EFFICACY OF COMPOST MADE OF FOOD WASTES WITH ORGANIC AMENDMENTS FOR ENVIRONMENT FRIENDLY AGRICULTURE

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INTRODUCTION

Sustainable agriculture is farming in sustainable ways and composting is an effective and a sustainable means of organic matter restoration through carbon restitution to the depleted soils as an organic amendment. Dalzell et al. (1987), has reported that composting is the most important and rewarding method for increasing agricultural output by raising the level of soil fertility, improving the long-term structural stability and moisture retention of the soil and increasing the supply of plant nutrients. Composting of food waste will reduce the food wastes being disposed in land fill and will also help the food industries to manage their wastes.

Composting is a long-used technology, but there are shortcomings such as pathogen detection, low nutrient status, long duration of composting, long mineralization duration, and odour production (Ayilara et al., 2020). According to the fourth assessment report of the IPCC, food waste composting is associated with greenhouse gases (GHGs) such as carbon dioxide (CO_2) and nitrous oxide (N_2O), which can contribute to global warming and stratospheric ozone depletion (Solomon, 2007). According to Barthod et al., (2018), the negative aspects of composting can be limited through the addition of organic, inorganic or biological substrates to the composting mixture. Several studies have also investigated the efficacy of various compost mixtures with different types of additives such as biochar (Awasthi et al., 2020) and mature compost (Luo et al., 2014) to decrease the emission of gases such as greenhouse gases during composting of various organic waste types. The effects of organic amendments on soil organic carbon and greenhouse gas emissions have received very little attention from researchers.

The significance of this research is to present a quality compost with an organic amendment for the sustainability of the agricultural system. The main aim is to develop a good quality compost by adding different organic amendments to food waste and to improve the sustainability of agricultural systems in an environmentally friendly way while enhancing soil functions and plant growth and reducing emissions.

Thus the objectives of this research are, to report the quality of the compost made with different organic amendments based on physicochemical parameters as a potting mixture, to evaluate the performance of different compost types on growth parameters with and without amendments, to investigate the potential of using organic amendments in reducing greenhouse gas emissions from compost for an environmentally friendly agricultural system and to find out the best type of co-compost as a sustainable product.

METHODOLOGY

Food waste was co-composted with banana peels, egg shells, onion peels and papaya peels individually with a 1:1 ratio and the quality of the mature compost was measured using the physicochemical parameters such as total nitrogen (TN), total phosphorus (TP), total potassium (TK), organic carbon, organic matter (OM), C:N ratio, pH, EC and moisture content. Six seedlings of *Capsicum annuum* each were planted in potting mixtures with a 1:1:1 ratio of co-compost, top soil and sand, with a positive control of food waste compost and a negative control with no compost. The performance of the six treatments were evaluated by measuring the plant height, number of leaves in a plant, number of buds, number of pods and the average weight of pods. The CO_2 emission of the six treatments were measured by absorbing it to $Ca(OH)_2$.

Excel Microsoft Office 2013 was used for descriptive statistics and graphical data representations. MINITAB version 14.1 was used in statistical analysis.

RESULTS AND DISCUSSION

3.1 Quality of compost based on physicochemical properties

The composition of the compost was measured using the physicochemical parameters such as Total nitrogen, Total phosphorus, Total potassium, organic carbon, organic matter content, C:N ratio, pH, EC and moisture content to find out the quality of the product.

Table 3.1. Mean values of physicochemical properties of different compost types.

Compost Type	Total N %	Total P %	Total K %	Organic C	Organic Matter	C:N Ratio	pH	EC ($mScm^{-1}$)	MC %
Control	0.50 (0.14)	0.40 (0.00)	0.20 (0.00)	3.20 (0.14)	7.40 (0.42)	9.00 (0.00)	7.00 (0.57)	0.010 (0.00)	44.11(6.49)
Banana	0.70 (0.00)	0.50 (0.00)	0.90 (0.00)	5.20 (0.14)	15.00 (0.28)	12.50 (0.00)	7.60 (0.57)	0.010 (0.01)	44.13 (3.41)
Egg	0.40 (0.00)	0.30 (0.00)	>0.1 (0.00)	3.60 (0.14)	6.9 (0.42)	9.00 (0.00)	7.70 (0.14)	0.010 (0.01)	33.00 (6.87)
Onion	0.40 (0.14)	0.30 (0.00)	0.1 (0.00)	4.10 (0.14)	9.30 (0.42)	12.00 (0.00)	7.65 (0.21)	0.012 (0.01)	40.30 (7.25)
Papaya	0.60 (0.14)	0.60 (0.00)	0.70 (0.00)	4.30 (0.14)	10.30 (0.14)	9.00 (0.00)	7.95 (0.07)	0.005 (0.00)	33.00 (0.12)

Values represent means of 3 replicates (Standard Deviation).

In Table 3.1 the composts made with the banana peel amendment and papaya peel amendment showed higher NPK content than the control, while the composts made with the egg shell amendment and onion peel amendment showed values lower than the control.

According to Reddy (2005), the average value of nitrogen in composts are considered as 0.5%, the average value of phosphorus is 0.27% and average value of potassium is 0.81%. In the present study, composts made with banana peel amendment showed NPK values approximately closer this value. Choy et al. (2015) has reported that banana peels could enhance the release of nitrogen from food waste proving the results of the present study. The phosphorus content of compost with banana peels also showed a higher value than the control. It is simultaneous with the study by Sial et al. (2019) where available phosphorus concentrations of soil showed a statistically significant difference between the waste treatments of banana peel as compared to the control, with values ranging from the 21.1 to 70.6 mg kg^{-1}. Banana peels are found to be rich in potassium and it has been suggested by Islam et al. (2019) as an alternative source of potassium for plant productivity in sustainable agriculture.

In this study, all the co-composts showed higher organic C values than the control which contained only food waste. It can be explained by the research done by Choy et al. (2015) where they showed that total carbon loss was higher for mixtures containing food waste than with fruit peels which indicated that the degree of degradation of compostable part in mixtures with food waste was more than the mixtures with fruit peels. Composts made with the amendment of banana peels showed the highest amount of organic carbon and organic matter content. This could be due to the higher carbon content in them as carbohydrates and fibres. According to Anhawange, Ugye & Nyiaatagher (2009), the percentage concentrations of protein, crude lipid, carbohydrate and crude fibre in banana peels were found to be 0.90, 1.70, 59.00 and 31.70 respectively.

The pH values of composts showed the final values of pH close to neutrality and within the range (6.0-8.5) suggested for the agricultural use of compost (Hogg et al., 2002).

Composts made with the banana peel amendment showed higher MC than the control. Moisture contents are important in keeping microbial populations active because sufficient moisture is required for microbial nutrition and transport. Also, it determines the Cation Exchange Capacity (CEC) of the soil.

3.2 Performance of the compost by plant growth and yield

The performance of the compost types was compared using the growth parameters of *Capsicum annuum*. The growth parameters measured were the plant height, no. of leaves in a plant, no. of flowers in a plant, no. of pods per plant and the average weight of pods in a plant.

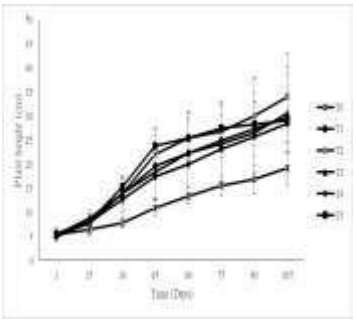


Figure 4.2.1.The changes of mean plant height of *Capsicum annuum* in different treatments of potting mixture during 105 days.
Values represent means of 2 plants in 3 replications and error bars indicate the standard deviation.
T_0 = control with no compost, T_1 = control containing compost made of other wastes, T_2 = banana peel co-compost, T_3 = egg shell co-compost, T_4 = onion peel co-compost and T_5 = papaya peel co-compost.

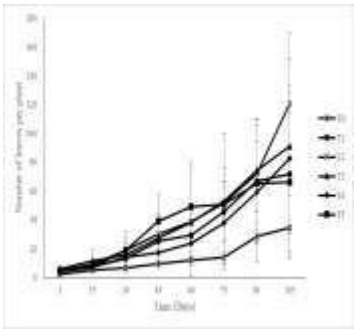


Figure 4.2.2. The changes of No. of leaves per plant of *Capsicum annuum* in different treatments of potting mixture during 105 days.
Values represent means of 2 plants in 3 replications and error bars indicate the standard deviation.
T_0 = control with no compost, T_1 = control containing compost made of other wastes, T_2 = banana peel co-compost, T_3 = egg shell co-compost, T_4 = onion peel co-compost and T_5 = papaya peel co-compost.

Table 3.2. The No. of flowers per plant, No. of pods per plant and the weight of pods per plant of *Capsicum annuum* in different treatments of potting mixture after 105 days.

	No. of buds per plant	No. of pods per plant	Average weight of pods (g)
T_0	0.00 (0.00)	0.00 (0.00)	0.00
T_1	3.67 (5.54)	1.33 (2.80)	1.63
T_2	9.83 (9.56)	0.50 (1.22)	2.00
T_3	10.67 (16.16)	2.00 (4.43)	1.75
T_4	2.83 (5.60)	0.00 (0.00)	0.00
T_5	8.00 (9.81)	1.83 (2.04)	1.50

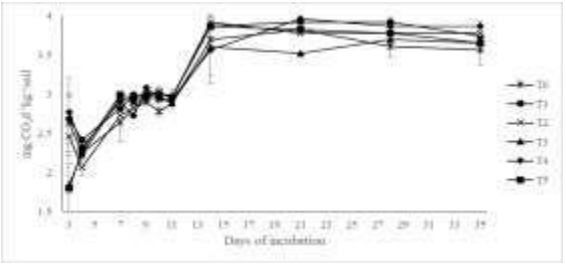
Values represent means of 2 plants in 3 replications (Standard Deviation)
T_0 = control with no compost, T_1 = control containing compost made of other wastes, T_2 = banana peel co-compost, T_3 = egg shell co-compost, T_4 = onion peel co-compost and T_5 = papaya peel co-compost.

The plant heights of *Capsicum annuum* with compost showed a higher growth than on potting mixes without compost. These results are in agreement with Mercy et al. (2014) who stated that height of the fenugreek plant was higher in fruit peel powder applied soil than the control.
According to the statistical analysis, only T_2, which contained banana peels as an amendment showed a significant growth rate ($p<0.05$) compared with the treatment without compost. Other treatments did not show a significant difference in respect to T_0. When comparing treatments with composts with each other, there was no significant difference between the treatments.
According to Table 3.1, composts made with banana fruit peels as an amendment had more nitrogen content than other composts. In a study by Cechin & Fumis (2004) shoot dry matter production of high N-grown plants was nearly four-fold than that of low N-grown plants. Therefore, it can be shown that nitrogen induces plant growth. Potassium (K) is also an essential nutrient that affects most of the biochemical and physiological processes that influence plant growth and metabolism (Wang et al., 2013). When comparing other physicochemical values of the composts made with amendments in the current study, banana peels always showed higher values and therefore it was able to enhance physical properties of soil, microbial activity and nutrient availability which was measured by the significant plant height increase.
In the current study, composts made with banana peel amendment showed higher amounts of phosphorus, potassium and organic matter. Phosphorus and potassium content in mixture elements have been suggested to promote fruit set of crops such as pepper (Aydemir & Ince, 1988) which might have resulted in a good harvest from the banana peel amended compost.

3.3 Carbon dioxide as a greenhouse gas emission

All the emissions showed 3.50 mg – 4.00 mg of CO_2 d^{-1} kg^{-1} soil after 2 weeks of incubation. This behavior was similar to the observation in Ray et al. (2020) where CO_2 emission spiked following the organic amendment regardless of organic amendment types and their application rates. In the current study, the CO_2 emission was low compared to research studies.

Figure 3.3. Carbon dioxide emission from different organic amendments.



Values represent means of 2 replications and error bars indicate the standard deviation.
T_0 = control with no compost, T_1 = control containing compost made of other wastes, T_2 = banana peel co-compost, T_3 = egg shell co-compost, T_4 = onion peel co-compost and T_5 = papaya peel co-compost.

According to Figure 3.3, T_0 had the least CO_2 emission and that is mainly due to the absence of an organic amendment to the soil. This is in correlation with Ray et al. (2020) where cumulative soil CO_2 emissions from all of the amended plots were higher than those from respective un-amended (control) plots. In research on contrasting effects of banana peels waste and its biochar on greenhouse gas emissions and soil biochemical properties by Sial et al. (2019), showed that the cumulative carbon dioxide (CO_2) emissions for biochar 1 and biochar 2 made with banana peel treatments decreases 20.0% and 24.0% in comparison to the banana peel amendment, respectively. Thus, biochar made with banana peel seems to be a more efficient reducer of greenhouse gases than the normal peel.

CONCLUSION

Composts made with the banana peel amendment was identified as a high-quality soil amendment which can be used as an organic fertilizer in agricultural systems. When considering the different compost types, plants treated with the compost made of banana peel amendment showed a significantly higher growth rate and yield. Thus, we can conclude that composts with banana peels perform well compared to other amendments. All the amended compost types had a higher emission of CO_2 than the soil without compost. Therefore, the composts made with banana peels can be recommended as an additive, soil conditioner and potting media for sustainable use, which could also be enhanced as biochar.

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