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Efficiency of Vermicompost on Quantitative and Qualitative Growth of Tomato Plants

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ABSTRACT: In this research, the effect of using vermicompost on growth rate, fertility and characteristics of tomatoes has been studied. Four vermicompost: soil mixture were supplied with ratios of 1:1, 1:2, 1:3, and 1:4 and also four different beds were provided. Total of 24 small globe tomato plants were tested and in each bed combination, six tomato plants were embedded. Rate of growth and yielding of plants grown in each of four beds were investigated in two periods of 40 days and 90 days after planting. The results showed a significant rise in growth of tomato plants by increasing ratio of vermicompost combined with soil. Obviously, the plant was mostly appeared in the main stem of the plant and there was no significant enhancement in the number of leaves. The main stem diameter, height, the number of leaves per plant, and yielding of tomato plants obtained the highest rate in four tested beds after 40 days in vermicompost to soil ratios of 1:3, 1:1, 1:3, and 1:2, respectively. In aforementioned observations some changes were made after 90 days of testing and maximum yielding and height of tomato plants were obtained in 1:1 ratio. Vitamin C and total sugar content in tomatoes increase with using vermicompost. The maximum amount of vitamin C and total sugar, soluble solids, insoluble solids and total nitrites of fresh tomato were observed in ratios of 4:1, 4:1, 3:1, 2:1 and 3:1, correspondingly.

Key words: Vermicompost, Soil ratio,Yielding,Tomato plant,Plant growth,Organic agriculture

INTRODUCTION

By growing population, increasing prosperity, changing in food consumption and growing urbanism, waste and organic waste disposal has became a problem, especially in metropolitans (Nouri *et al.*, 2011; Hyun *et al.*, 2011; Thanh and Matsui, 2011; Maqbool *et al.*, 2011; Chen *et al.*, 2011; Arshad *et al.*, 2011). There are mainly three methods for handling organic wastes which are incineration, landfilling and composting (Shafieiyoun *et al.*, 2012; Mahmoudkhani *et al.*, 2012; Abdoli *et al.*, 2012; Nada *et al.*, 2012; Rashidi *et al.*, 2012). A growing body of evidence indicates that secondary plant metabolites play critical roles in human health and may be nutritionally important (Asami *et al.*, 2003). The quality and value of agricultural organic soil amendments are often measured in terms of their contributions on nutrient supplies and soil fertility (Arancon *et al.*, 2006). The cost of inorganic fertilizers is very high and sometimes it is not available in the market for which the farmers fail to apply the inorganic fertilizers to the crop field in optimum time. On the other hand, the organic manure is easily available to the farmers and its cost is low compared to that of inorganic fertilizers (Alam *et al.*, 2007). The compost and vermicompost quality is the most essential criterion in recycling organic waste, as well as its marketing and utilization in agriculture as organic amendments (Mavaddati *et al.*, 2010). Vermicompost is organic-biologic manure obtained by passing semi-decayed organic material through the digestive tract of earthworms' species and its disposal from their body. When the materials pass through the worm body, impregnate with gastrointestinal mucosa, vitamins and enzymes. The result is an enriched organic fertilizer which has major applications in agricultural lands and greenhouses. Recently, there has been much interest in the potential of vermicompost, which are products of a mesophilic, aerobic biodegradation and stabilization of organic materials, produced through interactions between earthworms and microorganisms, as plant growth media and soil amendments (Arancon *et al.*, 2008). Vermicompost has also been reported to result in higher survival and growth of aquatic organisms including fish and prawn without adversely affecting the water quality (Kaur and Ansal, 2010). The most appropriate species for producing vermicompost is Eisenia Fetida which is reddish brown and smaller than ordinary earthworms. In this regard,

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increasing the population of worms in each generation approximately will be as a geometrical progression. Earthworms consume various organic wastes and reduce the volume by 40–60%. Each earthworm weighs about 0.5 to 0.6 g, eats waste equivalent to its body weight and produces cast equivalent to about 50% of the waste it consumes in a day (Nagavallemma *et al.,* 2004). So there are about 1000 to 2000 worms per kilogram. The distance between the two generations (from fry to fry) in normal conditions, is approximately 3 months and the life of worms lasts between one to two years. The earthworms fragment the organic waste substrates, stimulate microbial activity greatly and increase rates of mineralization (Ansari and Sukhraj, 2010). Producing vermicompost requires some specific conditions such as optimum moisture, proper aeration, appropriate range of pH, anaerobic substrate and so on. Vermicomposting is one of the best ways to dispose the wastes, not only due to its capacity of reducing the wastes, but also for its ability to remediate and amend the soil (Aleagha *et al.,* 2009). Vermicompost production has many environmental impacts, some of which can be highlighted such as pollution reduction from manufacturing, collection and transportation of organic waste, pollution minimization from discharging of leachate contamination on the surface streets, pollution decreasing thanks to unpleasant odor, diminution of insects and vermin, loss of problems from waste accumulation in streets and generation centers, general environmental protection, and pollution reduction of agricultural lands used as landfill. Greenhouse experiments have shown that low substitutions of vermicompost into soil-less plant growth media can decrease the amounts of feeding and damage by sucking pests such as aphids and mealy bugs and chewing pests such as caterpillars (Edwards *et al.,* in press).

There is also evidence that humic acids extracted from vermicompost stimulated increase in the number of roots, giving the plant ability to scavenge nutrient from the growing environment for growth and development (Alvarez *et al.,* 1995). In addition, production and use of vermicompost has abundant economic impacts which are as follows: Production of high quality organic biologic fertilizer for agricultural use, income from production and sales of vermicompost, costs dropping in collection and transport, and declining in costs of landfilling and manufacturing of byproducts of high property organic biologic fertilizer specially compost tea in order to increasing in production and pest controlling in agriculture industry. In the present study, along with all the significant features of vermicompost, it has been attempted to investigate the effect of using this organic-biologic fertilizer on yielding and quality of agricultural and greenhouse products. Optimum plant growth and development is important for greater final dry matter and yields. In order to achieve this purpose, sufficient amounts of nutrients should be applied to the soil through inorganic and organic sources. Vermicompost for example, an organic source of plant nutrients, contains a higher percentage of nutrients necessary for plant growth in readily available forms (Table 1) (Theunissen *et al.,* 2010).

Table 1. Examples of nutrient content in vermicompost, compared with farm yard manure

Nutrient*	Vermicompost	Farm yard manure
N (%)	1.6	0.5
PO (%)	0.7	0.2
KO (%)	0.8	0.5
Ca (%)	0.5	0.9
Mg (%)	0.2	0.2
Fe (ppm)	175.0	146.5
Cu (ppm)	5.0	2.8
Zn (ppm)	24.5	14.5
Mn (ppm)	96.5	69.0
C:N Ratio	15.5	31.3

*These values are subject to variation depending on the type of organic waste

MATERIALS & METHODS

The vermicompost used in this research was resulted from processing on the cow refuse with the help of Eisenia Fetida worms which lasted about two months. Due to stack regular aeration in production, it had a superior quality. Moreover, humidity of 80% was used in Vermicomposting.

The amounts of worms used in manufacturing process, according to manufacturer, is about 25 grams per kilograms of cow refuse which is equal to 2.5 kg worms per square meter of composting bed. The vermicompost used has certain specifications such as pH of 8.5, carbon content of about 230 g per kg of vermicompost, nitrogen of 14 g per kg of vermicompost, and water content of 375 g per kg of vermicompost. Earthworms are very sensitive to pH, thus pH of soil or waste is sometimes a factor which limits the distribution, numbers and species of earthworms. Little information is available on effect of substrate pH during Vermicomposting. The availability of nutrients may be affected by the change in pH caused by the addition of vermicompost to the soil (Nada *et al.,* 2011). Several researchers have been stated that most species of earthworms prefer a pH of about 7.0 (Singh *et al.,* 2005; Allee *et al.,* 1996; Arrhenius, in press; Petrov, 1986; Salisbury, unpublished). Bhawalkar (1995) suggests for neutral pH of substrate to be used in Vermicomposting. Edwards (1995), however, reports a broad range of pH varies from 5.0 to 9.0 for maximizing the productivity of earthworms in the waste management. The experiments have been shown that this discrepancy is directly linked to type of raw material and animal feed. Therefore, one of the most significant remarks in growing tomatoes is keeping the pH in suitable range, which is applied in this experiment. Different beds required for this trial prepared by certain proportions of vermicompost and natural soil which are 1:1, 2:1, 3:1, and 4:1, respectively.

Overall, 24 tomato plants were planted in prepared beds and six samples were supplied from each defined compound. Suggested area that each plant requires for optimal growth is 10×10 cm which is a base for selecting experimental beds. Another point that should be taken into account is the depth of the plant that is suitable for planting. In this study, the quality of tomatoes has been investigated by some chemical components such as soluble and insoluble solids, total nitrite (N), sugar content and vitamin C.

RESULTS & DISCUSSION

Results and observations obtained from this study, examined by 24 samples. In order to analyze the attained results from different compounds of soil with vermicompost, after 20 days from starting the operation, some of the parameters including Plant height, stem diameter, number of leaves per plant and also rate of yielding of 12 samples from ready-made beds were investigated. This survey was conducted every week till 40 days and again the mentioned investigations were repeated weekly. Results of pertinent experiments are graphically shown in Tables 2 and 3 which are for 40 and 90 days, correspondingly. The presented results are the mean values obtained from testing beds for any combination ratio. The point of interest in this experiment is pH of samples which remained constant after mixing soil with vermicompost. By analyzing the data in Table 2 and 3, it would be decided about the optimum ratio of vermicompost to soil in order to achieve desirable products. As can be seen, in plants which their pertinent mean data have been recorded after 90 days, the maximum growth of plant height, the mean maximum stem diameter, the number of leaves per plant, and the mean maximum plant yielding were observed in ratios of 1:1, 3:1, and 2:1, correspondingly. Regarding the yielding, only the weight of desirable and consumer products has been calculated and total weight of harvested products during the tests is presented in Tables 2 and 3. The second phase of experiment began as a weekly process and continued until 120th day of the experiment. Published data in this stage indicate the variation in results. For instance, the maximum yielding was occurred after 120 days and in composition ratio of 1:1.

As can be seen in Fig. 1, a comparison has been made between two periods of 40 days and 90 days for all aforementioned characteristics of tomato plants in four different ratios of vermicompost to soil. Obviously, in most cases, the values obtained in 90 days are dramatically higher than ones resulted in 40 days, except in average plant height, which this difference is appeared slightly.

Table 2 . Recorded data from the four plants grown in beds after 40 days

Type of combination bed (vermicompost:soil)	Average plant height (cm)	Average stem diameter (cm)	Average number of leaves per plant	Average plant yielding (gr)
1:1	38	0.7	96	729
2:1	33	0.7	89	783
3:1	35	0.8	125	681
4:1	36	0.6	75	628

Table 3 . Recorded data from the four plants grown in beds after 90 days

Type of combination bed (vermicompost:soil)	Average plant height (cm)	Average stem diameter (cm)	Average number of leaves per plant	Average plant yielding (gr)
1:1	42	1.1	138	1153
2:1	38	1.1	145	1092
3:1	36	1.1	142	898
4:1	37	1.1	133	716

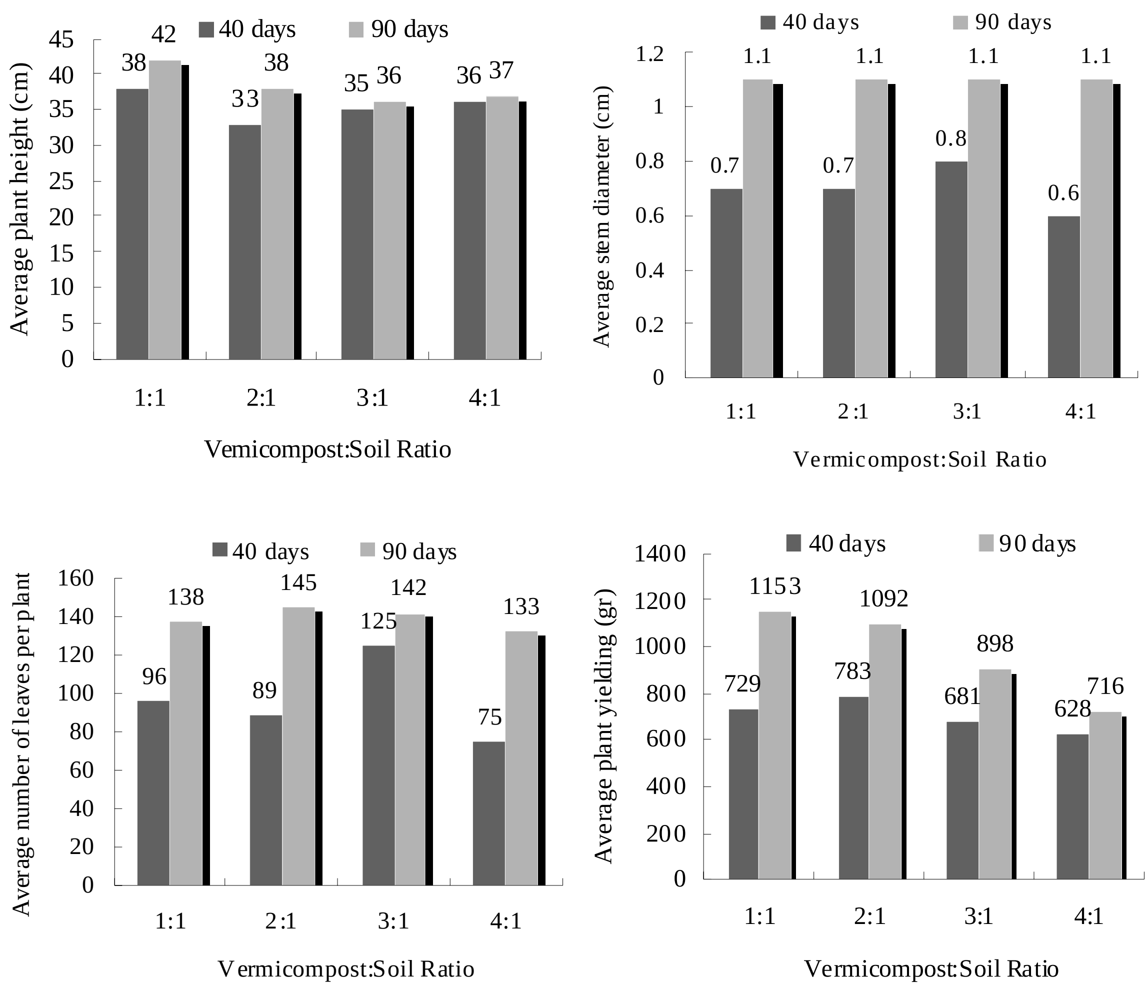

Fig. 1. Comparing various characteristics of tomato plants in two tests of 40 days and 90 days

Table 4. The chemical analysis of tomato from the four plants grown in beds after harvesting

Type of combination bed (vermicompost:soil)	pH	Soluble solids (%)	Insoluble solids (%)	Total N (%)	Total sugar (%)	Vitamin C mg/100g fresh tomato
1:1	4.3	5.90	3.92	1.96	4.3	15.38
2:1	4.1	5.85	4.13	1.85	4.7	18.64
3:1	4.1	6.19	3.84	2.01	5.3	20.21
4:1	4.2	6.18	3.54	1.89	5.5	21.35

The positive effect of vermicompost on growth, yield, and characteristics of peppers, tomatoes, and strawberries might be related to humic acids and other plant growth regulators, improvement of physical structure of soil and the presence of microorganisms (Oliva Llaven *et al.*, 2008). Fresh tomato samples are used to determine the pH, soluble and insoluble solids, total N, total sugar and vitamin C content. An amount of 50 gr crushed-tomato tested for verifying the aforementioned chemical data. By analyzing the data in Table 4, the optimum ratio of vermicompost: soil in order to achieve better quality of products can be elicited.

It would also appear that the combination of soil and vermicompost increases amount of soluble and insoluble solids, total sugar and vitamin C in tomatoes significantly, but the total N contents of tomatoes are not affected by extra vermicompost. Since soluble solids more than 5.85% and pH less than 4.3, tomatoes from plants grown in mixed bed of soil and vermicompost are beneficial for juice production. Tomato juice with pH 4.0–4.1 can be preserved more easily because the growth of pathogenic microorganisms is inhibited (Villareal, R.D., 1982).

CONCLUSION

As a consequence, optimum ratio of vermicompost to soil in order to achieve the maximum product is 1:1; it means that a unit of vermicompost to be added per unit of soil. With the difference of yielding rate among plants grown in both composition ratio 1:1 and 4:1, about 38% rising in the products can be seen. Obviously, the maximum amount of vitamin C and total sugar, soluble solids, insoluble solids and total nitrites of fresh tomato were observed in ratios of 4:1, 4:1, 3:1, 2:1 and 3:1, respectively. Vitamin C and total sugar content in tomatoes increase with using vermicompost.

Another issue is related to the water supply for tomato plants in order to achieve maximum yielding. Tomato plants required a great deal of water for rapid growth. Precise controlling of the amount and timing of irrigation will be effectual in balancing between vegetative and reproductive growth of plants and consequently in the fertility rate and quality of tomato product. Although it is so difficult, but using from Psychomotor can be helpful. According to conducted experiments, each greenhouse tomato plant uses 65 liters water during the growth period. In organic agriculture and greenhouse cultivation, using from composition of soil and vermicompost as bed is the most pure, suitable and economical method. Also, using such these materials which investigated already will be resulted in more efficient agricultural products. As a result, vermicompost has a potential for improving plant growth and dry matter yield when added to the soil (Atiyeh, 2000; Zaller, 2007).

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