Current Trends in Biotechnology and Pharmacy
Vol. 18(4) 1967-1976, October 2024, ISSN 0973-8916 (Print), 2230-7303 (Online)
DOI: 10.5530/ctbp.2024.4.42

Morphological and Physico-biochemical Characterization of Tomato Plant using Different Waste Vermicompost by Earthworm *Eudrilus eugeniae*

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Abstract

Vermicomposting is an environmentally friendly and cost-effective process for decomposing organic waste. Paper mill sludge waste (PW) and sugar mill press mud waste (SPW) are often indiscriminately discarded into the environment, causing health hazards and environmental pollution. Due to its high nitrogen content, this waste can be turned into organic fertilizer to reduce pollution and provide an inexpensive raw material for fertilizer production. Four compost mixtures (E1, E2, E3 and E4) were prepared in different proportions. PW and SPW with CD + PW + SPW cow manure control mix. After 90 days of composting, the nutritional composition of the compost was analyzed and the vermicompost obtained was applied to *Solanum lycopersicum*. The pH, N, P, K, C: N, and Total Organic Carbon (TOC) of the vermicompost were chemically analyzed. Randomly selected seedlings from each treatment were transplanted into pots, and various parameters such as Plant growth, leaf chlorophyll content, mineral concentrations, fruit characteristics, yield and fruit quality (including color, pH, ascorbic acid, titratable acidity and total solids) soluble) **is** evaluated. Most of the growth, yield, and quality indicators increased quite well compared to the control, but the difference between the treatments was not significant. In conclusion, vermicomposting of PW and SPW resulted in the production of high-quality organic fertilizer that can improve plant growth, yield, and quality. This can help reduce pollution and minimize the need for additional nitrogen sources, thereby reducing costs. The findings of this study suggest that vermicomposting can be a useful tool for sustainable waste management and agricultural practices.

Key words: Paper mill waste, β-Carotene, Lycopene, Total chlorophyll, Total yield

Introduction

Paper mill industries play an important role in the global economic environment and people's ability to make a living. With the passage of time, it was discovered that there had been a significant increase in global paper production. For the time being, the United States is the world's biggest paper producer. However, the Confederation of the European Paper Industry predicts that global paper demand will exceed 500 million tons by 2025 (1). India produces 2.6% of the world's paper, contributing to the country's economic development (2). Due to the high organic matter content, developing countries like India face major barriers in the area of proper waste management (3,4,5). Traditional sugar sludge management methods, including

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composting, land filling, incineration, pollute the soil and impact global warming by generating harmful gases. Water pollution due to improper disposal of domestic and industrial waste is also a serious problem in this country (6).

Large volumes of sludge from paper mills and sugar mills cause environmental problems, polluting air, water and soil ecosystems. One of the essential techniques for valorization is vermi-technology, a biotechnological invention that holds tremendous promise for the sustainable management of wastes by bio-converting solid organic wastes into a valuable molecule under favorable ecological conditions (7,8). Most reassuringly, it maintains the region's economy and promotes livelihood in rural areas. It outlines a good biodegradation technique in which earthworms and microorganisms work together to cause severe deformation in organic solid wastes. (9,10). In contrast, soil bacteria ferment them into organic nitrogen that can be used for agricultural purposes. Population growth coupled with inadequate food supplies, declining quality of health care, high unemployment and increasing environmental degradation are some of the key underlying issues affecting global prosperity. Around the world. the future of "humanity". These problems are expected to increase in severity as the world population continues to farm (11).

Tomato (*Solanum lycoperscium*) is a major vegetable crop grown around the world. Lycopene, the main pigment responsible for the red color of tomatoes, is one of the most abundant natural carotenoids found in tomatoes (90%) (12). It is a commercial vegetable grown all over India due to its high nutritional value and reliable price. India ranks first in area (5.1 million hectares) and production (880,000 tons). It has ayurvedic medicinal properties and is known to benefit diabetics (13). Carotenoids such as carotene and lycopene play important roles in antioxidant protection against lipid peroxidation in living cells (14). The unsaturated open-chain carotenoid of lycopene has 11 covalent double bonds and is an effective free radical scavenger (15) also they are important dietary sources of vitamin A. After bioconversion of retinol-carotene to provitamin A (16). Therefore, the introduction of these biodegradable materials into the soil not only increases the organic matter content and soil fertility, but also increases the microbial activity (17,18,19,20). Improvements in soil fertility and microbial activity due to the return of crop wastes such as compost improve farmland health and increase root strength and biological properties. plant physiology such as photosynthesis rate, chlorophyll and carbohydrate content. (21,22). However, it was discovered that using organic fertilizer along with fertilizers high in nitrogen, phosphate, and potassium was more beneficial for increasing production and supplying macronutrients to tomato plants.

The goal of the current research was to handle waste from sugar and paper mills using a combination of innovative vermicompost method techniques. Evaluation of the effect of treated waste on the content of β-carotene, lycopene and chlorophyll in tomato fruit and growth of the plant.

Materials and Methods

Raw material collection

Paper mill sludge waste is collected from TNPL in Pugalur, Karur district, Tamil Nadu. Sugar mill press mud waste is collected from Mohanur sugar mill industry. Cow dung were also collected at the same location. The collected waste was washed several times with tap water, dried in the sun and used in composting experiments.

Experimental setup

Raw materials (CD:SW:PW) are put into 5 round barrels (25cm diameter, 40cm high) and mixed in different ratios C (4:0:0), E1 (4:2:2) and E2 . (4:3:1), E3 (4:1:3) and E4 (4:4:4). Compost moisture was maintained at 40-60% throughout the experimental period (90 days). Five types

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of compost were introduced into the soil 3 days before sowing at the rate of 30 kg per field (25 sowing). General stages such as irrigation, weeding, pest control are carried out according to the process. This study was conducted on tomato plants (*Solanum lycopersicum*) grown on sandy soil combined with drip irrigation system. Tomato seeds were sown in seedling trays in June 2021 and placed in a greenhouse. Healthy seedlings of 30 days old were planted in plots of 15 m^2. Seedlings were planted in vertical rows (25 plants per row) with 1.0 m row spacing and 0.5 m row spacing, experimental setup consisting of completely randomized plots and 5 composting treatments. . Each formula was repeated 5 times. Each compost treatment was separated from each block by 1 m grooves. Each plot is 10 m long, including 25 trees, of which 10 central trees are selected to determine growth characteristics, yield, and fruit quality.

Physico-chemical analysis

Use DH2O dual organic fertilizer solution at the ratio of 1:10 (w/v) and analyze the results with a digital pH meter (23), The pH of compost sample was determined. Total organic carbon (TOC) was calculated using (24).The Micro Kjeldahl technique was used to determine Total Nitrogen (TN) (25, 26). A colorimetric method was used to determine total phosphorus (TP) (27). After digesting the sample in an acidic mixture (HNO3 concentrate; concentrated HClO4, 4:1, v/v), total potassium (TK) was measured using a flame photometer (28).

Morphological parameters

The following morphological data were recorded: plant height (cm), fruit diameter (cm), fruit weight (g) and total yield (g/plant) (29).

Biochemical analysis of fruit pigments

10-20 ml of acetone-hexane (4:6) solvent was used to homogenize 1 g of tomato fruit. After homogenization, the supernatant was used for biochemical analysis (30).

Amount of lycopene, β-carotene and chlorophyll

The amounts of lycopene, beta-carotene and chlorophyll were determined using the analytical method and technique described by the technique of Mackinney and Kimura. For lycopene, β-carotene and other nutrients, chlorophyll a, b and total are expressed in mg/100 ml.

Fruit quality characteristics

10 fruit samples were previously used to evaluate fruit quality characteristics. Fruit was cut into small pieces and tomato juice from each of the 10 fruit samples was extracted by measured volume (ml) using a juicer. Pure juice is used for quality control. After removing the seeds, skin and pulp, the volume of juice was measured in a graduated cylinder (31).

pH

In 50 ml of filtrate containing 10 g of pulp mixed in 100 ml of distilled water, determine the pH of tomato juice (32).

Titrated acidity (TA)

Titration of 10 g of homogenized tomato juice sample after dilution with 50 ml of distilled water, 0.1% NaOH solution **at** pH 8.17 was used to determine the acidity (33) and the results are reported in g/L.

Ascorbic acid (AA)

The concentration of ascorbic acid in selected tomatoes was determined by the method of (34). The procedure consisted of homogenizing a mixture of fruit pulp (5 g) and 5 ml of 0.1% HCl (w/v), then centrifuging the mixture at 10,000 rpm for 10 min and accumulating supernatant into the condenser. The absorbance of the supernatant at 243 nm was then evaluated using a spectrophotometer.

Statistical analysis

Statistical analyzes were performed using one-way ANOVA and Duncan's multiple test

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(DMRT) in SPSS (version 21) and the data were compared.

Results and Discussion

90 days after transplanting, tomato plant height responded significantly to 5 different treatments. The results of physical and chemical testing of the final product are shown in (Table 1). The pH level is one of the most important aspects of the composting process. The pH level is reduced as much as possible during the E2 treatment. The maximum available nitrogen content of E2 was 7.33%, which is consistent with the conclusion (35). Nitrogen is an essential component of amino acids, the basic structural unit of proteins. At the same time, due to the ammonification process, the nitrogen content in the compost is significantly reduced, leading to the conversion of a part of organic NH3 into NH4+ ions (36). Phosphorus provides energy for plant growth and maintains plant balance (37). The waste compost in our present study contained less phosphorus than the control (0.26%). Phosphorus increases the amount of chlorophyll in plants. E2 has a gradually increasing potassium (K) content (4.40%). Wool and feather waste can provide nutrients (N, P, K) to plants and improve soil biology and chemistry (38). A significant increase in plant height was observed with an organic fertilizer rich in E3 (67.64 cm) and then treated with E2 (66.25 cm). However, the shortest plants were found in the control variant (58.38 cm) (Table 2). These results may be related to the physico-chemical state of the palm waste modified by the addition of water and fertilizer for plant growth (39). All tomatoes showed a significant difference. Plant height is a significant component, according to (40), because it has the most beneficial effect on fruit yield. Fruit weight, volume, and therefore total fruit production were highest in vermicompost enhanced with a greater rate of E2, while control yield was lowest. (E4 and C) gave the lowest values of total yield and its components. In terms of average fruit weight and diameter, E2 produced the highest values (2.197 kg) and (1.283 kg), respectively, when compared to C. In general, all compost treatments with differing waste ratios produced significantly higher yields and components than control soil. These findings support the findings of (41) who found that adding cow dung vermicompost to tomato plants increased plant growth and yield while decreasing element uptake, primarily N, P, and K. In addition, compost enriched with different vermicompost ratios (E1 to E4) significantly increased fruit length and diameter compared with enriched control compost. The high yield and nutrient concentration of tomato plants fertilized with organic fertilizers added to cow manure may be due to the fact that these substances not only contain sufficient nutrients, but also because nutrients are slowly released into the soil. This minimizes nutrient loss and leaching while increasing nutrient utilization (42). Furthermore, compared with balanced chemical fertilizers, the use of organic fertilizers increases the organic carbon content and fertility of the soil, leading to a tendency for higher yields (43). The weight and number of fruits determine the yield of the plant. As a result, fruit weight is directly proportional to plant yield (44). The pigment composition of tomato fruit was determined and the results published (Table 3). The results showed that increasing the sulfur content resulted in a 44.5% higher lycopene content in the fruit for a tomato variety (45), with the highest lycopene content recorded being E2 (0.571 mg/100 ml).). , E1 (0.563 mg/100 ml), E4 (0.538 mg/100 ml), E3 (0.521 mg/100 ml) and the lowest C (0.472 mg/100 ml). Plants treated with E2 had higher β-carotene content than control plants (E2 (0.271 mg/100 ml), E1 (0.249 mg/100 ml), E4 (0.205 mg/100 ml), E3 (0.173 mg/100 ml). ml). ml), E4 (0.205 mg/100 ml), E3 (0.173 mg/100 ml) and control (0.147 mg/100 ml) (46). Tomatoes from control plants had 0.183 mg/100 ml of chlorophyll (a) and 0.338 mg/100 ml of total chlorophyll, while

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Table 1 Physicochemical parameter of feather compost samples

Treatments	pH	OC (%)	N (%)	P (%)	K (%)
C	8.5 ±0.52	0.85 ±0.02	1.02 ±0.14	0.20 ±0.02	1.95 ±0.53
E1	8.32 ±0.42	1.08 ±0.14	1.54 ±0.05	0.51 ±0.05	2.05 ±0.27
E2	8.09 ±0.27	1.41 ± 0.05	3.02 ±0.21	0.96 ±0.12	3.15 ±0.15
E3	8.15 ±0.36	1.30 ±0.21	2.68 ± 0.09	0.72 ± 0.15	2.74 ±0.36
E4	8.43 ±0.41	1.01 ±0.13	1.27 ±0.15	0.35 ±0.08	2.01 ±0.18

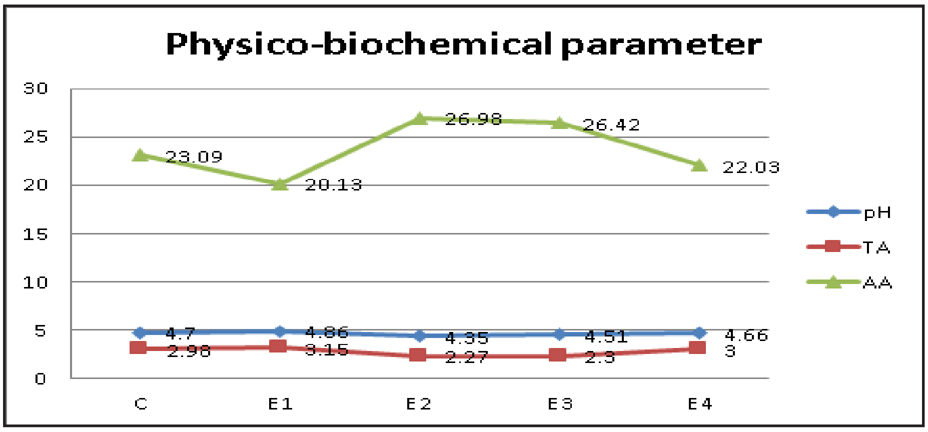
Table 2: Total yield parameters of tomato plants

E2 had the lowest chlorophyll (b) content of 0.227 mg/100 ml.

Treatment	Plant height at 90 days (cm)	Fruit diameter (cm)	Fruit weight (g)	No. of fruits/ plant	Total yield (Kg/ plant)
C	58.38 ± 1.26	2.61 ± 0.18	10.33 ± 0.85	45.62 ± 3.86	1.283±1.52
E1	61.71 ± 0.98	2.82 ± 0.27	11.33 ± 1.15	60.93 ± 3.55	1.483±0.96
E2	66.25 ± 1.52	3.79 ± 0.59	11.87 ± 0.92	71.13 ± 4.04	2.197 ± 1.36
E3	67.64 ± 1.81	3.88 ± 0.36	13.33 ± 1.23	62.15 ± 4.16	2.015 ± 2.04
E4	68.45 ± 1.20	3.74 ± 0.27	12.57 ± 1.28	59.17 ± 3.75	1.305 ± 2.18

Table 3: Analysis of plant pigments chlorophyll, lycopene and β-carotene

Experimental treatment	Chlorophyll a (mg/100 ml)	Chlorophyll b (mg/100 ml)	Total Chlorophyll (mg/100 ml)	Lycopene (mg/100 ml)	β-Carotene (mg/100 ml)
C	0.176	0.092	0.269	0.472	0.147
E1	0.150	0.143	0.305	0.563	0.249
E2	0.183	0.227	0.338	0.571	0.271
E3	0.182	0.105	0.287	0.521	0.173



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E4	0.133	0.153	0.264	0.538	0.205

Figure 1: Physico-biochemical parameter of tomato fruit

Fruit quality characteristics

The results in Table 5 show that different compost combinations influenced the AA, TA, pH, and fruit juice (%) of tomatoes. Ascorbic acid is vital to one's diet because it will be cure chronic disease, scurvy, and stress. According to data reported in, the E2 had the greatest AA concentration (26.98 0.51 mg/100 g), followed by the E3 and the shortest control (23.09 0.15 mg/100 g) (Table 4). Light rates in tomatoes at the end of harvest, temperature conditions during pre-harvest, at harvest and after harvest, and changes in AA content for the same variety are reasonable explanation. (47). At maturity, the level of AA was higher, but it later decreased (48). In this investigation, the TA values ranged from 0.28 to 0.49%. The E1 compost had the highest TA value (0.45-0.56%), while E2 organic fertilizer has the lowest TA value (0.30-0.32%). These results contradict the conclusion of (49) who found that TA values were higher in plants treated with organic compounds compared with plants treated with fertilizers or controls. . The pH of the fruit is an important factor in the consumption of fresh tomatoes; The low pH improves the flavor of the fruit (50). All organic fertilizers have pH values that range from 4.35 to 4.86. These values are relatively similar to those reported by different researchers in previous studies (51, 52). They found pH values between 4.19 and 4.45 in many varieties of tomatoes grown on soils that had been improved with multiple applications of organic and mineral fertilizers.

Conclusion

This study found that using vermicompost made from paper and sugar mill waste as a fertilizer for tomato plants grown in the field can enhance plant growth and fruit quality by increasing the levels of photosynthetic pigments, vitamin C, lycopene, carotene, and other nutrients. The study evaluated different waste-to-waste ratios of vermicompost and found that tomato plants responded differently to each type of vermicompost. However, when vermicompost material was modified with high concentrations of paper mill waste and sugar press sludge (E2), significant differences in tomato fruit growth, yield and quality were observed compared to those amended with NPK chemical fertilizer and soil.The study concluded that no single nutrient source, such as chemical fertilizer, organic manure, or biofertilizer, can fully meet all nutrient requirements. However, vermicompost can increase the quantity and quality of nutrients, leading to quicker nutrient absorption and improving growth and yield parameters in crop plants.

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Current Trends in Biotechnology and Pharmacy
Vol. 18(4) 1967-1976, October 2024, ISSN 0973-8916 (Print), 2230-7303 (Online)
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