kraft paper bags and kept in a forced-air oven at 70 °C, until reaching constant weight (72 hours). The results were expressed as mg seedling⁻¹.

The data referring to the analyzed characteristics were transformed: emergence $Y = [\text{arc sine } (x/100) 1/2]$ and the others, by $[(x + 0.5) 1/2]$, observing the assumptions of the normality test, homogeneity of variance, and regression analysis for the quantitative data. The software R (R Development Core Team 2019) was used to analyze the data.1

3 RESULTS

In all the variables analyzed, the influence of sewage sludge was observed. With increasing concentration of sewage sludge in substrates, lower percentages values and emergence rate were observed (Figures 1A and 1B).

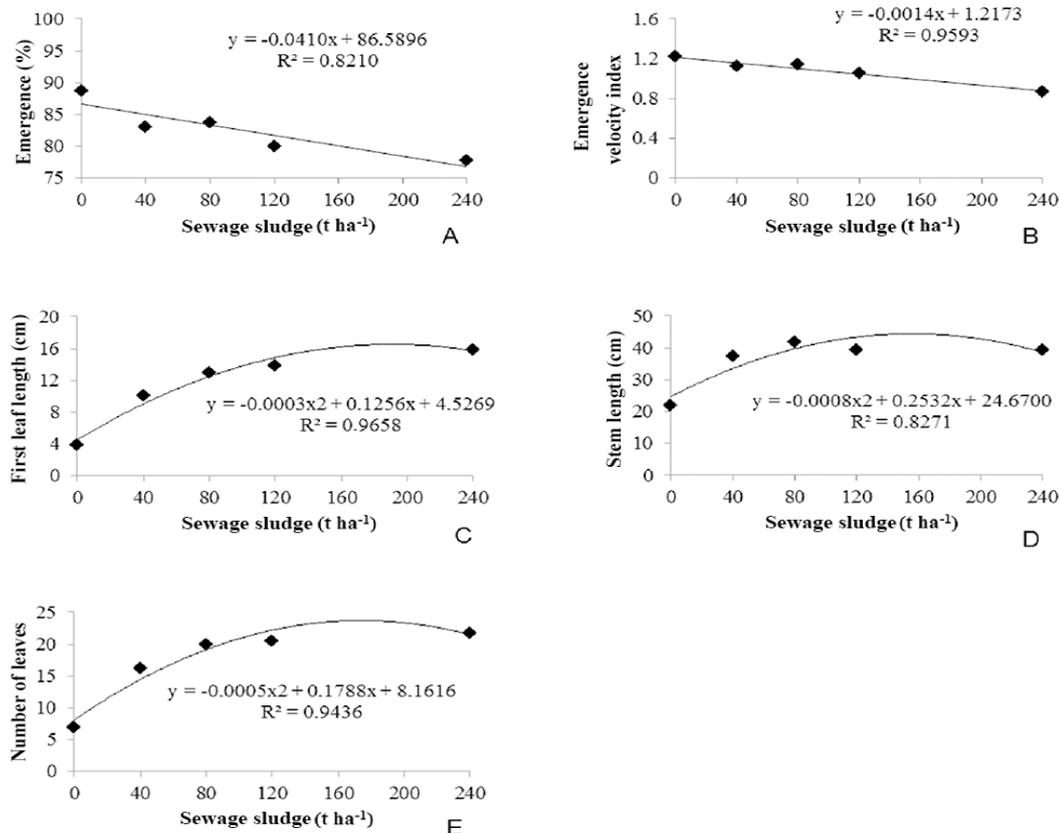


Figure 1. Emergence (A), emergence speed index (B), first leaf length (C), stem length (D), number of leaves (E) of Italian zucchini (*Cucurbita pepo* L.) as a function of the concentrations of sludge of sewage.

From the regression analysis, the highest averages for the length of the first leaf and stem length in Italian zucchini were observed in the concentrations of 452.04 t ha⁻¹ and 394.64 t ha⁻¹, respectively (Figure 1 C and 1 D) and for the leaf number in the concentration of 398, 56 t ha⁻¹ of sewage sludge (Figure 1 E). Therefore, the availability of essential elements for the plant led to greater growth.

The highest averages of fresh and dry aerial plant part were observed in the concentrations of 240 t ha⁻¹, as well as the highest mean root volume and root dry mass (Figure 2).

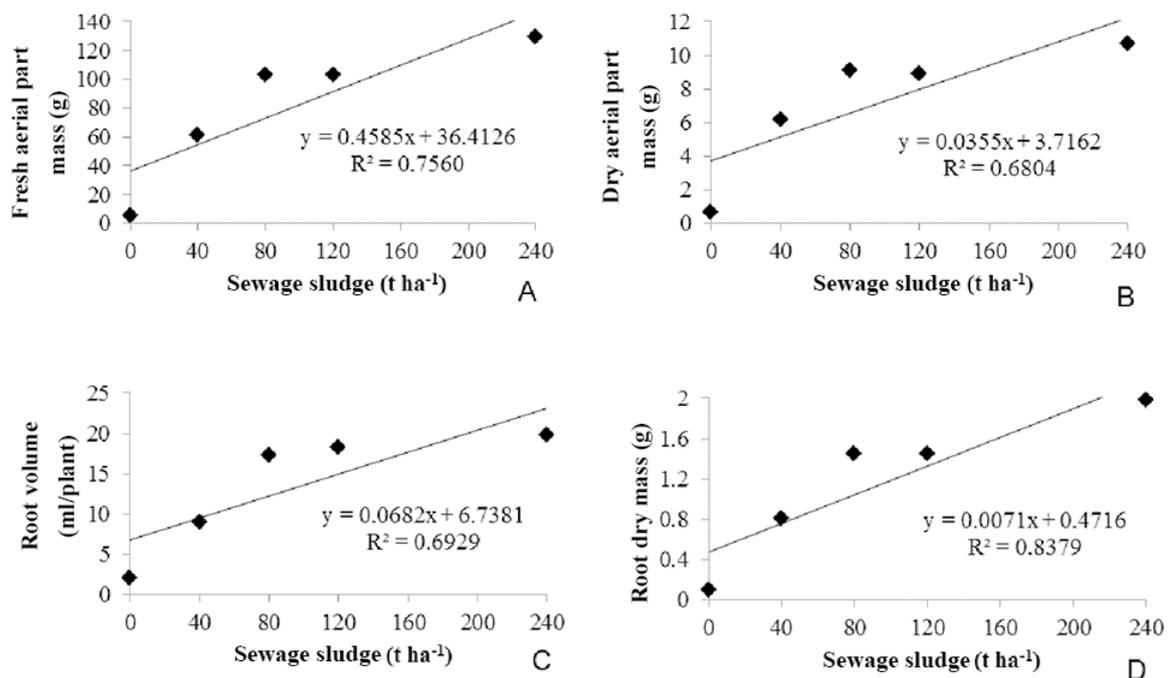


Figure 2. Fresh mass of aerial part (A), dry mass of aerial part (B), root volume (C), dry mass of root (D) of Italian zucchini (*Cucurbita pepo* L.) as a function of concentrations of sewage sludge.

The production data were not analyzed due to the prolonged period of high temperature in the environment, which resulted in flower abortion. The climatic conditions during the experiment are shown in Figure 3, and presented average temperature between 30 and 35 °C with a minimum of 19 °C and a maximum of up to 43 °C, with extremely low rainfall for the crop, although they were watered twice a day (8:00 a.m. and 5:00 p.m.).

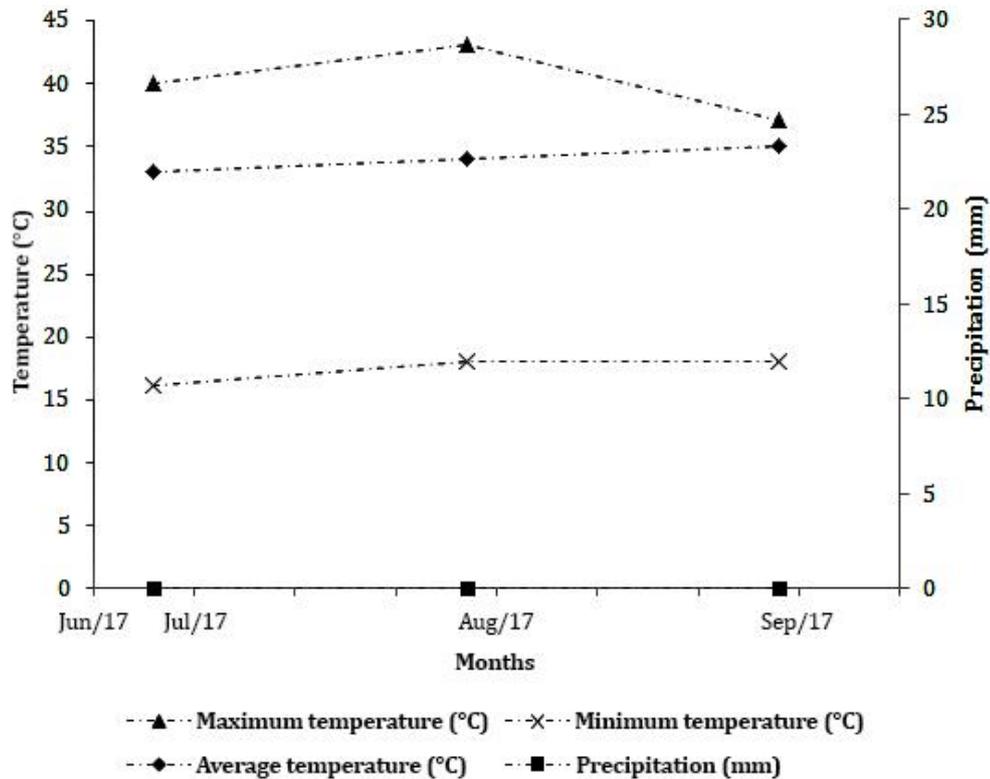


Figure 3. Maximum, minimum and average temperature (°C) and monthly rainfall (mm) in the greenhouse during the conduction of the experiment in CCAE-UFES, Alegre-ES, 2017.

4 DISCUSSION

With increasing concentration of sewage sludge in substrates, lower percentages values and emergence rate were observed. These results corroborate with those obtained by Freitas et al. (2015), when evaluating the emergence and growth of sweet passion fruit seedlings due to sewage sludge and light, verified that the treatments containing only sewage sludge presented lower averages of emergence and emergence speed index in relation to the control. A possible explanation for this plant behavior is their association with nutritional disorders due to the inadequate supply of elements, as verified by yellowing and shading of the seedlings and according to Taiz et al. (2017), these disorders are related to the roles developed by the element in the normal operation of the plant. Similarly, Rieling et al. (2014) observed a decrease in the germination percentage for the treatment composed of 100% of

sewage sludge, in relation to the treatment composed of 50% of sludge and 50% of soil for *Schinus terebinthifolius* Raddi.

Sewage sludge has shown to provide important macro and micronutrients for the plant, such as nitrogen, phosphorus and potassium, providing increases in the physical, chemical and biological properties of the soil (PINTO et al., 2014; FREITAS et al., 2015). The presence and level of N in plants are fundamental in the metabolic processes and influence the absorption and distribution of other nutrients. There is a high concentration of nitrogen in biosolids and cucurbitaceous, its increase increases leaf area, and consequently in the production of photoassimilates and fruit production (QUEIROGA et al., 2007). The authors verified the influence of N supply on the productive characteristics of hybrid pumpkin crop and number of fruits.

K is important in the regulation of osmotic potential, controlling the opening and closing of stomata, and the activation of enzymes involved in photosynthesis and respiration, while P is involved in metabolic processes such as cell division and expansion, respiration and photosynthesis (MALAVOLTA, 2006). Guard cell turgor pressure is a key parameter regulating stomatal control, and this in turn is mediated by ionic fluxes across the cell membranes through K^+ and anion channels (GARCIA-MATA et al., 2003).

Evaluating the initial growth and quality of *Jatropha* seedlings fertilized with domestic and industrial sewage sludge, Boechat et al. (2014) observed at the doses of 6.1 and 9.2 mg of domestic sewage sludge ha^{-1} , equivalent to 200 and 300 kg of total N ha^{-1} , the highest values for stem length; while for the number of leaves, the highest values were observed at the dose of 6.1 mg ha^{-1} , equivalent to 200 kg of total N ha^{-1} . According to Pôrto et al. (2012), the appropriate dose of N is according to the desired productivity, cultivar, management techniques, source and edaphoclimatic conditions. In the production of pumpkin seedlings, fertilizations with N, there was a linear increase in the accumulation of fresh and dry aerial plant part, height and number of leaves, with the use of doses of nitrogen (COSTA et al., 2017; MAROUELLI et al., 2017). Similarly, the nitrogen function was highlighted in the production components, both for fruit numbers and for productivity of the *Menina Brasileira* zucchini, with a linear increase, up to the dose of 200 kg ha^{-1} (AZAMBUJA et al., 2015).

The increase of biomass in the plant parts (Figure 2) is indicative of the beneficial effects, by the availability of nutrients to the plants, with the adjustment of the adequate doses of sewage sludge, mainly because the nutrients play an important role in the vegetal metabolism and in the aid of the synthesis and accumulation of carbohydrate (TAIZ et al., 2017). In the

hybrid pumpkin in N, followed by K was the most absorbed nutrients (ANDREAN et al., 2017; COSTA et al., 2017). Results that corroborate with observations by Ramos et al. (2010) in pumpkin culture. However, considering the phosphorous, its deficiency in zucchini determines low vegetative development, with older leaves exhibiting a yellowish coloration, and with little brightness, thus reducing productivity (FAQUIN; ANDRADE, 2004).

Research has shown that soils treated with sewage sludge provide an increase in dry mass production, as verified by Freitas et al. (2015), in the growth of *Passiflora alata* Curtis seedlings in soils enriched with sewage sludge, in which there was increase in the fresh and dry masses of the root, as well as fresh and dry aerial plant part. These results corroborate with those of Trigueiro and Guerrini (2014), who observed greater growth of the root system in treatments composed of 70 and 80% of sewage sludge.

According to Caldeira et al. (2013), the sewage sludge improved the chemical properties of the substrate, resulting in increased substrate fertility due to the amount of phosphorus, potassium, and calcium provided by adding sewage sludge to the substrate. Sewage sludge is an important source of nutrients, which improves soil fertility, elevates the soil organic matter content and contributes to improve the soil physical attributes (COSTA et al., 2014). However, the maximum amounts of inorganic and organic substances present in the sewage sludge, in which the criteria and procedures for its proper use are indicated, based on the elevation of pH, accumulation of heavy metals in the soil and the amount of available nitrogen are determined by Conama (BRASIL, 2006).

Considering heavy metals, according to Conama's resolution (2006), all the heavy metals present in the sewage sludge used in this work were below the maximum limits allowed by Brazilian legislation, being suitable to use this substrate in agriculture.

The most recommended period for Italian zucchini cultivation is in the autumn and spring, and can be done in mild winters in locations with temperatures of 18 to 35 °C, considering that very high temperatures can hinder pollination and fertilization, and consequently the fruit development, therefore decreasing productivity (EMBRAPA HORTALIÇAS, 2010; FILGUEIRA, 2013). Considering that the temperatures were very high in the experimental period (Figure 3), the plants were analyzed, disregarding the production. However, for the Southeast region, it is recommended that planting should be done from August to May, and the ideal temperature is between 15 and 25 °C (EMBRAPA HORTALIÇAS, 2010). The temperature above 39 °C causes abortion of the flowers and inhibits the production of Italian zucchini fruits.

The sewage sludge adversely affects the emergence and favors the initial growth of Italian zucchini seedlings and the sewage sludge dosages of 240 t ha⁻¹ and 398.56 t ha⁻¹ are the most responsive for the post-seminal growth of Italian zucchini seedlings.

5 ACKNOWLEDGMENTS

The authors thank the Federal University of Espírito Santo (UFES) for providing facilities and equipment available for research; the Coordination for the Improvement of Higher Education Personnel (CAPES); the National Council for Scientific and Technological Development (CNPq) for financial support and research productivity grants to the first and fourth authors and PIBIC to the second author, respectively; to the Foundation for Research and Innovation Support of Espírito Santo (FAPES), for the granting research fee to the first author (FAPES Notice No. 19/2018 - Research Rate - FAPES Process N°. 82195510).

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