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Full length Research Paper

Study of hybrid Hermosa indeterminate yield Tomato (*Solanum lycopersicum*) under greenhouse conditions

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The organics alternatives in the vegetables production are a strategy to produce free chemical polluted foods that endanger human health. In the present study, the Hermosa indeterminate tomato variety was used and the following treatments were evaluated in a completely randomized design: Compost 2 tons/ha + VAM and BAC + Compost tea 50% (Treatment 1), Compost 4 tons/ha + VAM and BAC + Compost tea 50% (Treatment 2), Compost 6 tons/ha + VAM and BAC + Compost tea 50% (Treatment 3), VAM and BAC + Compost tea 50% (Treatment 4) and Absolute control (Treatment 5). The results indicate that Treatment 3 (Compost 6 ton/ha + VAM and BAC + Compost tea 50%) had the highest plant height at 120 days after planting (414.07 cm). Regarding the number of fruits per plant, fruit weight per experimental unit, fruit weight per m² and fruit weight per plant, no significant differences were identified. The five treatments show no significant difference in polar and equatorial diameter of the fruit weight, fruit density and unit volume. For five treatments evaluated, the pH, Brix and fruit firmness variables do not show significant difference.

Key words: Tomato*, Lycopersicum*, manure.

INTRODUCTION

The organic production alternatives in vegetable, is currently one of the better strategies to produce chemical polluted free food healthier for the human consumption. According to Marquez and Cano (2005) and Marquez-Hernández et al. (2006), organic production is a free contaminant food generation option; it is a farming method that does not use synthetic fertilizers or pesticides. In Latin America, organic agriculture is

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Table 1. Physical-chemical analysis of the compost.

Moisture (%)	pH	CE (mS)	N-NO$_3$ (mg/L)	N Ammonia (mg/L)	Nitrite (mg/L)	P (mg/L)	K (mg/L)	C Org. (%)	Ca + Mg (meq/100 g)	Mg (mg/L)	Mn (mg/L)
37.38	8.6	3.9	180	2	2	198	735	4	40	4	0

understood in its broadest form, to not only include restricting inputs of chemical synthesis, but also pursues the conservation of the environment as a whole. (Céspedes, 2005).

An alternative to reducing land degradation is the use of compost obtained from the composting process consisting of degrading organic matter to stabilize biologically controlled experiment under aerobic conditions, and can be applied to improve soil and crop (Widman et al*.,* 2005). The process of composting opens another market for waste producers, as it is a potential and inexpensive source of organic matter and fertilizers (Iwegbue et al*.,* 2006; Iwegbue et al*.,* 2007), thereby supporting the production of chemical pesticides and fertilizer particles free food (De la Cruz et al*.,* 2009).

Raviv et al. (2005) found that the compost covered the nutritional requirements during the four months following transplantation of tomato. Likewise, Cano and Marquez (2005) determined that the nutrients contained in the compost, were sufficient to obtain acceptable yields in cherry tomato.

The importance of endomycorrhizae has increased in the past decade due to numerous reports of beneficial effects on plants, such as increases in absorption of nutrients in the soil, water relations influence, protection against pathogens and important ecological roles these associations appear to play in the succession of species in natural plant communities (Aguilera, 2007). This is because mycorrhiza is an association formed by a group of fungal hyphae (mycelium) that upon contact with the roots of the plants allows a free flow of nutrients to them, offering to host plant and the ecosystem, different benefits in terms of survival and functioning (Camargo et al*.,* 2012).

MATERIALS AND METHODS

In the present study, the Hermosa indeterminate tomato hybrid is identified by its excellent performance potential, having an enviable quality in comparison with market requirements. Its better response to high temperatures enables them to achieve an excellent development of plant and fruit quality. This hybrid can produce 6 to 7 bunches per plant between 11 and 13 fruits each. The fruit ripening is very uniform so there is greater percentage of packaging. Relative maturity is intermediate type, ranging from 72 to 74 days after transplantation. The fruit is medium to large, bright red color, is likewise resistant: HR: Aal/Fol: 1, 2/ToMV: 0-2/Vd: 1.

The experiment was established in a greenhouse shade mesh conditioner on the roof to reduce the heat incidence. During the course of the experiment, average temperatures of 25 to 28°C, minimum temperature of 16°C and maximum temperature up to 36°C was observed outside the greenhouse. The greenhouse has a width of 10.80 m, length of 30 m, maximum height of 5 m and a 2.40 m tutoring cable. The plant production was made in styrofoam trays of 242 cavities on October 31, 2013 and before transplanting, trenching was performed incorporating compost and the installation of drip irrigation system. Complete randomized design was used with five treatments and three replications. Transplantation experiment was realized on 20th November of the same year.

The compost employed before transplantation was produced in the period from May to July 2013 based on bean straw, cattle manure, yeast, brown sugar and mature compost. The physicochemical analysis of the compost (Table 1) was performed using the methodology of saturation extract by vacuum filtration of the saturated paste compost, obtaining the liquid extract to make the following determinations: pH by potentiometric method; Nitrate-N (mg/l), N (mg/L), Ammonia (mg/L), Nitrite (mg/L), Phosphorus mg/L, Potassium (mg/L), conductivity (mS), Ca + Mg (meq/100 g), magnesium (mg/L) Mn (mg/L) by the HACH method; Moisture (%) by the gravimetric method; Organic carbon (%) by the method of wet combustion of Walkley-Black (Brito et al., 1990) as amended.

The treatments were: 1) Compost 2 ton/ha + VAM and BAC. + Compost tea 50%, 2) Compost 4 ton/ha + VAM and BAC + Compost tea + 50%, 3) Compost 6 tons / ha + VAM and BAC + Compost tea 50%, 4) VAM and BAC + Compost tea 50% and 5) Absolute control. The compost incorporation into the soil was done on the same day of planting with VAM and BAC being a complex product containing mycorrhizal fungi belonging to *Glomus intraradices* varieties, *G. mosseae* and *G. aggregatum* as well as beneficial bacteria such as *Bacillus cereus*, *B. pumilus*, *B. megaterium*, *B. licheniformis, B. subtilis and B. amiloquefaciens*.

It was applied to the base of the plant by mixing 1.5 L of the product in 4 L of water, applying 20 ml of the solution per plant 8 days after transplantation. The compost tea was applied weekly to each plant providing 100 ml of solution (1:1 ratio of compost tea and water) resulting from the mixture of 25 kg of compost per 100 L of water. The experimental unit size was a twin row of 5 m long planted "staggered" formation with the following dimensions: 0.75 m bed width, distance between beds of 1.50 m, and distance between pairs of grooves 0.40 m, and plant spacing of 0.50 m. The plant density was 2.6 plants per m². Pest control was performed with *Bacillus thuringiensis* and disease control with Cupravit applications. Tomato water supply was performed using drip irrigation, with two tracts bed (one tract per row) whose emitters were 15 cm distant from them.

The intensity and frequency of irrigation was 1 h everyday during the first two months and after that, it was increased to two hours a day. When the plant reached a height of 0.30 m, the tutoring was performed using black raffia, tying the base of the plant with the end of raffia around it and in the other hand holding onto cable tutoring, located 2.40 m. The removal of outbreak activity began when the first shoots were present in plants, ensuring that they do not reach a larger size than 3 cm. Shoots were removed using scissors or a knife. At the beginning of flowering, the crop began to perform the "pollination" which is based on pressurized air application just in the flowers using a motorized sprayer dorsal mark Toru 3 WF-3S, with 25 L capacity, performing during all flowers formation period, during

Table 2. Mean values of the variables: Plant height (cm) at 60, 75, 90, 105 and 120 DDT (days after planting).

Treatments	Plant height (cm)				
	60 DDT	75 DDT	90 DDT	105 DDT	120 DDT
1) Compost 2 tons/ha + VAM Y BAC + Compost tea 50%		^{bc}	^{b}	^{b}	^{bc}
2) Compost 4 tons/ha + VAM Y BAC + Compost tea 50%		^{b}		^{b}	^{b}
3) Compost 6 tons/ha + VAM Y BAC + Compost tea 50%					
4) VAM y BAC + Compost tea 50%	152.73^{b}	223.4^{c}	262.67^{b}	309.47^{b}	358.6^{c}
5) Absolute control	^{b}	235.47^{bc}	^{b}	^{b}	369.13^{bc}

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$).

Table 3. Mean values of the variables: Fruits numbers per plant, fruit weight (kg) per experimental unit (7.5 m²), fruit weight per m² and fruit weight per plant.

Treatments	Fruit number	Fruit weight (kg)	Fruit weight (kg per m²)	Fruit weight (kg per planta)
1) Compost 2 tons/ha + VAM Y BAC + Compost tea 50%				
2) Compost 4 tons/ha + VAM Y BAC + Compost tea 50%				
3) Compost 6 tons/ha + VAM Y BAC + Compost tea 50%				
4) VAM y BAC + Compost tea 50%				1.2
5) Absolute control				

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$).

the fruiting stage, fruit filling and plant leaves removal using scissors, pliers or pruning shears.

The variables dimensions are randomly selected between five different plants treatments; in every treatment and measurement a tape measured mark was realized. Truper of 5 m was used, at 30, 45, 60, 90, 105 and 120 days after transplantation, from the base to the apex of the plant. The fruits number per plot was calculated in every cut; when they had an orange to red color, fruits were cut. Fruit weight (kg) per plot in each cut was determined, using a ToroRey digital scale; fruit yield (kg/m²) and yield in kg/plant was calculated, using the density as a planting base; fruit size (mm) was determined by measuring the polar diameter and equatorial diameter on every plot and every cut, using a vernier; evaluating firmness (N) by using a penetrometer. Weight was also determined using the ToroRey scale and individual fruit size (g) by the water displacement technique. Density was determined using the weight and unit volume. Brix was determined using a refractometer (Method 920.39 AOAC, 1990) while the pH was measured with a potentiometer (Method 16,023 AOAC 1990). Acidity was determined through titratable acidity method (Method 30,071 AOAC, 1990) while statistical evaluated variables analysis was determined with SAS 9.1.

RESULTS AND DISCUSSION

Table 2 shows that for the variable plant height, analysis of variance reflects the significant difference between treatments, noting that Treatments 3, 1 and 2 are statistically equal and have the highest plant height at 60 days after transplantation, with 186.07, 178.8 and 178 cm, respectively, compared with Treatments 4 and 5 (absolute control). At 75 days after transplantation, the tallest plants was obtained by Treatment 3 (275.27 cm), resulting in significantly different compared with Treatments 1, 2, 4 and 5. Also, at 90 days after transplantation, greater heights (323.07 and 311.73 cm) were observed for Treatments 3 and 2, respectively. At 105 and 120 days after transplantation, treatment 3 shows greater plant height, compared to the other treatments. These results reflect that reported by Allen et al. (2003) and Camargo et al. (2012), who note that in mycorrhizal association, the fungus promotes better plant uptake of water and mineral nutrients with low availability in the soil (mainly phosphorus) directly influencing the growth of plants. It is also similar to that noted by Mujica et al. (2010) who evaluated different doses of liquid mycorrhizal inoculant in growing tomato and found positive effects on plant height, leaf dry mass and performance. It also creates a synergistic effect with compost tea, which according to Ingham (2005), can be used as fertilizer because it contains soluble nutrients and beneficial microorganisms that promote plant growth.

Regarding the fruits number per plant, fruit weight per experimental unit, fruit weight per m² and fruit weight per plant (Table 3), treatments evaluated were not significantly different; however, these outcomes are similar to those found by De la Cruz et al. (2009) who evaluated compost as a substrate prepared with bovine

Table 4. Mean values of the variables: Polar and equatorial (cm) diameter, weight unit (g) and volume unit (ml) and fruit density (g/mL).

Treatments	Polar diameter (cm)	Equatorial diameter (cm)	Weight unit (g)	Volume unit (ml)	Fruit density (g/mL)
1) Compost 2 tons/ha + VAM Y BAC + Compost tea 50%					
2) Compost 4 tons/ha + VAM Y BAC + Compost tea 50%					
3) Compost 6 tons/ha + VAM Y BAC + Compost tea 50%					
4) VAM y BAC + Compost tea 50%	5.1				
5) Absolute control					

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$).

Table 5. Mean values of the variables of fruit quality.

Treatments	pH	Degree Brix	Firmness (N)
1) Compost 2 tons/ha + VAM Y BAC + Compost tea 50%			
2) Compost 4 tons/ha + VAM Y BAC + Compost tea 50%			
3) Compost 6 tons/ha + VAM Y BAC + Compost tea 50%			
4) VAM y BAC + Compost tea 50%			
5) Absolute control			

Means followed by the same letter in the column do not differ significantly by the Tukey test ($p < 0.05$).

manure, corn stover, elephant grass and black earth, in the hybrid tomato production SUN 7705 under greenhouse conditions, obtaining an average yield of 3.98 kg/m², and found by Preciado et al. (2011), in assessing compost tea production, genotype Cid greenhouse tomato, earning yields of 1.45 kg per plant.

As regards the variables, polar and equatorial diameter, weight and unit volume of the fruit and fruit density (Table 4), the Treatment 5 do not reflect significant difference between them; however, a slight tendency of superiority is observed at Treatment 3 for the five characteristics observed above. In the present study, the polar diameter results are similar to those obtained by Preciado et al. (2011), who obtained a polar diameter of 5.8 cm fruit in assessing compost tea production, genotype Cid greenhouse tomato and De la Cruz et al. (2009), who reported diameters of 5.9 cm polar and equatorial diameters of 4.7 cm, the evaluation of compost as substrates for the production of hybrid tomato SUN 7705 under greenhouse conditions.

However, these results reflect lower values than those reported by Ochoa et al. (2009) who evaluated four types of fertilization (nutrient solution enriched with compost tea humic acids, organic nitrogen and phosphorus, compost tea and diluted application fractional compost) in three genotypes of tomato and a density of 4.2 plants per square meter, and found values of 7.2 to 7.4 cm in equatorial diameter, and 164 to 184 g of unit weight of the fruit.

Analyzing the variables of pH, brix and fruit firmness (Table 5), the five treatments evaluated do not reflect significant difference between them, however, data Brix (4.1 to 4.5) reported by De la Cruz et al. (2009) and Preciado et al. (2011) respectively, are similar to those obtained in this study (4.2 to 4.6), and found by Ochoa et al. (2009), who report values from 4.3 to 4.6, when assessing compost tea enriched with humic acids, nitrogen and phosphorus in the organic cultivation of tomato under greenhouse conditions.

Conflict of Interests

The authors have not declared any conflict of interests.

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