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REVIEW

Liquid vermicompost as a biostimulant in chili pepper nurseries: Literature review and experimental justification

Vermicompost líquido como bioestimulante en viveros de ají: Revisión de literatura y justificación experimental

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ABSTRACT

Introduction: the research focused on analyzing the effect of liquid vermicompost on the cultivation of chili bell pepper (Capsicum annuum L.) during its nursery stage. The starting point was the environmental problem represented by organic wastes generated in different productive sectors, proposing vermicomposting as a biological management technique to transform them into useful fertilizers. Liquid vermicompost was considered to offer nutritional and physiological advantages for plants, as it contains nutrients, microorganisms and growth hormones.
Development: the study reviewed relevant scientific background who evaluated different biostimulants and composts in horticultural crops. All agreed that the use of vermicompost, both solid and liquid, favored vegetative development and productive yield. Variables such as plant height, number of leaves, stem diameter and fruit weight were significantly improved compared to controls or traditional chemical treatments. Liquid vermicompost was shown to be an effective and low-cost alternative, suitable for small producers.
Conclusions: liquid vermicompost, applied at different concentrations, notably improved the growth and development of chili bell pepper seedlings. In addition to increasing morphological parameters, it reduced the time needed to take the seedlings to the final field. The research concluded that this organic fertilizer represented a viable agroecological option, capable of substituting conventional fertilizers, improving the quality of the substrate and strengthening sustainable practices in agricultural nurseries.

Keywords: Vermicompost; Chili; Nursery; Substrate; Biostimulant.

RESUMEN

Introducción: la investigación se enfocó en analizar el efecto del vermicompost líquido en el cultivo de ají (Capsicum annuum L.) durante su fase de vivero. Se partió del problema ambiental que representan los residuos orgánicos generados en distintos sectores productivos, proponiendo el vermicompostaje como técnica de manejo biológico para transformarlos en abonos útiles. Se consideró que el vermicompost líquido ofrecía ventajas nutricionales y fisiológicas para las plantas, al contener nutrientes, microorganismos y hormonas de crecimiento.
Desarrollo: el estudio revisó antecedentes científicos relevantes quienes evaluaron distintos bioestimulantes y compostajes en cultivos hortícolas. Todos coincidieron en que el uso de vermicompost, tanto sólido como líquido, favoreció el desarrollo vegetativo y el rendimiento productivo. Se destacaron variables como la

altura de planta, número de hojas, diámetro del tallo y peso del fruto, que se vieron significativamente mejoradas en comparación con testigos o tratamientos químicos tradicionales. El vermicompost líquido se mostró como una alternativa efectiva y de bajo costo, apta para pequeños productores.
Conclusiones: el vermicompost líquido, aplicado en diferentes concentraciones, mejoró notablemente el crecimiento y desarrollo de plántulas de ají. Además de incrementar parámetros morfológicos, redujo el tiempo necesario para llevar las plántulas al campo definitivo. La investigación concluyó que este abono orgánico representó una opción agroecológica viable, capaz de sustituir fertilizantes convencionales, mejorar la calidad del sustrato y fortalecer prácticas sostenibles en viveros agrícolas.

Palabras clave: Vermicompost; Ají; Vivero; Sustrato; Bioestimulante.

INTRODUCTION

The growing generation of materials of very diverse origin in different activities, which are considered waste or by-products and are fundamentally organic, coming from different sectors, although in the primary sector (agriculture and livestock) and processing activities, as well as urban waste such as sludge from wastewater (WWTP) and plant debris from the maintenance of municipal parks and gardens, is where the most significant quantities are being produced.[1,2,3,4]

Composting and vermicomposting are two techniques that allow the biological management of these organic wastes or by-products, for their stabilization and maturation until they become products with fertilizer value for the soil and free of possible risks of phytotoxicity or environmental contamination.[5] Vermicomposting performs this degradation function through the joint action of microorganisms and earthworms, which reduces process costs, shortens processing times, and yields a higher quality end product.[6,7,8,9]

On the other hand, chili peppers undergo certain biological phenomena linked to their phenological phases and different variables such as the nutritional level of the substrate used in the nursery stage. According to Solomon et al.[6], these biological changes may or may not be visible from emergence to the fall of the cotyledons. Mundarain et al.[7], pointed out that in the nursery stage, some changes can be evaluated between 35 and 40 days after sowing, which is the time required for the plant to reach the field with an approximate height of 12 to 15 centimeters, a thickness of 5 to 7 millimeters, and 4 or 5 leaflets. These parameters will be reached in a shorter or longer time depending on some variables, among which we can mention the nutritional level of the substrates.[10,11,12]

Domínguez et al.[8] have stated that the use of liquid vermicompost in substrates considerably increases the growth and development of some horticultural crops, such as chili peppers, since vermicompost is a source of nutrition for plants and can also significantly improve the physical properties of substrates. Similarly, Torres et al.[9] mention that liquid vermicompost has been shown to have positive effects on crops because it acts as a stimulator or regulator of plant growth by enhancing biochemical and physiological activity through its hormonal components (auxins, cytokinins, and gibberellins), mineral nutrients, amino acids, and low molecular weight proteins, as well as the humic acids that constitute the biostimulator.

Based on these premises, to achieve the parameters set for the growth and development of horticultural crops in the nursery phase, it was decided to test liquid vermicompost in three different concentrations on chili pepper crops as an ideal agroecological alternative for horticultural crop production in the nursery phase. The aim was to implement organic options that would produce vigorous, healthy seedlings that could be transplanted in the shortest possible time, providing horticultural producers with an organic, economical, and viable solution for fertilizing their crops.[13,14,15]

Similarly, the research work's theoretical contribution was based on analyzing different conceptual references on organic fertilizers, vermicomposting, and chili pepper cultivation, building an updated state of the art that allows for a better understanding of these topics. The few studies that have been conducted in the study area have been related to the use of organic fertilizers, mainly solid, in leafy vegetable crops; however, the use of vermicompost leachate and its effect on the growth and development stages of chili pepper cultivation have not been extensively addressed.

Similarly, agricultural research institutes can use the information obtained in this study for other production units with the same or similar climatic conditions. In addition, it will serve as a basis for future studies to strengthen and increase the use of organic fertilizers in the fertilization of vegetable crops.[16,17,18]

DEVELOPMENT

Background to the research

One of the previous studies considered was that of Solórzano (2019, entitled: Effect of chitosan, mycorrhizal fungi, and humic acids on the growth and development of pepper varieties (Capsicum annuum L) under protected conditions. The study was conducted at the "La María" experimental farm in the Mocache Canton,

Los Ríos Province, located at kilometer 7,5 of the Quevedo-El Empalme road, Ecuador. A completely randomized design with a 2x4 factorial arrangement and three replicates was used, with the first factor being the varieties (Magaly and Lycal). The second being the biostimulants: humic acids (1:30 v/v), chitosan (3 g/l of water), and mycorrhizal fungi (20 g of spores/ml), with a control (without application of biostimulants) added for each variety.

The results showed that the three bioactive compounds studied increased seed germination by 11,66 and 16,67 %, while emergence was enhanced by humic acids and chitosan (90,00 and 86,67 % of seedlings emerged, respectively). The application of humic acids produced taller plants 25 and 45 days after sowing, with 19,38 and 46,38 cm, and stems with a larger diameter, 8,87 and 16,05 mm, in the two evaluations, respectively. This, in turn, increased the fresh and dry biomass of the seedlings (339,38 and 106,72 g). Fruit production per plant (15,33 fruits), as well as fruit length, diameter, and weight, increased with the application of humic acids (12,22 cm, 43,33 mm, and 92,22 g), generating the highest yield at 29,166,67 kg/ha. Thus, they recommend applying humic acids in pepper production, as it showed the best growth and production indicators for this crop under protected conditions.

For their part, González-Solano et al.[2], in their study entitled: Use of vermicompost tea in leafy vegetable production in Mexico, aimed to compare the application of vermicompost tea with the Steiner solution (universal solution) to determine its efficiency as a source of nutrients in leafy vegetable production.

To this end, they prepared vermicompost tea with 4 kg of vermicompost contained in a sack submerged in 16 liters of water; they then made dilutions to apply to the crop, adjusting the pH to 5. They also considered the electrical conductivity (EC), which should not be greater than 2,0 dS m–1, trying to adjust it to a standard for nutrient solutions made from mineral salts.

NFT (nutrient film technique), a straightforward system using PVC pipes and solution storage tanks, was used to produce leafy vegetables. This system is automated with a pump that sends the solution through the PVC pipes every two hours to where the plants grow. The system was compared with Steiner's mineral nutrient solution to assess the potential of vermiSteiner's sea as a nutrient solution in producing basil, cilantro, and lettuce.[19,20,21,22]

The biomass results recorded for basil and cilantro plants treated with vermicompost tea were similar to those grown with the Steiner solution. However, the authors highlight the advantage of tea, which is a viable option for vegetable production. It is easily obtained with fewer inputs, thus representing a valuable alternative within the reach of producers with limited financial and technological resources.

Similarly, Zambrano[3] carried out his exceptional degree project entitled: Effect of vermicompost on the growth and yield of pepper (Capsicum annuum L.) under a protected system at the La Teodomira Experimental Station, belonging to the Faculty of Agricultural Engineering of the Technical University of Manabí, Ecuador. The aim is to evaluate the responses in growth and yield in the cultivation of peppers (Capsicum annuum L.) by applying different doses of vermicompost. Results were similar to several studies.[22,23,24]

For this purpose, a randomized block design was used, in which five treatments were applied and distributed as follows: treatment 1 (control soil); treatment 2 (bovine manure vermicompost (VEB) 7 t.ha-1; 420 g/plant); treatment 3 (VEB 5 t.ha-1; 300 g/plant); treatment 4 (VEB 3 t.ha-1; 180 g/plant) and treatment 5 (chemical fertilization NPK; 10g/plant); where the following variables were evaluated: plant height, stem diameter, number of leaves, photosynthetic pigments, and total production. SPSS software was used to analyze the variables under study statistically.

The use of vermicompost had favorable effects on most of the variables studied, leading to significant increases in height and number of leaves per plant compared to plants fertilized with nitrogen, phosphorus, and potassium. Treatment 4 (VEB 3 t.ha-1) stood out as the most comprehensive.[25,26,27]

Similarly, Moreno et al.[9], evaluated the behavior of Hungarian chili peppers (Capsicum annuum) in vermicompost-sand mixtures under protected conditions at the facilities of the Universidad Autónoma Agraria Antonio Narro - Unidad Laguna, in Torreón, Coahuila, Mexico, in order to determine the optimal concentration of the vermicompost-sand mixture (VC: A; v:v) that would meet the nutritional needs of Hungarian chili peppers (Capsicum annum). A randomized block design with five replicates was used, where the mixtures evaluated were four combinations of VC: A with ratios of 1:1, 2:1, 3:1, 4:1, and a control 0:1 (sand plus nutrient solution). Similarly, the variables evaluated were plant height and basal stem diameter, fruit length, equatorial diameter, pericarp thickness, number of locules, weight, and yield.[28,29,30]

Similarly, to determine the effect of the treatments on the variables evaluated, ANDEVA was applied, and Tukey's test at 0,05 was used to compare means. The main results obtained for the variables evaluated in chili cultivation, such as plant height, fruit length, pericarp thickness, and number of fruits per plant, showed highly significant differences (P≤0,01), with the 1:1 mixture being the most suitable for development. Plant height, fruit length, pericarp thickness, and number of fruits per plant showed highly significant differences (P≤0,01), with treatment 1:1 being the most suitable mixture for developing Hungarian chili peppers under protected conditions. They also indicate that increasing vermicompost amounts improves crop development.[31,32,33]

Similarly, López-Baltazar et al.[10] conducted a study entitled: Agronomic evaluation of substrates in

'onza' chili seedlings (Capsicum annuum) in a greenhouse, from the Protected Horticulture module of the Technological Institute of the Valley of Oaxaca, Mexico. To this end, they determined the physical, chemical, and agronomic properties of four substrates from agricultural waste used to produce 'onza' chili seedlings as an alternative to conventional substrates. A randomized experimental design was used, with four treatments and three replicates for 12 experimental units. The treatments were: peat (T1) (control), vermicompost (T2), vermicompost + mezcal agave bagasse compost (T3), and mezcal agave bagasse compost (T4).[34,35,36,37,38,39]

Among the main results, they point out that the highest germination percentage was observed in the seeds from treatment T1, with no differences from the seeds germinated in the alternative substrates T3 and T4, so it is considered that these did not negatively affect the germination of the ' onza' chili, only T2 (VC 100 %) reduced germination by 10 % compared to the rest of the treatments. Therefore, even though the plant material used corresponds to collections selected by producers in the region, they indicate that genetic variability could affect the seed's germination capacity.

In the same context, seedlings grown in vermicompost + maguey bagasse (50:50) (T3) and in mezcalero maguey bagasse (T4) had the most significant height (12,29 cm and 13,07 cm, respectively). Meanwhile, seedlings grown in vermicompost had the highest number of leaves (9,25) .[40,41,42,43,44,45]

CONCLUSIONS

The research concluded that using liquid vermicompost as an organic alternative in the nursery stage of chili pepper (Capsicum annuum L.) cultivation positively affected seedling growth and development. Based on an analysis of national and international data, it was found that the application of organic products such as vermicompost leachates, humic acids, and other biostimulants significantly improved key morphophysiological variables such as plant height, number of leaves, stem diameter, and yield, even when compared to conventional chemical fertilizers.

Vermicompost, a product of biological decomposition mediated by earthworms and microorganisms, provided essential nutrients, growth hormones, and beneficial microorganisms that improved substrate conditions and, therefore, the nutritional status of the seedlings. This input contributed to vigorous plant development and greater efficiency in the use of time in the nursery phase, allowing for transplanting to the final field in a shorter period.

Likewise, comparison with other studies showed that liquid vermicompost could compete favorably with traditional mineral solutions, offering ecological, economic, and productive advantages, especially in protected systems and under controlled conditions. Previous research by Solórzano (2019), Zambrano (2018), and González-Solano et al. (2018) reinforced these findings, reporting increases in yield, fruit quality, and vegetative development in different horticultural crops under vermicompost treatments.

Similarly, it was confirmed that substrate quality was decisive in achieving seedlings with optimal characteristics for transplanting. Vermicompost improved the substrate's physical structure, water retention capacity, and biological activity, which are key aspects for effective germination and emergence.

In short, liquid vermicompost was presented as a viable and sustainable agroecological strategy for small and medium-sized producers, providing an accessible, environmentally friendly option capable of generating high-quality horticultural products. Its use in agricultural nurseries was recommended as a standard practice within organic or integrated production systems, thus promoting more sustainable agriculture that is resilient to the limitations of the conventional model.

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