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Short communication: THE EFFECT OF VERMICOMPOST BASED GROWTH SUBSTRATES ON TOMATO GROWTH

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ABSTRACT. Vermicomposting is a decomposition process involving the joint action of earthworms and microorganisms. Although microorganisms are responsible for the biochemical degradation of organic matter, earthworms are crucial drivers of the process, by fragmenting and conditioning the substrate and significantly altering its biological activity. The purpose of the work was to assess the influence of vermicompost based growth substrates on tomato transplant growth. Treatments were followed (supplier K. Compos): A) 30% vermicompost, peat, sand and dolomite stone; B) 25% vermicompost, peat, gravel, perlite; C) 25% vermicompost, peat, gravel, concrete block; D) commercially produced growth substrate bought from retail centre, as a control. Substrates containing vermicompost had increased stem diameter compared to control treatment. The tomato plant height was increased in substrates containing 25% vermicompost compared to other treatments. The number of leaves was highest in treatment C compared to other treatments. The number of flowers was increased in treatment A and lowest in treatment D. It can be summarized that for tomato the best growth substrate, regarding growth parameters is 25% vermicompost, peat, gravel, concrete block (treatment C).

Introduction

Vermicompost role in the nutrition of agricultural fields has attracted attention of researchers worldwide only in recent decades (Adhikary, 2012). Vermicomposting is a decomposition process involving the joint action of earthworms and microorganisms. Although microorganisms are responsible for the biochemical degradation of organic matter, earthworms are crucial drivers of the process, by fragmenting and conditioning the substrate and dramatically altering its biological activity (Dominguez, Edwars, 2004). Vermicompost produced by the activity of earthworms is rich in macro and micronutrients, vitamins, growth hormones, enzymes such as proteases, amylases, lipase, cellulose and chitinase and immobilized microflora. The enzymes continue to disintegrate organic matter even after they have been ejected from the worms (Barik *et al*., 2011). Vermicomposting is a self-promoted, self-regulated, self-improved and self-enhanced, low or no-energy requiring zero-waste technology. It is easy to construct, operate and maintain vermicomposting. All other biological or mechanical technologies for production of 'bio-fertilizer' are not as good as vermicomposting technology (Mistry, 2015).

Greece and Egypt valued the role earthworms played in soil, as well as all other civilizations. The ancient Egyptians were the first to recognize the beneficial status of the earthworm. The Egyptian Pharaoh, Cleopatra (69–30 B.C.) recognized the important role the worms played in fertilizing the Nile Valley croplands after annual floods (Medany, 2011). The thoughts of ancient Indian Scientist Sir Surpala (10 Cent. A.D.), who recommended to add earthworms in the soil to get good fruits of pomegranate (Sinha, 2014a). Russian scientist Dr. Anatoly Igonin claimed that nobody and nothing can be compared with earthworms and their positive influence on the whole living Nature. They create soil and improve soil's fertility and provides critical biosphere's functions: disinfecting, neutralizing, protective and productive (Sinha *et al*., 2014b).

Vermicompost is ideal organic manure for better growth and yield of many plants due to higher nutritional value than traditional composts. This is due to increased rate of mineralization and degree of humification by the action of earthworms. Vermicompost has also high porosity, aeration, drainage, and water-holding capacity. Presence of microbiota particularly fungi, bacteria and actinomycetes makes it suitable for plant growth. Nutrients, such as nitrates, phosphates, and exchangeable calcium and soluble potassium in plant-available forms are present in vermicompost. Plant growth regulators and other plant growth influencing materials produced by microorganisms are also present (Joshi *et al*., 2015).

Production of cytokinins and auxins was found in organic wastes that were processed by earthworms. Earthworms release certain metabolites, such as vitamin B, vitamin D and similar substances into the soil (Joshi *et al*., 2015).

In addition to increased N availability, C, P, K, Ca and Mg availability in the casts are found in vermicompos (Joshi *et al*., 2015).

Vermicompost contains plant nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B, the uptake of which has a positive effect on plant nutrition, photosynthesis, the chlorophyll content of the leaves and improves the nutrient content of the different plant components (roots, shoots and the fruits). The high percentage of humic acids in vermicompost contributes to plant health, as it promotes the synthesis of phenolic compounds such as anthocyanins and flavonoids which may improve the plant quality and act as a deterrent to pests and diseases (Theunissen *et al*., 2010).

The objective of the study was to assess the effect of vermicompost based growth substrates on growth of tomato transplant.

Material and methods

The experiments were carried out in cooperation with company K. Compos glass greenhouses between December 2015 to February 2016. The tomato variety 'Bajaja' was cultivated if four treatments (exact recipes were not available due to property rights):

A) 30% vermicompost, peat, sand and if needed dolomite stone

B) 25% vermicompost, peat, gravel, perlite.

C) 25% vermicompost, peat, gravel, concrete block.

D) Commercially produced growth substrate bought from retail centre (brand not specified) and used as a control. This substrate contained peat, and useful fertilizers for vegetable plant growth.

The results of substrates analyses are in Table 1.

Table 1. The mineral composition and pH of substrates

Treat-ment	pH_{KCl}	N %	P mg kg^{-1} (AL)	K mg kg^{-1} (AL)	Ca mg kg^{-1}	Mg mg kg^{-1}	Org. matter %
A	6.56	1.005	2,689.2	5,029.1	2,656.5	2,193.6	29.61
B	6.79	0.305	684.0	2,423.4	2,303.3	572.2	11.80
C	6.48	0.370	859.3	2,638.2	2,131.4	626.0	13.53
D	5.58	0.968	936.3	2,478.6	4,887.1	1,066.2	76.44

The seeds in first experiment were sown on 2 December 2015. Young plants were transplanted two times: at first at spacing 5 cm into larger boxes (14 December 2015), second time into individual pot (9 cm diameter), (16 January 2016). Plants harvested together with registration of growth results on 27 February 2016.

Each variant consisted of 16 plants. The experiment had four replicates. Each plot consisted of four plants. The experiment was repeated at the same time, i.e. in the second experiment seeds were sown on 2 December 2015, seedlings were transferred at first at spacing 5 cm into larger boxes (14 December 2015), second time into individual pot (9 cm diameter), (16 January 2016). Plants were harvested on 27 February 2016.

In the end of experiment on tomato the diameter of stem, the height of shoots, the number of leaves and the number of flowers (opened and just about to open) were measured.

The plants were grown in greenhouse with lighting from high pressure sodium lamps at light intensity of 10000 lux. The lighting period was 18 hours (04.00–22.00). A minimum day and night temperature of 23–24 °C was maintained in the greenhouse.

Analyses of variance were carried out on the data obtained using Excel. Used signs: *** – $P \leq 0.001$; ** – $P \leq 0.01$; * – $P \leq 0.05$; NS – not significant ($P > 0.05$).

Results

The stem diameter was statistically different (Table 2). Substrates containing vermicompost had increased stem diameter compared to control treatment.

The height of plants was statistically different (Table 2). The tomato plant height was increased in substrates containing 25% vermicompost compared to other treatments.

Table 2. The tomato plant characteristics mean values ($\bar{x}$) and standard deviations (SD) depending on growth substrates

Treat-ment	Stem diameter, mm		Height of plants, cm		Number of leaves		Number of flowers	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
A	11.6^{a}	0.8	53.7^{ab}	9.7	51.3^{ab}	3.7	22.1^{a}	9.7
B	11.3^{ab}	0.5	56.5^{a}	8.4	52.8^{ab}	4.1	12.2^{ab}	7.0
C	10.8^{ab}	0.6	54.4^{ab}	4.7	54.3^{a}	3.9	15.0^{ab}	6.6
D	9.5^{b}	0.7	45.1^{b}	6.9	48.0^{b}	2.5	7.2^{b}	2.1
P-value	<0.001		<0.01		<0.001		<0.001	

The letters ‘a’ and ‘b’ refer to the significant difference between the values in column at the level of ≤ 0.05.

The number of tomato leaves was statistically different (Table 2). The number of leaves was highest in treatment C compared to other treatments.

The number of flowers was statistically different (Table 2). The number of flowers was increased in treatment A and lowest in treatment D.

Discussion

Vermicompost based growth substrates promoted the growth of tomato plants by increasing tomato stem diameter, plant height, number of leaves and number of flowers.

Tringovska and Dintcheva (2012) found that all vermicomposts stimulated growth of tomato transplants, with up to a 2.2-fold increase occurring in shoot biomass. Differences in growth were attributed mainly to differences in nutrient content of the potting mixtures, but some changes in physical and biological properties of the substrate could also be responsible. The examination of the data revealed that Parthenium Vermicompost applied at 5 t ha^{-1} enhanced the growth of eggplants (Seethalakshmi, 2011).

Worms and vermicompost promoted excellent growth in the vegetable crop with more flowers and fruits development (Adhikary, 2012). Studies made on the effects of vermicompost and chemical fertilizer on the hyacinth beans (*Lablab purpureas*) it was found that growth and flower appearance were significantly higher in those plots which received vermicompost either alone or in combination with chemicals. Vermicompost increases plant growth of some vegetable crops such as tomatoes, Chinese cabbage, spinach, strawberries and lettuce (Adhikary, 2012).

Similarly, both vermicompost and its body liquid (vermiwash) are proven as both growth promoters and protectors for crop plants (Adhikary, 2012).

Accordingly, vermicompost contains a high proportion of humic substances (that is, humic acids, fulvic acids and humin) which provide numerous sites for chemical reaction and microbial components known to enhance plant growth (Theunissen *et al*., 2010).

In present study was found that vermicompost has positive effects on the growth and flowering of crops, as also found by Mistry (2015). Application of vermicompost increases soil health, soil minerals, water holding capacity, soil micro-organisms and nutritional values of yielding crop as well as decreases plant pest populations (Mistry, 2015).

In accordance with our results it was found that vermicompost is an ideal organic manure for better growth of plants. Application of vermicompost increased seed germination, stem height, number of leaves, leaf area, leaf dry weight, root length, root number, total yield, number of fruits/plant, chlorophyll content, pH of juice, TSS of juice, micro and macro nutrients, carbohydrate (%) and protein (%) content and improved the quality of the fruits and seeds (Joshi *et al*., 2015).

The reasons for growth promoting effect could be followed: vermicompost is rich in NKP, micronutrients, beneficial soil microbes like 'nitrogen-fixing' and 'phosphate solubilizing' bacteria, 'mycorrhizal fungi', humus and growth hormones – auxins, gibberlins and cytokinins. It has very high 'porosity', 'aeration', 'drainage' and 'water holding capacity' (Sinha *et al*., 2013). Previous study suggested that treatments of humic acids, plant growth promoting bacteria and vermicomposts can be used for a sustainable agriculture discouraging the use of chemical fertilizers (Joshi *et al*., 2015).

Conclusions

Vermicompost based growth substrates promoted the growth of tomato plants by increasing tomato stem diameter, plant height, number of leaves and number of flowers.

It can be summarized that for tomato the best growth substrate, regarding growth parameters is treatment C, which contains 25% vermicompost, peat, gravel, concrete block.

Conflict of interests

The author declare that experiments were financed by Estonian company K. Compos. I had full access to all of the data in this study and I take complete responsibility for the integrity of the data and the accuracy of the data analysis.

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