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Effect of Vermicompost Produced from Vegetable Wastes and Cow Dung on the Growth of Tomato Plant.

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Abstract

The aim of the present study was to investigate the suitability for vermicomposting of vegetable waste amended with cow dung using the earthworm species Eisenia fetida. Our previous results showed that Eisenia fetida was unable to survive in 100% uncooked vegetable waste. So, three different proportions i.e. 1:1, 1:2 and 1:3 of cow dung and vegetable were prepared and subjected to vermicomposting after 3 weeks of precomposting. The growth and reproduction of earthworms were assessed at regular intervals. Moreover, the effect of different vermicomposts on tomato plants in pot culture experiment was also investigated. Our results revealed that the 1:1 ratio (cow dung: vegetable waste) of substrates used in vermicomposting shows minimum mortality of earthworms. Moreover, the mean height, stem diameter and no. of flowers were also found significantly higher in 1:1 group. In conclusion, our results show that vegetable waste amended with cattle manure in appropriate ratio produces ideal compost which could have attributed to the plant growth as well as fecundity of earthworms.

1. Introduction

In the past two decades, there is abrupt rise in high living standards, educational and tourism sectors, development of hotels, hotels, and restaurants etc. Consequently, accumulation of biodegradable waste materials (BOW) like vegetable waste, yard waste etc. have been increasing in the environment continuously which persistently deteriorating our environment. Another major reason of rise in the amount of BOW is non-segregation approach of BOW at the source of generation that results in the mixing of biodegradable and non-biodegradable wastes. As a result, management of waste becomes more complicated to handle. These accumulating wastes increasing pressure on limited available sanitary landfill areas. On one hand, our soils are getting deficient in all essential plant nutrients due to over-exploitation of agricultural land (Blum, 2013). Large amount of nutrients available in BOW is increasing the amount of mixed refuse. Moreover, open dumping of such BOW act as a breeding ground for the disease vectors like flies, mosquitoes, rats, insects and also create the environmental pollution. Different methods are employed for the disposal of food wastes such as dumping in open or landfills sites. Improper disposal of these wastes further causes air pollution, produces foul odour, creates health hazards and also act as a source of greenhouse gases emission (Eleazer *et al.*, 1997). Biotransformation of BOW has become a crucial part of society and environment almost all over the world.

Therefore, to handle all these issues, BOW should be collected, segregated and processed to some valuable product by applying a lucrative and ecofriendly waste conversion technology such as vermitechnology. Vermitechnology is a composting process involving the synergistic action of earthworms and microorganisms in an aerobic environment to break down and stabilize BOW (Suthar, 2010). Earthworm's excretion of castings is a dark-colored, homogeneous, and humus rich product called as vermicompost that contains high levels of plant nutrients. Vermicompost is environment friendly organic manure that has high quantities of humic acids, plant growth hormones, enzymes and antimicrobial substances (Tajbakhsh *et al.*, 2011).

Numerous experimental studies have reported the vermicomposting of organic wastes including tomato residue waste(Fernández-Luqueño *et al.*, 2010), rice straw and paper waste. In the recent years, various research labs performed vermicomposting by using sewage sludge, municipal solid waste, and human faeces (Srivastava *et al.*, 2005; Gupta *et al.*, 2008; Yadav *et al.*, 2010b; Xing *et al.*, 2015). Recently, Sharma and Garg reported the comparative analysis of vermicompost quality produced from rice straw waste and paper waste employing earthworm Eisenia fetida (Sharma *et al.*, 2018). However, limited data is available on the vermicomposting of vegetable processing waste. The present study was designed to evaluate vermicomposting potential of vegetable waste mixed with cow dung as a bulking agent. To assess the quality of vermicomposting, we analyzed physicochemical properties such as pH, electrical conductivity, and total organic carbon (TOC). Afterwards, we have determined the quality of vermicompost by applying the vermicompost on tomato plant. After 45 days, plant height and diameter was measured and reported in the present study.

2. Materials and Methods

Collection of wastes and culturing of earthworms

Vegetable waste was collected from hostels of K.I.E.T group of institutions and cow dung was collected from a dairy farm, Muradnagar, Ghaziabad, India. Eiseniafetida species of earthworms was employed for vermicomposting purposes. E. fetida worms were taken from the stock vermicultures maintained in our laboratory.

Experimental set-up and vermibin preparation

The experimental set-up was established with three different combinations of VW with CD to explore their bioconversion and stabilization by earthworms. Composition of VW and CD was as follows:

Vermireactor no. 1 (VB 1): VW 50% + CD 50% (1:1)

Vermireactor no. 2 (VB 2): VW 33.33% + CD 66.66% (1:2)

Vermireactor no. 3 (VB 3): VW 25% % + CD 75% (1:3)

Experiments were conducted in circular plastic vermireactors (diameter 40 cm, depth 12 cm), and each vermireactor was established in triplicate. Waste mixtures were pre-composted for 21 days to make waste mixture suitable for the growth and development of earthworms. During pre-composting period,thermophillic stage of decomposition prevails where readily decomposable compounds are degraded. Whereas, pathogenic organisms are killed due to high temperature and the potential toxic substances lethal to earthworms are eliminated.

Forty healthy clitellate worms were picked from the stock vermicultures, weighed and released in each vermireactor after 21 days of pre-composting(Yadav *et al.*, 2010a). Earthworm E. fetidaare epigeic, aerobic species and sensitive to anaerobic conditions.Therefore, to maintain the aerobic condition, the mixed organic substrates were turned manually time to time. All the vermibins were kept in the dark by covering it with jute bags at a room temperature of 25 ± 3 °C. The moisture was maintained at 60–70%. The experiment was conducted for 90 days. After the conduction of vermicomposting, earthworms were removed out and weighed(Garg *et al.*, 2006).

Physico-chemical analysis of raw wastes and vermicompost

Physico-chemical analysis of vermicompost was carried out at 0, 45, and 90 days.Different feedstocks and final product (vermicomposts) were analysed as per standard protocols. The vermicompost was air-dried at room temperature, homogenized and packed in the airtight plastic bags for physico-chemical analysis. Raw wastes and vermicomposts were analysed for different parameters like pH, electrical conductivity (EC), total organic carbon (TOC). The pH and EC were determined by a digital pH and EC meter using double-distilled water suspension of each sample in the ratio of 1:10 (w/v). TOC was determined by a dry combustion method as reported by Nelson and Sommers (1982)(Nelson, 1982).

Biomass growth of earthworms

Total earthworm weight was measured separately for each vermireactor at 0 and 90 days. Distilled water was used to clean earthworms and dried with filter paper and then the weights of earthworms were determined by analytical balance.

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Analysis of impact of vermicompost on Plants growth and materials

Tomato seeds were purchased from a local market. Individual seeds of tomato were sown in flower earthen pot containing appropriate substrate mix of 70% soil and 30 % of prepared vermicompost. Seeds were allowed to germinate and grown for seven days. Three individual pots per vermicompost ratio were used. A pot without any vermicompost (100% soil) was used as a standard.In total nine individual pots were used where each ratio was evaluated in triplicate. Plants were grown in shed and plants were watered with tap water on regular basis. After 45 days, plant height and diameter was measured.

Statistical analysis

The data are represented as mean with standard error of mean (mean ± S.E.M). One way-ANOVA followed by Turkey test was applied on the data. The P<0.05 was considered as statistical significant. Statistical analysis of the data was performed with the help of Graph-pad prism software.

3. Results and Discussion

Average weight of E. fetida before and after vermicomposting process

Weight analysis of earthworms revealed that weight of earthworms significantly increased in all the vermireactors during vermicomposting process. Amongst the different vermicompost mixtures, vermicompost (1:1) showed the highest increase in weight of 37.08 g on 90th day of experiment (fig. 1). Assessment of biomass of earthworms is considered as an important index for comparing the quality of vermicomposts. The rise in weight of earthworms in all vermireactors reflects sufficient availability of organic matter and non-assimilated carbohydrates to earthworms (Edwards *et al.*, 1998). Moreover, microbial biomass present during the vermicomposting process also considered as major factor for the biomass of earthworms (Suthar, 2006). Our study results regarding weight of earthworm during vermicomposting process are corroborated with previous findings (Suthar *et al.*, 2008; Bhat *et al.*, 2016).

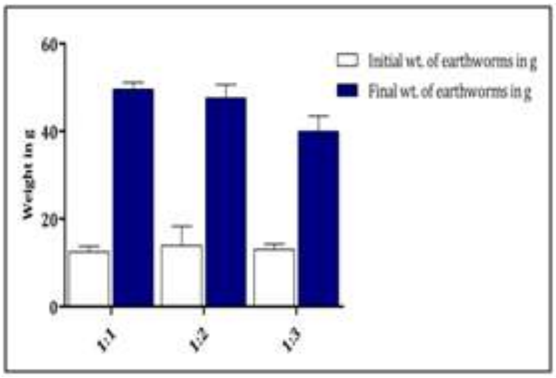

Figure 1: *Effect of vermicomposting on weight of earthworms during the study. Data were represented as mean ± S.E.M. (n = 3).*

Physico-chemical analysis

The pH of vermicompost is a crucial factor which affects vermicomposting process. Earthworms can readily survive between the pH 5-9 (Garg *et al.*, 2011). Physico-chemical properties of cow dung and vegetable waste were mentioned in Table 1. pH analysis found that pH was significantly altered throughout the vermicomposting process. The final pH of different vermicomposts was found in the range of 6.97-7.45. The maximum reduction in the pH was observed in vermicompost (1:1). pH was significantly (*P<0.001*) reduced between starting day to day 90 in all vermibins. A previous study reported that earthworms secrete calcium and ammonium ions that are responsible for the reduction of pH during vermicomposting (Pramanik *et al.*, 2007).

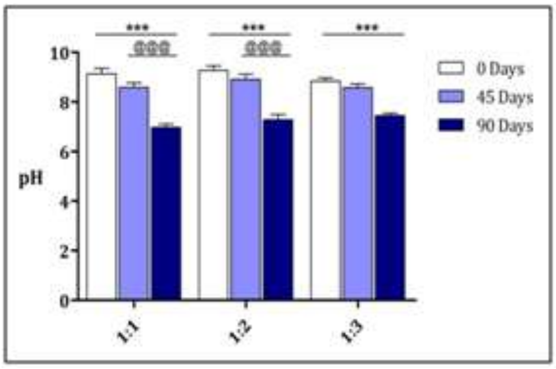

Figure 2: *Effect of vermicomposting on pH during the study. Data were represented as mean ± S.E.M. (n = 3). Two-way analysis of variance (ANOVA) followed by Bonferroni's test was applied (***p<0.001 comparison between 0 and 90 day; @@@p<0.001 comparison between 45 and 90 day).*

Table 1: *Physico-chemical properties of cow dung and vegetable waste at day-0*

Raw material	pH	Electrical conductivity (mS/cm)	Total Organic carbon (g/kg)
Cow dung	8.95	0.27	479
Vegetable waste	9.47	0.19	524

Optimum salt concentration is essential for the plant growth (Shrivastava *et al.*, 2015). High salinity in the soil may cause phytoxicity (Lazcano *et al.*, 2008). We found significant (*P<0.001*) increase in the EC after 90 days of all final vermicomposts. The maximum rise in EC was observed in vermicompost (1:1). In this vermibin (1:1), EC was significantly (*P<0.001*)increased continuously throughout the vermicomposting period. The trend of increase in EC was found 1:1>1:2>1:3. Higher EC reflects presence of more soluble salts in the vermicompost sample. The reduction in organic carbon is responsible for rise in EC during vermicomposting process (Karmegam *et al.*, 2009).

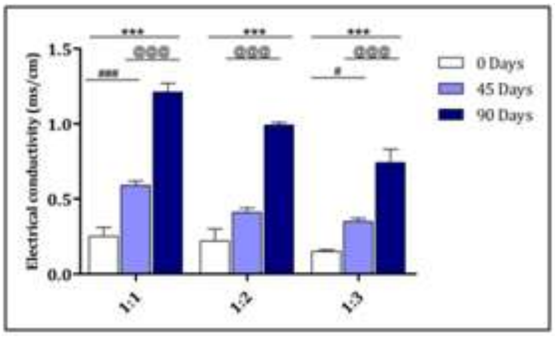

Figure 3: *Effect of vermicomposting on electrical conductivity during the study. Data were represented as mean ± S.E.M. (n = 3). Two-way analysis of variance (ANOVA) followed by Bonferroni's test was applied (***p<0.001 comparison between 0 and 90 day; @@@p<0.001 comparison between 45 and 90 day; ###p<0.001, #p<0.05 comparison between 0 and 45 day).*

TOC content reflects the presence of organic wastes in the vermicompost (Yadav *et al.*, 2011). We found that TOC significantly (*P<0.001*) and gradually decreases during the vermicomposting process. The TOC content of the initial vermicompost mixtures were found in the range of 478.39-501.80 g/kg. After vermicomposting process at 90th day, TOC was found in the range of 343.30-400.59 g/kg. The TOC loss in all vermicomposts was found in the following order: 1:1>1:2>1:3. The respiration of microbes and earthworms present in the vermicompost are responsible for the reduction in TOC (Varma *et al.*, 2015). Loss of TOC indicates loss of organic carbon in the vermicompost samples. Our study results are in line with the previous reports (Khwairakpam *et al.*, 2011; Bhat *et al.*, 2016).

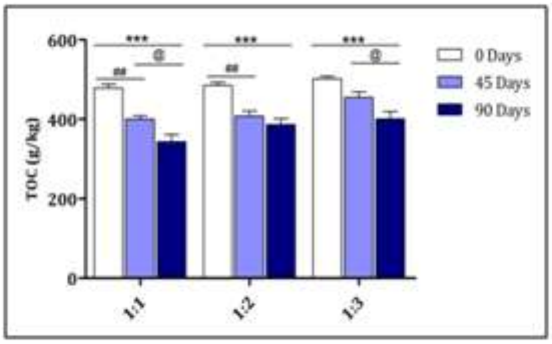

Figure 4: *Effect of vermicomposting on Total organic carbonduring the study. Data were represented as mean ± S.E.M. (n=3). Two-way analysis of variance (ANOVA) followed by Bonferroni's test was applied (***p<0.001 comparison between 0 and 90 day; @p<0.05 comparison between 45 and 90 day; ##p<0.01 comparison between 0 and 45 day).*

Effect of vermicompost on growth characteristics of tomato plants after 45 days

In earlier studies, tomato plant has been grown to assess the effect of vermicompost on growth characteristics of plant (Hashemimajd *et al.*, 2004; Gutiérrez-Miceli *et al.*, 2007). We did not find any sign of seed germination in the control pot containing soil without any vermicompost or manure. Seeds were sown in pot containing soil and vermicompost in a ratio of 7:3. Seeds were germinated in all pots containing vermicompost mixtures (1:1, 1:2 and 1:3) and soil. Fig 5 and 6 shows the growth characteristics (plant height, biomass and leaf number) and stem diameter of tomato plants. The highest measures for plant parameters (plant height: 55.19 cm, leaf number: 103.76, plant biomass: 49.02 g and stem diameter: 0.92 cm) was observed in (1:1) vermicompost mixture. Thus, the physico-chemical properties of (1:1) vermicompost mixture were found optimum for the plant growth. The leaf no. in 1:1 mixture was significantly (*P<0.01*) high as compared to 1:3 mixture. Moreover, stem diameter of 1:1 mixture was found significantly (*P<0.05*) large compared to 1:3 mixture. The lowest values of plant parameters were found in (1:3) vermicompost ratio.

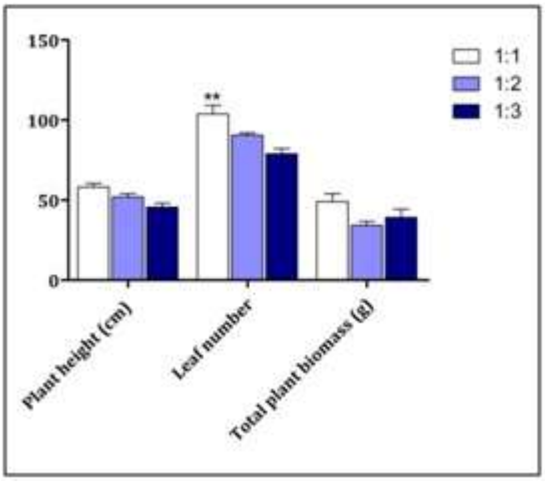

Figure 5: *Growth characteristics (Plant height, biomass and leaf number) of tomato plants cultivated in a7:3 ratio mixture of soil and different vermicompost after 45 days of transplanting. Data were represented as mean ± S.E.M. (n=3). One-way analysis of variance (ANOVA) followed by Tukey test was applied (**P<0.01 comparison between 1:1 and 1:3).*

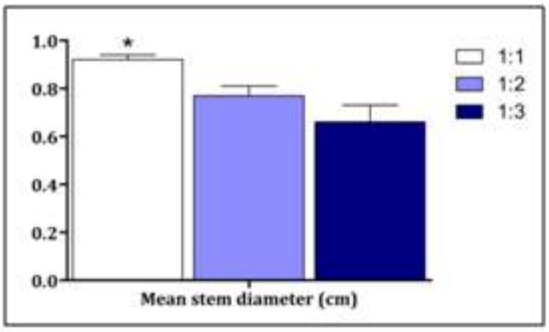

Figure 6: *Stem diameter of tomato plants cultivated in a7:3 ratio mixture of soil and different vermicompost after 45 days of transplanting. Data were represented as mean ± S.E.M. (n=3). One-way analysis of variance (ANOVA) followed by Tukey test was applied (*P<0.05 comparison between 1:1 and 1:3).*

4. Conclusion

Our results prove the potential of vermitechnology for degradation of vegetable waste mixed with cattle manure. Vermicomposting of vegetable waste with the cow dung leads to drop in pH and TOC with increase in EC. The physico-chemical properties and growth parameters of plants clearly indicate the effectiveness of cow dung and vegetable waste in a ratio of 1:1. Vermicompost technology can pave the way for the management of vegetable waste and cow dung.

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