Colegio de Postgraduados

Effect of Vermicompost and Phyto-regulator on Zucchini Fruits (*Cucurbita pepo* L.) Grown in Shade Houses

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ABSTRACT
Objective: To assess the influence of vermicompost (LC) and phytoregulator (AMP) in the cultivation of zucchini, under shade house conditions.
Design/methodology/approach: A randomized block experimental design with eight treatments and six repetitions was used.
Results: The treatments did not affect fruit diameter and pH variables. The Jacobo+LC+AMP treatment induced fruit length, and all treatments where the phytoregulator was applied increased fruit weight and commercial yield. For fruit firmness and total soluble solids, the trend was not clear due to the effect of the treatments.
Findings/conclusions: The application of the phytoregulator induced fruit weight and yield.

Keywords: Fruit growth, commercial yield, fruit firmness.

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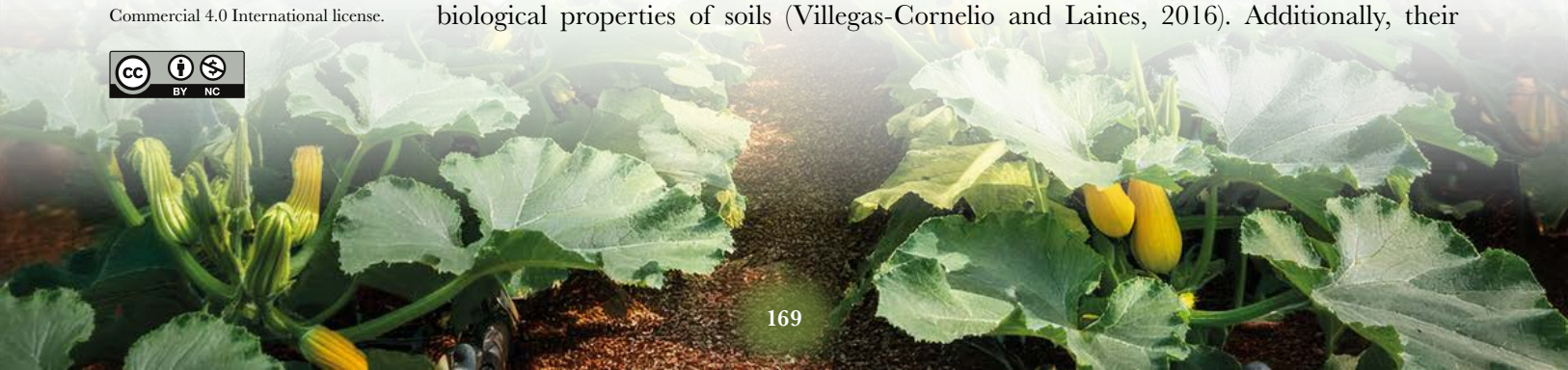
INTRODUCTION

Currently, the use of chemical fertilizers is indiscriminately applied to increase agricultural production, posing a significant threat to soil fertility and the environment, as well as altering microbial composition (Syed *et al.*, 2021). Intensive soil use leads to depletion and erosion, causing the loss of organic matter and necessitating high amounts of synthetic fertilizers (Tyagi *et al.*, 2019). An alternative to reduce the harmful effects of conventional agriculture is organic production, which has a lower negative impact on the environment and yields high-quality products (SIAP, 2019). According to Zambrano and Lima (2023), there are sustainable practices that conserve soil fertility and maintain crop productivity. Among these practices are vermicomposts, organic fertilizers that can meet the nutritional needs of plants (Moreno-Resendez *et al.*, 2019) and improve the physical, chemical, and biological properties of soils (Villegas-Cornelio and Laines, 2016). Additionally, their



derivatives, such as leachates and vermicompost teas, are also alternatives for sustainable production (Piña-Ramírez *et al.*, 2015).

Regarding the effect of vermicomposts on the soil, it is an organic fertilizer with a high percentage of humic and fulvic acids that provides assimilable nutrients (Cervantes *et al.*, 2022), which consequently promotes desirable yield enhancement (Sarmiento-Sarmiento *et al.*, 2019).

On the other hand, the application of phyto-regulators based on auxins, cytokinins, and/or gibberellins for fruit setting and yield increase has been the subject of several studies in crops such as chili, watermelon, and prickly pear (Ramírez-Luna *et al.*, 2005; Rueda-Luna *et al.*, 2015; Varela-Delgadillo *et al.*, 2018).

The objective of this research was to evaluate the effect of applying vermicompost and a complex of plant growth regulators (phyto-regulator) on the production and quality of zucchini under shade house conditions.

MATERIALS AND METHODS

The research was conducted within a crop protection structure, specifically a shade house, at the experimental field of the Faculty of Agronomy, Autonomous University of Sinaloa, located at 24° 48' 30" N, 107° 24' 30" W, and an altitude of 38.54 m. The fertility analysis conducted prior to planting indicated that the soil has a clayey texture (59% clay, 21% sand, and 20% silt), low organic matter content (1.21%), a saturation percentage of 79%, a pH of 7.85, EC of 0.58 dS m^{-1}, SAR of 1.77, and PSI of 1.33. In Culiacán, Sinaloa, the climate is BS1(h')w(w)(e): very warm semi-arid, extreme with summer rains, with less than five percent of the total annual precipitation occurring in winter (García, 2004). The average temperature (21.9 °C) and relative humidity (69.5%) recorded with thermohygrometers (DT171, Twilight®) were within the optimal ranges (18 to 24 °C and 65 to 80%) for zucchini cultivation (Molinar *et al.*, 1999; Cortés, 2003).

Soil preparation was done using manual agricultural tools, creating beds spaced 1.8 meters apart. Vermicompost was applied at a rate of 10 t ha-1 to half of the beds. Two lines of drip irrigation tape with emitters spaced every 0.20 meters were installed above each bed, and white/black co-extruded polyethylene mulch was applied. Sowing was carried out on November 14, 2021, in polystyrene trays with 128 cavities filled with peat (Brown 025W, Kekkila®). When the plants had two true leaves, 17 days after sowing (das), they were moved to the field for transplanting at a density of 11,820 plants per hectare.

A fertigation system (drip irrigation) was used, applying Steiner's (1984) solution at 50% concentration from transplanting until the anthesis of the first female flowers (33 days after transplanting, dat). Afterward, the full solution was applied. Irrigation was carried out when the tensiometers (2725ARL, Soil Moisture Equipment®) placed at a soil depth of 30 cm indicated a moisture tension of 20 to 25 kPa.

An experimental design with a randomized block arrangement was used, featuring a factorial design of 2A×2B×2C, with eight treatments and six replications. Factor A was the zucchini variety, with two levels: 'Jacobo', a "green zucchini" type, and 'Aurora', a "gray zucchini" type. Factor B, also with two levels, corresponded to vermicompost

(LC): applied at 0 and 10 t ha^{-1} to the soil. Factor C, likewise with two levels, was Agromil®Plus (AMP): plant extracts with 83.39% active ingredients; cytokinins at 2081.9 ppm; gibberellins at 31.0 ppm; auxins at 30.5 ppm; vitamins at 947.95 ppb; applied at doses of 0 and 2.5 mL L^{-1}.

Zucchini fruits were harvested between five and seven days after anthesis to evaluate fruit growth: fruit diameter (FD) was measured with a digital caliper (6MP, Truper®); fruit length (FL) was measured with a tape measure; and fruit weight (FW) was recorded with a precision scale (CP622, Sartorius®), along with yield (Molinar *et al.*, 1999; USDA, 2016).

To assess fruit quality, five fruits per replication or treatment were evaluated according to the methodology proposed by AOAC (1998). For pH, 10 g of fruit were weighed on a precision scale (PR802, Mettler Toledo) and mixed with 50 mL of distilled water adjusted to a pH of 7, blended in a blender (85554, Osterizer), and then filtered through organza fabric. A 10 mL aliquot of the filtrate was analyzed with a pH meter (HI98130, Hanna®). Firmness (N) was evaluated using a penetrometer (GY-4, Yuchengtech®) with an 8 mm steel tip, and total soluble solids (SST: °Brix) were determined by adding three drops of fruit juice to a digital refractometer (RHW040, Yieryi®).

The results obtained from the evaluated variables were subjected to analysis of variance and Tukey's multiple comparisons test ($P \leq 0.05$) using STATISTICA version 7.0 software (StatSoft, 2004).

RESULTS AND DISCUSSION

Yield Components

The variable fruit diameter of zucchini did not show differences due to the treatments (Table 1). However, Román-Román *et al.* (2023) observed an increase in zucchini fruit diameter due to the application of naphthaleneacetic acid auxin. Moreno-Resendez *et al.* (2019) reported a fruit diameter of 55.4 mm for the variety 'Mona Lisa F1' of the "gray zucchini" type.

The greatest fruit length was promoted by the Jacobo+LC+AMP treatment, which was 81.1% higher than that obtained with the Aurora treatment, but without differences compared to the other treatments. Plants of the 'Jacobo' variety had the longest fruit, surpassing those of the 'Aurora' variety, which can be attributed to the variety effect, as Moreno-Resendez *et al.* (2019) reported fruit lengths of 123.3 to 138.9 mm, consistent with the observations for the 'Aurora' variety in this study.

Fruit weight was significantly affected by the plant growth regulator factor (Table 1), such that all treatments that included the plant growth regulator (Jacobo+AMP, Aurora+LC+AMP, Jacobo+LC+AMP, and Aurora+AMP) induced increases in fruit weight, which were statistically higher ($p \leq 0.05$) than the effect of the other treatments, ranging from 24.7% (Jacobo+LC) to 56.8% (Aurora).

Moreno-Resendez *et al.* (2019) reported zucchini fruit weights (180.4 to 274.6 g) higher than those observed in the present study due to the treatments. This increase in fruit weight induced by the plant growth regulator aligns with findings by Román-Román *et al.* (2023) for zucchini fruits, as well as with observations in mango fruits (Pérez-Barraza *et al.*, 2009).

Table 1. Effect of vermicompost (LC) and plant growth regulator (AMP) on fruit diameter (FD), fruit length (FL), fruit weight (FW), and yield of zucchini, varieties Jacobo and Aurora, under shade house conditions. Culiacán, Sinaloa, Mexico.

Treatment	DF (mm)	LF (mm)	PF (g)	Yield (t ha^{-1})
Jacobo+LC+AMP	47.9 a[§]	228.6 a	134.8 a	40.8 abc
Jacobo+LC	42.7 a	211.5 ab	108.1 b	34.5 cd
Jacobo+AMP	42.1 a	203.1 ab	145.0 a	45.1 a
Jacobo	41.3 a	205.7 ab	96.0 b	31.9 d
Aurora+LC+AMP	45.9 a	138.9 ab	139.7 a	48.1 a
Aurora+LC	45.2 a	141.3 ab	93.2 b	35.7 bcd
Aurora+AMP	53.0 a	159.6 ab	137.6 a	43.5 ab
Aurora	40.4 a	126.2 b	92.5 b	33.0 cd
DMSH	19.4	84.4	20.1	7.7
Significance				
VARIETY	ns	***	ns	ns
LC	ns	ns	ns	ns
AMP	ns	ns	***	***
VARIETY × LC	ns	ns	ns	ns
VARIETY × AMP	ns	ns	ns	ns
LC × AMP	ns	ns	ns	ns

[§] Medias con letras iguales no son estadísticamente diferentes (Tukey≤0.05). DMSH=diferencia mínima significativa honesta; ns, *, **, ***: no significativo a p≤0.05, significativo a p≤0.05, p≤0.01 y p≤0.001.

The application of the plant growth regulator (AMP) promoted an increase in zucchini yield for both varieties, with up to a 31.4% increase in the four treatments where it was applied. The treatments Aurora+LC+AMP and Jacobo+AMP resulted in higher yields (48.1 and 45.1 t ha^{-1}), statistically similar to those obtained with Aurora+AMP and Jacobo+LC+AMP (Table 1), but higher than the yields achieved with Aurora+LC, Jacobo+LC, Aurora, and Jacobo, ranging from 26.3% to 50.8%. The yield obtained is consistent with the 45.5 t ha^{-1} of zucchini reported by Nogueira *et al.* (2011) for the 'Caserta' variety. This indicates that the application of plant growth regulators in zucchini fruits promotes commercial yield (Ayala-Tafoya *et al.*, 2020; Román-Román *et al.*, 2023).

Fruit quality parameters

The treatments did not influence the pH of the zucchini fruits (Table 2), which ranged from 6.3 to 6.6. Soriano-Melgar *et al.* (2020) reported a pH of 7.2 in fruits of the 'Grey Zucchini' variety, which differs from the values observed in the present study. The total soluble solids content was significantly affected by the variety factor, as well as by the interaction between the variety and plant growth regulator factors.

The total soluble solids content of the fruits harvested from the 'Jacobo' variety exceeded that of the 'Aurora' variety by 11.1%. However, the fruits obtained from

Table 2. Effect of vermicompost (LC) and plant growth regulator (AMP) on pH, firmness, and total soluble solids (°Brix) of zucchini fruits, varieties Jacobo and Aurora, under shade house conditions. Culiacán, Sinaloa, Mexico.

Treatment	pH	Firmness (N)	SST (°Brix)
Jacobo+LC+AMP	6.5 a[§]	69.4 ab	4.1 a
Jacobo+LC	6.3 a	79.1 a	3.7 ab
Jacobo+AMP	6.5 a	68.1 ab	3.9 a
Jacobo	6.4 a	76.6 ab	4.0 a
Aurora+LC+AMP	6.6 a	68.2 ab	3.3 b
Aurora+LC	6.6 a	64.4 ab	3.7 ab
Aurora+AMP	6.6 a	63.1 b	3.3 b
Aurora	6.6 a	64.8 ab	3.7 ab
DMSH	0.4	14.5	0.5
Significance			
VARIETY	*	**	***
LC	ns	ns	ns
AMP	ns	ns	ns
VARIETY × LC	ns	ns	ns
VARIETY × AMP	ns	*	**
LC × AMP	ns	ns	ns

[§] Medias con letras iguales no son estadísticamente diferentes (Tukey≤0.05). DMSH=diferencia mínima significativa honesta; ns, *, **, ***: no significativo a p≤0.05, significativo a p≤0.05, p≤0.01 y p≤0.001.

the Jacobo+LC+AMP, Jacobo, and Jacobo+AMP treatments showed the highest °Brix values, with significant differences (p≤0.05) compared to those from the Aurora+LC+AMP and Aurora+AMP treatments, surpassing them by 18.2% and 24.2%, respectively (Table 2).

These values are consistent with the 3.9 °Brix reported by Soriano-Melgar *et al.* (2020). However, Moreno-Resendez *et al.* (2019) reported TSS values ranging from 4.61 to 6.79 °Brix, which differ from those observed in this study.

CONCLUSIONS

Fruit diameter was not affected by the treatments, while fruit length was promoted by the combination of the 'Jacobo' variety with vermicompost (LC) and plant growth regulator (AMP). The application of the plant growth regulator (AMP), in both varieties, induced greater fruit weight and yield. Therefore, the application of plant growth regulators can be an alternative to increase zucchini yield under shade house conditions.

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