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Use of By-Products from the Tequila Industry. Part 12: Composted Agave Bagasse for Growing Grape Tomatoes

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Abstract

Here, we evaluated the possibility of growing grape tomatoes on three different mixtures of composted agave bagasse substrate. Tomatoes were grown in 28-L pots for 106 days under a drip irrigation system with a hydroponic crop nutrient solution. The average production of grape tomatoes was 338.9, 358.9, and 325.7 g/pot/cut for each of the substrates studied, and no significant difference was observed between treatments ($p > 0.5$). The mean of numbers of grape tomatoes were 34.6, 38.8, and 34.2/pot/cut for each of the substrates studied, and no significant difference was observed between treatments ($p > 0.5$). The mean weight of individual grape tomatoes was about 10.4 g for all of the substrates tested. These results confirmed the notion that a composted agave bagasse substrate could replace an expensive imported substrate. The remaining challenge is to produce agave bagasse substrate commercially, because to date, agave bagasse substrates have only been produced on a pilot scale for testing. Therefore, it is necessary to implement a stabilized process for producing agave bagasse at a commercial level. This process must consider economic production costs and market value to ensure that the product is competitive with other substrates typically used in soilless crops.

Keywords

Agave Bagasse, Grape Tomatoes, Tequila Industry

1. Introduction

The importance of the tequila industry in Mexico, mainly located in the state of Jalisco, is known worldwide. Its industrial development has been growing, and for a long time, one of the main problems has been the managing and disposing of agave bagasse, a byproduct of the extraction of fermentable sugars from the heads of the *Agave tequilana* Weber. According to Cedeño [1], agave bagasse comprises about 40% of the weight of the ground agave heads. Accordingly, in the year 2021 [2], 2,018,700 tons of agave were used to produce tequila and 100% agave tequila, and in that year alone, 807,480 tons of bagasse were produced, but unfortunately this by-product, due to its toxicity for agriculture, has to be stabilized by some procedure such as composting Iñiguez *et al.*, [3]. Agave bagasse, particularly from the largest tequila producing companies, is used as a support medium for the disposal and treatment of wastewater, commonly called vinasses. However, intermediate-sized and small tequila-producing plants generally send the agave bagasse to municipal garbage dumps or to agricultural land for disposal, without treatment. The environmental impact of the agave bagasse is not as severe as the impact of vinasses, due to the need for highly technical treatments. However, agave bagasse presents a management and disposal problem, which can be resolved by considering it a renewable resource and an opportunity for new business and for incorporating new input into the hydroponic industry. The substrates used in tomato production systems in Mexico under greenhouse conditions are so heterogeneous yields vary. Several studies evaluating tomato yields in greenhouse using inert substrates such as tezontle (volcanic rock), sawdust, compost and coconut coir, show differences, mainly due to physical and chemical properties. The observed one of the problems is the yield. The interest in using different substrates is based on lower costs, increased yield, fruit quality and optimal use of water and fertilizer (Vargas *et al.*, 2008 [4], Ortega *et al.*, 2010 [5], San Martin *et al.*, 2012 [6], Gomez, 2003 [7], Moreno and Valdes, 2005 [8], Marquez *et al.*, 2006 [9], Rodriguez *et al.*, 2008 [10], Inden and Torres, 2004 [11]). The objective of this study was to reinforce the notion that agave bagasse should be considered more as resource than a problem: a resource that can expand the range of substrate options for the hydroponic industry. Specifically, we aimed to evaluate the potential of composted agave bagasse as substrate for the production of grape tomatoes.

2. Materials and Methods

This study was designed as a completely randomized experiment of three treatments and 7 replicates per treatment. The experiment was conducted for 106 days. Each replicate of 5 pots (28 L each) were randomly placed in three rows, each row for a different treatment.

Treatment 1 consisted of 100% composted agave bagasse. Treatment 2 consisted of 50% composted agave bagasse and 50% commercial substrate. Treatment 3 consisted of 70% composted agave bagasse and 30% tezontle sand.

All grape tomato plants were grown under a drip irrigation plan, with Hoagland and Arnon nutrient solution [12]. During the first 36 days after the grape tomato seedlings were transplanted, the nutrient solution was diluted at 50% (pH 6.4, conductivity 1.53 μS/cm) with tap water. Subsequently, for 15 days, the nutrient solution was undiluted (pH 6.4, conductivity 2.21 μS/cm). The final nutrient solution had the same pH of 6.4, but a conductivity of 3.5 μS/cm.

At 64 days after transplanting the tomato seedlings, the first fruit cut was performed, and 6 more fruit cuts were performed each week. Thus, after 106 days, 7 fruit cuts were performed.

Analysis

The analyses included the total amount of tomatoes in the 35 pots/treatment (kg), the tomato production/pot, the number of tomatoes/pot, and the average tomato weight (g). Data were analyzed with ANOVA.

3. Results and Discussion

Table 1 presents the results of the grape tomatoes grown in the three substrates for 106 days. The average production of grape tomatoes was 338.9, 358.9, and 325.7 g/pot/cut for each of the substrates studied, with no significant difference between treatments ($p > 0.5$). The mean of numbers of grape tomatoes were 34.6, 38.8, and 34.2/pot/cut for each of the substrates studied, with no significant difference between treatments ($p > 0.5$). The mean grape tomato weight was about 10.4 g for all three substrates tested.

Previously, Virgen *et al.*, [13] conducted a study in a commercial greenhouse to compare the cultivation of tomatoes in coconut coir substrate compared to composted agave bagasse substrate. They found no significant difference between substrates ($p < 0.05$). Martínez *et al.*, [14] showed that maguey bagasse compost, used as a soilless organic substrate for tomato plants, outperformed a substrate containing coconut dust, and fruit quality was unaffected. They reported that the highest yield (3.5 kg/plant) and the largest number of marketable

Table 1. Production of grape tomatoes from plants grown in different substrates.

Evaluation	Substrate		
	100% cAB	**50% cAB 50% CS**	**70% cAB 30% TS**
Total grape tomatoes (kg)[1]	83.0	87.9	79.8
Production mean (g/pot)[2]	338.9[a]	358.9[a]	325.7[a]
Mean of number of grape tomatoes (fruit/pot)[2]	34.6[a]	38.8[a]	34.2[a]
Mean of grape tomato weight (g)	10.5 (±3.2)[b]	10.3 (±2.7)	10.3 (±2.6)

cAB: Composted agave bagasse; CS: commercial substrate; TS: tezontle sand. [1]7 cuts; 7 days between cuts; [2]Mean of 7 cuts; 7 days between cuts; [a]Means with the same superscript in the same row are not statistically different ($p > 0.5$), [b]Standard deviation.

fruit (26.4 tomatoes per plant) was obtained with 180 days of bagasse stacking. Iñiguez *et al.*, [15] conducted a field study with agave bagasse composts as substrate for tomato production, compared to the commercial substrates typically employed to improve nutrient uptake (coconut coir and cocopeat). At 55 days after the seedlings were transplanted, they found no significant differences ($p < 0.05$) in the first four cuts. Crespo *et al.*, [16] demonstrated that the formulations of agave bagasse compost and coconut powder could replace coconut powder and peat, because their physical and chemical characteristics were suitable for use as a substrate for plants cultivated in containers. Thus, agave bagasse compost could contribute to the local production of substrates for protected agriculture systems, which require substantial quantities of these types of materials.

Figure 1 shows the average number of grape tomatoes/pot produced for each of the three treatments. The average number of tomatoes for the three treatments increased from 148 in the first cut to a maximum of 2538 in the fifth cut. The production of grape tomatoes was lower for cuts 6 and 7, probably due to a reduction in ambient temperature (*i.e.*, from the beginning to the end of the experiment, the environmental temperature dropped 3˚C for the maximum temperature and 4˚C for the minimum temperature). Nevertheless, these results validated the potential of composted bagasse substrate for the cultivation of grape tomatoes.

Considering the cost of the macro and micronutrients used for tomato plant fertilization at the time this investigation was conducted (August 2020), the total cost was $0.175/kg tomatoes produced. On the other hand, 148 L water/pot was consumed during the 106 days of the experiment.

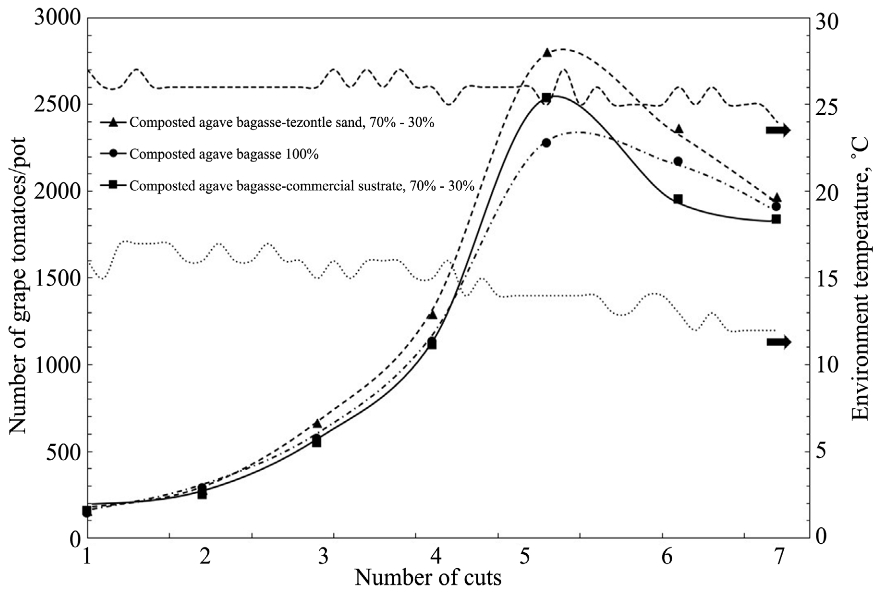

Figure 1. Grape tomato production in three different substrates as growth medium. The average numbers of tomatoes/pot are shown for each of 7 cuts (performed once every 7 days). Symbols and lines indicate the different growth media, and the dotted line indicates the environmental temperature throughout the study.

In summary, there is currently sufficient evidence to show that an agave bagasse substrate can replace commercial substrates commonly used in intensive agricultural production systems. The current challenge is to produce agave bagasse substrate commercially, because to date, the agave bagasse substrates tested have been produced only on a pilot scale.

4. Conclusion

This study enriched our knowledge about the usefulness of agave bagasse as a substrate for soilless crops or seed germination for transplantation. For use as a substrate, agave bagasse must be processed through solid substrate fermentation, commonly called composting. This process has only been implemented at a pilot level to obtain sufficient substrate for use in research. Therefore, it is necessary to develop a stabilized process for composting agave bagasse at a commercial level. Both production costs and market value must be considered to ensure that the commercially produced agave bagasse compost is competitive with other substrates typically used for producing soilless crops.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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