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Production and quality of habanero pepper (*Capsicum chinense* Jacq.) with chemical and organic fertilization

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ABSTRACT

Objective: To compare the effect of earthworm humus (vermicompost) with respect to that of a standard fertilization treatment with conventional chemicals on the yield and fruit quality in the cultivation of habanero pepper (*Capsicum chinense*).

Design/methodology/approach: The experimental design was of randomized blocks with seven replicates. The treatments consisted of 100% worm humus, 50% worm humus + 50% soil combination, as well as soil with chemical fertilizers as a control. The number of fruits, the quality of the fruits (length, diameter, and weight) of three cuts (harvests), in addition to the yield per plant, were evaluated. The data were analyzed with an analysis of variance and when statistical differences were detected, a means comparison was performed with the Tukey test ($P>0.05$).

Results: The 100% vermicompost treatment did not significantly reduce the height and diameter of the plant stem. Regard yield, a 15% increase was observed, although it was not significant compared to the control. Likewise, the quality of the fruits did not decrease.

Study limitations/implications: The combination of 50% vermicompost and soil or less could affect the development and yield of habanero pepper crops.

Findings/conclusions: Supplying earthworm humus does not affect the yield or quality of habanero pepper fruits, which is an alternative for nutrients supply at low cost which is also an environmentally friendly practice.

Keywords: humus, vermicompost, compost, nutrients.

INTRODUCCIÓN

The habanero pepper (*Capsicum chinense* Jacq.) is a vegetable high production at the state of Yucatán, Mexico, which in recent years has taken great economic importance (SIDETEY, 2014). At the national level, Yucatán contributes

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41% of the total production (SIAP, 2015), with a cultivated area of around 243 ha and an average yield of 13.69 t ha^{-1} (SIACON, 2018). Like all horticultural species, the yield and fruit quality depend on the nutrient availability and content in the soil (Borges-Gómez, 2010), which are often lower than their demand. This makes it necessary to use agricultural amendments, mainly synthetic (Noh-Medina *et al*., 2010), that raise production costs and generate environmental damage. This has motivated the search for low-cost and sustainable production alternatives (Nieves-González *et al*., 2013). Currently, 40% of the increase in agricultural production is attributed to synthetic fertilizers; However, their economic benefits are diminished due to fertilizer's high cost, in such a way that it is estimated that they increase the cost of production between 10 and 25% (Salgado and Núñez, 2012). A low-cost alternative that can potentially correct the nutrients deficiency in the soil is supplying organic amendments, which, in addition to providing nutrients, improves some physical properties; while, in the plant, humic acids stimulate the development of roots and stems, improve nutrients absorption, and control some soil pathogens (Felix-Herrán *et al*., 2008). Furthermore, given the goals set by FAO to ensure food for the world population, without affecting the environment and soil resources, through a more productive and resilient agriculture (FAO, 2018), alternatives have been proposed, such as the usage of low-cost available organic waste, like manure and composted plant waste (López *et al*., 2012; Nieves-González *et al*., 2013). In this regard, vermiculture, in which the Californian red worm (*Eisenia foetida*) is used to solubilize insoluble minerals, has become increasingly important (Román *et al*., 2013), because it improves the microbiological characteristics of the organic waste, due to the presence of *Bacillus* sp. responsible for macronutrients releases, such as N (nitrogen), P (phosphorus) and K (potassium) (Torres-González *et al*., 2017).

The application of vermicompost in agricultural production has shown the capability to reduce the use of chemical fertilizers without affecting yields. In this regard, Olivares-Campos *et al*. (2012) report that when applying vermicompost in a lettuce crop, the nutritional foliar N content was similar to the equivalent contribution of inorganic nitrogen fertilizer, which produced a similar behaviour in their production.

Particularly, for habanero pepper cultivation, there is little evidence that shows the impact of this kind of organic amendments on the production and quality of the fruit, which is why the present work aimed to compare the usage of earthworm humus or vermicompost compared to a standard treatment with conventional chemical fertilization, on the yield and quality of habanero pepper fruit (*Capsicum chinense*).

MATERIALS AND METHODS

The experiment took place in a 30 m^2 tunnel-type greenhouse at Oxkutzcab municipality, Yucatán, Mexico, during the autumn - winter 2019 cycle. The plant material developed from habanero pepper var. Mayapan seeds, these germinated in 200-cavity polystyrene containers in Canadian peat (Peat moss®). During the seedling stage, irrigations (with well water) were applied every second day, in 1 L per tray doses during the first two weeks after seedling emergence, followed by daily applications, in the same dosage, until transplant. Regard the fertilization in the seedbeds, it began nine days after seedling emergence, and when the seedlings exhibited the first pair of well-defined true leaves. After that, every third day. During the first and up to the second week after fertilization began, nutrients were applied as follows: 0.15 g L^{-1} of urea, 0.25 g L^{-1} of MAP and 0.1 g L^{-1} of NKS; from the third week onwards: 0.3 g L^{-1} of urea, 0.5 g L^{-1} of MAP and 0.2 g L^{-1} of NKS.

The soil used for the experiment was Luvisol type, locally known as K'ancab, with a loamy texture (40% sand, 44% silt and 16% clay) (Borges-Gómez *et al*., 2014). The vermicompost was produced by decomposing a mixture of organic materials (green and dry leaves, horse manure and discards of regional fruits, chopped as finely as possible, in addition to a portion of soil) made by the Californian red worms (*Eisenia foetida*). The mixture was supplied as worm food every third day along with water to maintain a constant humidity of 80%. After three months, when it had a brown appearance, the humus was collected, sieved with a 2 mm sieve, which broke existing lumps.

The pant transplantation occurred 40 days after sowing (das), when the seedlings reached 15 to 20 cm height, to 5 L volume black plastic bags containers. The distance used between the rows of bags was 80 cm and 30 cm between bags. The treatments consisted of 100% humus (H) and a mixture (1: 1 V/V) of humus+soil (H+S), supplied as a substrate, both without chemical fertilizer addition, plus a control which consisted of 100% soil with synthetic fertilizer supplied through irrigation every third day, at doses of 0.38 g of urea, 0.17 g of MAP and 0.20 g of NKS, per plant. The experimental design was of randomized blocks with seven replications and three plants as an experimental unit.

At 120 days after transplantation, data on the plants' height and stem diameter were recorded; the first with a tape measure, from the base of the stems to the apical meristems; the second with a digital vernier at a 5 cm height from the base of the stem. For the yield assessment, the total number of fruits per treatment in each cut was weighed, the three cuts were later added. In each harvest, the number of fruits produced by each plant was counted and at the end of the experiment, their average was calculated. For each treatment repetition, fruits were selected, their length measured with a millimeter ruler from the peduncle to the tip of the fruit; with a digital vernier, the diameter measured in the middle part of the fruits. Finally, to obtain the individual weight per fruit, fruits were weighed in a compact PCE-BSH 1000 scale with a 0.2 g precision.

The irrigations during crop development were manually carried out, applying 0.5 L per plant day^{-1} from the transplant until 20 days after (dat) with 1 L per plant day^{-1} of the 20 until 50 dat. From day 50 to 90 dat 1.5 L per plant day^{-1} and 2 L per plant day^{-1} from day 90 until harvest (Tucuch-Haas *et al*., 2012). Among other agronomic tasks, pruning took place to leave three branches per plant and tutored with thread. The data were analyzed with an analysis of variance, when statistical differences were detected, a comparison of means was carried out with the Tukey test (P≤0.05) in the SAS version 8.1 (SAS, 2004) statistical package.

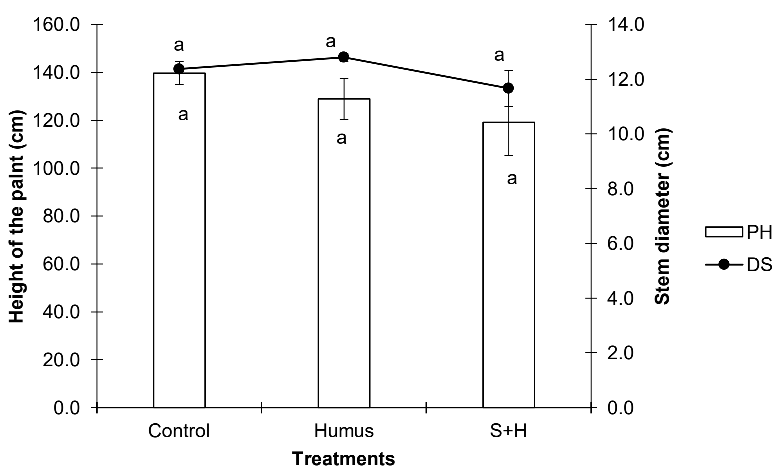

Figure 1. Effect on the height and diameter of the stem of habanero pepper plants (*Capsicum chinense* var. Mayapan) supplied with organic and inorganic sources, evaluated at 120 ddt. S + H = Soil-Humus combination; PH = height of the plant; DS = stem diameter. Treatments with the same letter are statistically equal (Tukey, P≤0.05).

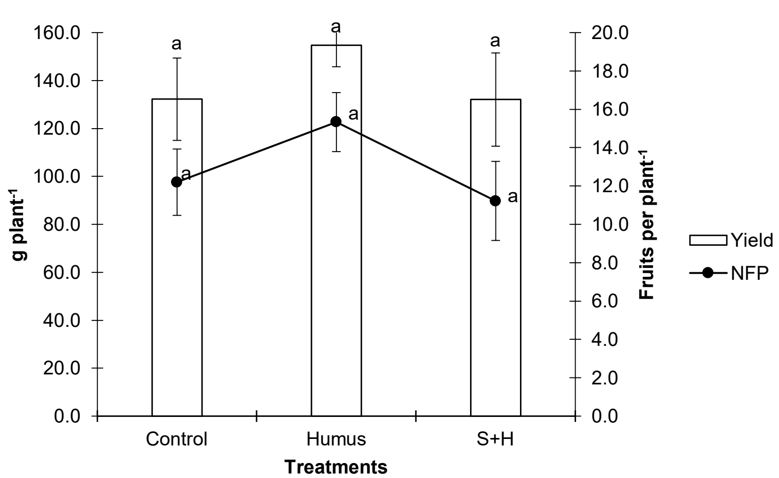

Figure 2. Effect of worm humus and chemical fertilizers on the yield and number of fruits per plant, accumulated from three harvests, on a habanero pepper crop (*Capsicum chinense*). S + H: Substrate-Humus combination; NFP: number of fruit per plant. Treatments with the same letter are statistically equal (Tukey, P≤0.05).

RESULTS AND DISCUSSION

The height variable reports no differences (P≤0.05) between the control and the treatments (Figure 1). This response is similar to that by Abreu *et al*. (2018) in plants from the same genus, and by Díaz *et al*. (2016) in squash cultivation (*Cucurbita* sp.). This behaviour demonstrates the earthworm humus ability in combination with the soil to supply the nutrients required during the vegetative development of crops.

The statistical analysis for the yield and total fruits number variables (sum of three cuts) had no significant differences (P≤0.05) between the control and treatments (Figure 2); However, the highest yield occurred in plants grown in 100% humus, with a value of 154.8 g per plant (15% higher than the control), followed by the control with 132.2 g and the humus-soil combination with similar values of 132.2 g per plant.

The number of fruits per plant followed the same trend behavior performance, registering 15.3 fruits per plant for the 100% humus treatment; 12.2 fruits per plant for the control; and 11.9 fruits per plant for the soil-humus combination. These trends are consistent with that reported by Reyes *et al*. (2017), who found that supplying 100% worm humus does not reduce the yield in *Capsicum annuum* and supports the idea of Abreu *et al*. (2018), where they propose that worm humus can be an effective alternative to reduce the use of chemical fertilizer without affecting productivity.

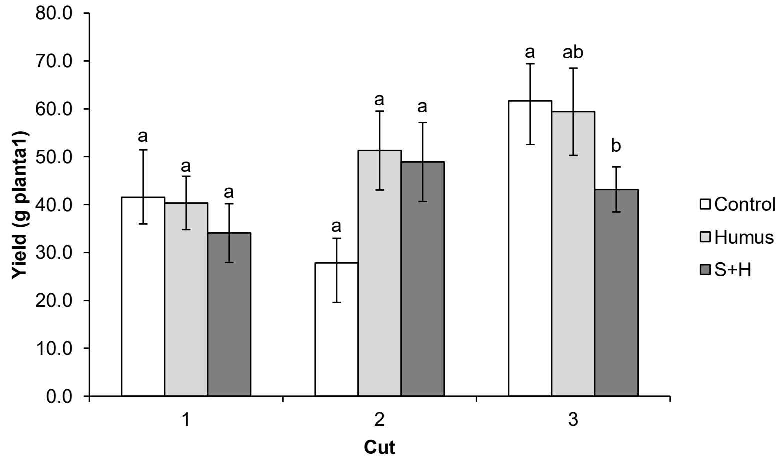

Figure 3. Fruit yield response of a Habanero pepper crop (*Capsicum chinense*) regard the effect of the substrate used as a nutrient source, from three cuts. S + H: Substrate-Humus combination. Treatments with the same letter are statistically equal (Tukey, P≤0.05).

The similarity between the control and 100% humus, was perhaps due to the physical and biological attributes, which have been suggested, are improved with humus (Pérez *et al*., 2008), along with the high bacterial fauna content and high content of assimilable nutrients for the plants (Manaf *et al*., 2019). In this regard, Torres-González *et al*. (2017) characterized and identified the microorganisms present in vermicompost, identifying bacteria from the genus *Bacillus* sp. and concluded that these make a more efficient generation of macronutrients such as nitrogen (N), phosphorus (P) and potassium (K), essential elements for plant nutrition.

Figure 3 shows the yield dynamics of the habanero pepper crop, from the three evaluated cuts, by treatments effect, where it can be seen that, particularly for the 100% vermicompost treatment compared to the control, in harvest one and three there were no significant differences (P≤0.05); not so for the second harvest, which was up to 80% higher than the control and favored the total yield (sum of three cuts), representing a slight increase respect to the control. For the humus + soil combination and the control, the first harvest showed no significant differences; but did at harvest two and three; in the latter the difference was negative. The above differs from that reported by Reyes *et al*. (2017), where the worm humus treatment exceeded the control in the first and second harvests and similar in the third.

The fruit quality, determined by the length, diameter and weight showed no differences (P≤0.05) with respect to the control in any of the parameters, which suggests that the fruit quality is not affected when using fertilizers from organic sources (Figure 4). Similar research, such as that of Reyes *et al*. (2017), supports these results by finding that worm humus favored the length, diameter and weight of the fruits. Authors such as Macías *et al*. (2012), when using manure as a source of nutrients in the production of jalapeño pepper (*C. annuum*), recorded that this organic amendment does not negatively affect the fruit quality. The obtained responses in all the evaluated variables showed that worm humus can supply the nutritional demand of habanero pepper crops, reflected with a similar response to chemical fertilization.

Various works developed with earthworm humus suggest this organic source as an important

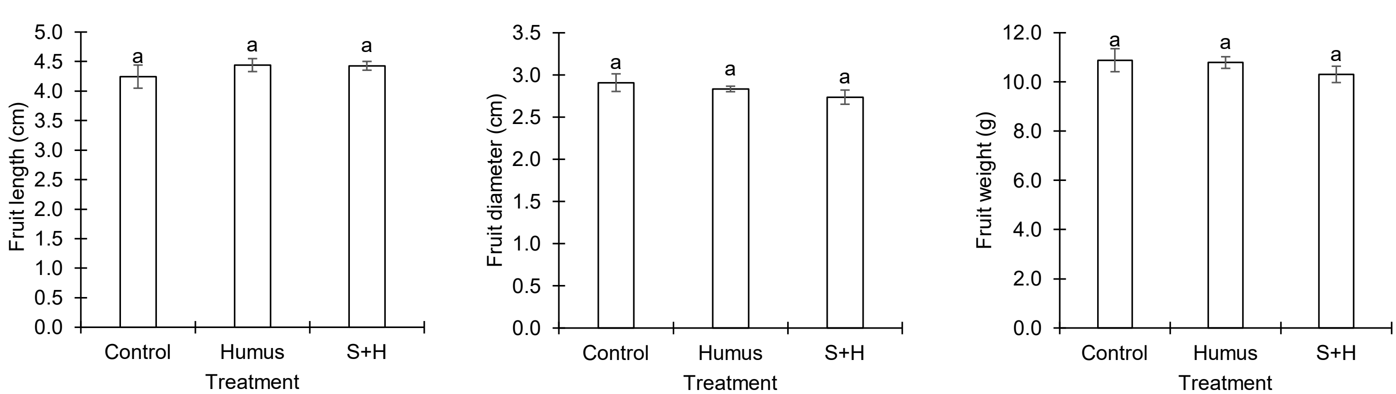

Figure 4. Response of a habanero pepper crop (*Capsicum chinense*) in the length, diameter, and weight of the fruit due to the effect of the substrate used as a nutritional source. S + H: Substrate-Humus combination. Treatments with the same letter are statistically equal (Tukey, P≤0.05).

means of supplying nutrients for agricultural production without affecting the quality of the fruit and yield, in terms of costs it could be a good alternative (Cantero *et al*., 2015; Abreu *et al*., 2018). These results, together with those reported for other organic sources such as compost (Vega *et al*., 2009) and manure (Vázquez-Vázquez *et al*., 2011), show the importance of organic amendments in agriculture to reduce the usage of inorganic fertilizers. In this regard, Vega *et al*. (2009) reported a significant economic effect with the use of vermicompost in the production of chili peppers (*C. annuum*), and Abreu *et al*. (2018) demonstrated that the potential of earthworm humus to reduce the application of chemical fertilizer without affecting the yield in *Capsicum* sp. Cantero *et al*. (2015) concluded that compost has a higher minimum marginal rate of return, and therefore, is a good alternative for sustainable fertilization.

CONCLUSIONS

The usage of earthworm humus as a substrate and source of nutrients in the production of habanero pepper does not affect the yield and quality of the fruits; which suggests it is an alternative to mitigate pollution due to excessive use of inorganic sources of fertilization and the reduction of the costs of production of this vegetable.

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