Annex IV

Suitability of Municipal Solid Waste Co-compost as a Growing Media Amendment for Chinese Evergreen (*Aglaonema commutatum)* Mother Plant Production

D.D.D. N MADUWANTHI[1], B. RANAWEERA[1], F. GRAU[2] and T. J. GRUNDMANN[3]

[1]*Department of Horticulture and Landscape Gardening, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP),60170, Sri Lanka*

[2]*Ruhr University Bochum, Institute of Geography, Germany*

[3]*University of Applied Sciences Osnabruck, Faculty of Agricultural Sciences and Landscape Architecture, Germany*

ABSTRACT

Municipal Solid Waste (MSW), become a major issue in urban areas of Sri Lanka. Co-compost production is one of the best solution to avoid this condition. An experiment was carried out to investigate the effect of co-compost when added as organic fertilizer in different application rates and what is the optimum application rate for co-compost as a growing media amendment for the cultivation of *Aglaonema commutatum.* Applied treatments were, T_1 - 10 % co-compost, T_2 - 10 % co-compost with 5 % biochar, T_3 - 20 % co-compost, T_4 - 20 % co-compost with 5 % biochar, T_5 - 30 % co-compost, T_6 - 30 % co-compost with 5 % biochar, T_7 - usual growing media in commercial cultivation and T_8 - coco coir. The experiment was arranged in Randomized Complete Block Design (RCBD) with four replicates. Number of leaves, drooping score, fresh and dry weight of shoots, roots and total plant, root length, root distribution, SPAD measurements, and pH, EC and NO_3^- amount in growing media were recorded. The study revealed that adding 10 % MSW co-compost level improve the plant growth and growing media characters. Further experiments are required to determine the co-compost level which is most suitable to improve plant quality parameters.

KEYWORDS: *Aglaonema*, Biochar, Co-compost, Municipal solid waste

INTRODUCTION

Municipal Solid waste management (MSW) is one of the major problem in most developing countries. Economic development, the degree of industrialization, public habits, population growth and local climate are influencing on MSW generation rates. The current MSW generation level in the world is 1.3 billion tons per year and it is expected to increase up to 2.2 billion tons per year by 2025 (Hoornweg and Bhada, 2012). Around 3,424 metric tons of MSW is collected daily in Sri Lanka (Anon, 2012).

As a remedy, compost preparation by using solid waste is suggested. Compost which is made from MSW and Fecal Sludge reduces the amount of waste to be transported and disposed, thus also reducing negative effects to the environment.

Biochar enhances soils. By converting agricultural waste into a powerful soil enhancer that holds carbon and makes soils more fertile. Increased cation-exchange capacity resulting in improved soil fertility, moderating of soil acidity, increased water retention, increased number of beneficial soil microbes (Anon, 2017).

Due to its importance in the industry, *Aglaonema commutatum* mother plants were selected for this experiment. The genus Aglaonema belongs to the family Araceae (Jianjun *et al*., 2015).

Foliage export companies used soil less media to export foliage plants. However, most of the growing media are materials, that require supplements of fertilizer. It increases the cost of production. By using co-compost derived from MSW and FS it helps to minimize the waste and cost of production of foliage.

Therefore, this study was carried out with the objective of studying impact of co-compost on plant growth, yield quality and quantity when added in different application rates with and without biochar to the growing media for the cultivation of *Aglaonema commutatum.*

MATERIALS AND METHODS

Location

The experiment was conducted at the Mike Flora (Pvt) Ltd. Nawala, Koswatta, situated in low country wet zone (WL_4), at elevation of 4.2 m above mean sea level from June to August 2017. During the period of study, average relative humidity and average temperature were 85 %, 33 °C respectively.

Variety

Chinese Evergreen (*Aglaonema commutatum*) was selected as the Ornamental foliage plant for the study.

Treatments

Six combinations of co-compost, biochar and coco coir, generally used medium of aglaonema and coco coir were applied as eight treatments of the experiment (Table 1).

Table 1.Tested treatment combinations

Treatment	Description
T1	10 % Co-Compost + coco coir
T2	10 % Co-Compost + 5 % biochar + coco coir
T3	20 % Co-Compost + coco coir
T4	20 % Co-Compost + 5 % biochar + coco coir
T5	30 % Co-Compost + coco coir
T6	30 % Co-Compost + 5 % biochar + coco coir
T7	Generally used growing media for aglaonema (sand: coir dust: compost, 1:2:1)
T8	Control, 100 % coco coir

Field Layout

Eight treatment combinations were arranged in a Completely Randomized Block Design with four replicates, Total of 160 plants were equally distributed among the four replicates.

Co-compost Preparation

MSW co-compost and Dewatered Fecal Sludge (DFS) were mixed in 70 %: 30 % (w/w) ratio at Kurunegala municipal council solid waste management site.

Crop Establishment and Maintenance

Rooted cuttings of Aglaonema were planted in 30 cm height, 17.5 cm width, black colour poly bags, filled with 7 L of growing medium. Plants were covered from rain and shaded 80 %, standing in beds on the ground. Carbendazim 0.6 g/L was applied monthly.

For T_7 and T_8, 400 ml of 1 g/L solution of N: P: K in ratio 30:10:10, 10:52:10, 20:20:20 applied to each bag in 1^{st} 2^{nd} and 3^{rd} weeks respectively. In the 4^{th} week and 8^{th} week, 400 ml of 1 g/L Calcium nitrate solution was applied.

Data Recording

Vegetative Parameters

Number of leaves were Counted at the initial stage and once in two-week period intervals; Leaf area was measured at the first week and at the 9^{th} week using a leaf area meter; Chlorophyll content was measured by using SPAD 502 Plus chlorophyll meter at the final week of experiment by using youngest unfold leaf of the plant.

Fresh weight and dry weights of shoots and roots were measured at the end of the experiment by using top loading balance. Dry weight was measured after oven drying at 50 °C for two weeks; Root length was measured from the plant base to the terminal end of the lengthiest root; Horizontal distribution of the roots from the plant base was recorded as root distribution.

Drooping score

Wilting appearance of the plants were observed once in two weeks period of time. Following score scale was used to quantify the droopiness (Table 3).

Table 2. Score scale for droopiness

Droopiness	Score
All the leaves are erect	1
More than 50 % of leaves are erect	2
Less than 50 % of leaves are erect	3
Almost all leaves are folded towards ground	4

Soil Parameters

Electrical conductivity and pH was measured by using EC and pH meter; NO_3^- was measured by using Merck, Rqflex plus 10.

Statistical Analysis

Data analysis was done by using the Statistical Analytical System (SAS) software version 9.4 and presented as mean ± SD with 95 % confident level. Two ANOVA procedures were done separately to analyze the treatment effect and the effect of biochar and co-compost.

RESULTS AND DISCUSSION

Vegetative Parameters

Leaf Area

Initial leaf area was not significant among experimental units. Effect of co-compost on final leaf area was significant (Table 3), whereas the effect of bio-char on final leaf area was not significant, and the interaction between co-compost and bio-char was not significant (Table 5). The highest final leaf area was recorded in 10 % co-compost (423.90 cm^2). The effect of 30 % co-compost on final leaf area was the lowest final leaf area (345.26 cm^2) and it was not significantly different with 20 % co-compost level.

Shoot Fresh Weight

Main effect of co-compost on shoot fresh weight was significant (Table 3) and effect of biochar on shoot fresh weight was not significant (Table 4), 10 % co-compost level recorded the highest shoot fresh weight (34.78 g); it is significantly different with 30 % co-compost level which recorded the lowest value (25.93 g) and the interaction between co-compost and bio-char was not significant.

Root Fresh Weight

Effect of co-compost and effect of biochar on root fresh weight both were significant; 10 % co-compost level recorded the highest root fresh weight value (3.201 g), whereas 30 % co-compost level recorded the lowest value (1.125 g) it is significantly different with 10 % co-compost level (Table 3); 0 % biochar level recorded the highest value and 5 % biochar level recorded the lowest value (Table 4).

Total Fresh Weight

Effect of co-compost on Total fresh weight was significantly different (Table 3) and effect of biochar on Total fresh weight was not significant (Table 4), 10 % co-compost level recorded the highest value (37.98 g) whereas 30 % co-compost level recorded the lowest value (27.05 g). It is significantly different with 10 % co-compost level.

Shoot Dry Weight

Effect of co-compost on shoot dry weight was significantly different (Table 3) and effect of biochar on shoot dry weight was not significant (Table 4), 10 % co-compost level recorded the highest value (4.01 g) whereas 30 % co-compost level recorded the lowest value (2.86 g). It is significantly different with 10 % co-compost level.

Root Dry Weight

Effect of co-compost and effect of biochar on root dry weight both were significant. However, the interaction between co-compost and biochar were not significant; 10 % co-compost level recorded the highest root dry weight value (0.29 g) whereas 30 % co-compost level recorded the lowest value (0.11), it is significantly different with 10 % co-compost level (Table 3); 0 % biochar level recorded the highest value and 5 % biochar level recorded the lowest value (Table 4).

Total Dry Weight

Effect of co-compost and effect of biochar on total dry weight both were significant, 10 % co-compost level recorded the highest value (4.35 g), whereas 30 % co-compost level recorded the lowest value (3.06 g). It is significantly different with 10 % co-compost level (Table 4); 0 % biochar level recorded the highest value and 5 % biochar level recorded the lowest value (Table 5).

Root length

Effect of co-compost and effect of biochar on root length both were significant. However, the interaction between co-compost and biochar were not significant; 10 % co-compost level recorded the highest value (10.30 cm), whereas 30 % co-compost level recorded the lowest value (4.09 cm). It is significantly different with 10 % co-compost level (Table 3). The negative effect of biochar was observed in different biochar levels; 0 % biochar level recorded the highest value and 5 % biochar level recorded the lowest value (Table 4).

Root Distribution

Effect of co-compost and effect of biochar on root distribution both were significant; 10 % co-compost level recorded the highest value (9.48 cm), whereas 30 % co-compost level recorded the lowest value (3.99 cm). It is significantly different with 10 % co-compost level (Table 3). The negative effect of biochar was observed in different biochar levels; 0 % biochar level recorded the highest value and 5 % biochar level recorded the lowest value (Table 4).

Chlorophyll Content(SPAD)

Effect of co-compost and effect of biochar on chlorophyll content both were significant. But the interaction between co-compost and biochar were not significant; 10 % co-compost level recorded the lowest value (21.26), whereas 30 % co-compost level recorded the highest value (31.12). It is significantly different with 10 % co-compost level (Table 3). The positive effect of biochar was observed in different biochar levels; 0 % biochar level recorded the lowest value and 5 % biochar level recorded the highest value (Table 4).

Table 3. Effect of co-compost levels on vegetative parameters

Compost level (%)	Shoot fresh weight(g)	Root fresh weight(g)	Total fresh weight(g)	Shoot dry weight(g)	Root Dry weight(g)	Total dry weight (g)	Root distribution(cm)	Root length (cm)	SPAD unit	Initial leaf area(cm^2)	Final leaf area(cm^2)
0	31.66^{a}	2.39^{a}	34.05^{a}	3.36^{b}	0.24^{a}	3.68^{b}	6.18^{b}	6.31^{b}	26.95^{b}	311.12^{a}	423.70^{ab}
10	34.78^{a}	3.20^{a}	37.98^{a}	4.01^{a}	0.29^{a}	4.35^{a}	9.48^{a}	10.30^{a}	21.26^{C}	338.12^{a}	423.90^{a}
20	31.12^{a}	2.49^{a}	33.61^{a}	3.41^{b}	0.25^{a}	3.66^{b}	6.42^{b}	6.77^{b}	30.17^{a}	335.22^{a}	354.33^{bc}
30	25.93^{b}	1.12^{b}	27.05^{b}	2.86^{c}	0.11^{b}	3.06^{c}	3.99^{c}	4.09^{c}	31.12^{a}	288.35^{a}	345.26^{c}
P	0.004	0.002	0.002	0.0002	0.001	<0.0001	<0.0001	<0.0001	<0.0001	0.074	0.005

The means in a column with same superscript letters are not significantly different at 0.05 level

Table 4. Effect of biochar on vegetative parameters

Biochar	Shoot fresh weight(g)	Root fresh weight(g)	Total fresh weight (g)	Shoot dry weight (g)	Root Dry weight (g)	Total dry weight (g)	Root distribution (cm)	Root length (cm)	SPAD unit	Initial leaf area(cm^2)	Final leaf area (cm^2)
0 %	31.61^{a}	2.56^{a}	34.17^{a}	3.44^{a}	0.26^{a}	3.77^{a}	6.74^{a}	7.11^{a}	26.48^{b}	318.53a	375.68a
5 %	29.69^{a}	1.87^{b}	31.52^{a}	3.36^{a}	0.17^{b}	3.55^{a}	6.14^{b}	6.48^{b}	28.86^{a}	317.71a	339.73a
p	0.286	0.044	0.195	0.439	0.007	0.141	0.039	0.015	0.010	0.694	0.245

The means in a column with same superscript letters are not significantly different at 0.05 level

Number of leaves

Number of leaves was not significantly different among the treatments except in week six. T_2 recorded the highest value (26.37) where as T_6 recorded the lowest value in week six (Table 5).

Drooping Score

Drooping score was significantly different among treatments in all weeks. T_1 recorded the lowest value and T_6 recorded the highest value for drooping score (Table 5).

Soil parameters

Effect of pH, EC and No_3^-, on treatment combinations were significantly different among weeks. T_2 recorded the highest pH value and T_5 recorded the lowest value. T_7 and T_8 showed the pH changes according to the fertilization.

For the EC and No_3^-, T_6 recorded the highest value and T_1 recorded the lowest value. T_7 and T_8 were showed the EC changes according to the fertilization (Table 6).

Table 5. Effect of treatment combinations on No. of leaves and Drooping score

Treatment	No of leaves					Drooping score			
	1WAP	3WAP	5WAP	7WAP	9WAP	2WAP	4WAP	6WAP	8WAP
T_1	16.00	21.12	19.62	22.63	21.00	9.5	10.5	9.5	9.2
T_2	22.12	23.00	26.37	27.63	23.87	13.5	14.5	13.3	9.2
T_3	6.25	13.00	13.75	12.37	13.50	17.5	22.5	13.3	18.2
T_4	21.75	23.87	21.50	18.00	18.75	21.5	18.5	22.8	21.5
T_5	21.5	18.50	16.37	14.12	12.87	25.5	22.5	21.1	24.8
T_6	10.00	8.62	2.75	6.12	5.87	25.5	22.5	25.0	24.8
T_7	14.62	10.05	14.62	13.87	14.37	9.5	10.5	17.2	12.1
T_8	19.75	13.62	17.00	17.25	21.75	9.5	10.5	9.5	12.1
P	0.1062	0.1264	0.0314	0.0536	0.1257	0.0035	0.0435	0.0338	0.0173

WAP- Weeks After Planting
Median values are not significantly different at 0.05 level

Table 6. Mean values of soil parameters on treatment combinations

T	3WAP			6WAP			8WAP		
	pH	EC	NO_3^-	pH	EC	NO_3^-	pH	EC	NO_{3-}
T_1	6.42^{d}	869.75^{e}	5.07^{f}	6.30^{b}	1031.0^{c}	2.53^{d}	6.25^{b}	1072.8^{cd}	0.00^{d}
T_2	6.67^{c}	1064.75^{d}	13.00^{f}	6.45^{a}	1276.3^{b}	8.68^{d}	6.40^{a}	1328.8^{bc}	9.40^{d}
T_3	6.15^{ef}	1197.25^{c}	84.61^{d}	6.00^{d}	1323.0^{b}	81.35^{c}	5.97^{de}	1400.5^{b}	95.46^{c}
T_4	6.3^{ed}	1473.00^{b}	133.77^{c}	6.10^{c}	1856.3^{a}	135.23^{b}	6.07^{c}	1809.3^{a}	139.93^{b}

T_5	6.02^{f}	1565.50^{ab}	181.88^{b}	5.85^{e}	1751.8^{a}	203.21^{a}	5.90^{e}	1886.3^{a}	210.08^{a}
T_6	6.1^{f}	1664.50^{a}	211.52^{a}	5.97^{d}	1862.5^{a}	232.13^{a}	5.92^{ed}	1768.5^{a}	224.54^{a}
T_7	7.0^{b}	584.00^{f}	50.98^{e}	6.00^{d}	845.8^{cd}	197.06^{a}	6.00^{cd}	875.0^{ed}	16.77^{b}
T_8	7.2^{a}	419.75^{g}	0.00^{f}	6.00^{d}	707.5^{d}	146.08^{b}	5.45^{f}	711.5^{e}	135.95^{b}
P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Mean values are not significantly different at 0.05 level

Increase in nitrate, will increase the osmotic concentration of the soil solution. The roots of the plant then have to take up minerals from a more concentrated solution. If the solution outside gets too concentrated, plant is not able to take up any water against the concentration gradient. Therefore, plant will grow slower and start to wilt (John, 2017). Similar results showed in this research for drooping score and plant vegetative parameters.

According to the results in the experiment 10 % co-compost level recorded the lowest while 30 % recorded the highest value of nitrate amount. This may be the reason of poor growth performance of plant in 30 % co-compost level than the 10 % co-compost level. However, in the SPAD measurements 30 % co-compost level showed the higher value than the 10 % co-compost level. That may be attributed to the higher nitrogen content in treatments with 30 % co-compost than in treatments with 10 % co compost.

The leaf color can indicate the amount and proportion of chlorophyll in leaves. Leaf greenness has proved to be positively co related with SPAD reading. A positive linear co relation has been discovered between SPAD readings and No_3^- leaf concentration (Papasavvasa *et al.*, 2008).

There is a statistically significant correlation between nitrate concentration, pH and EC. It is stated that nitrification was responsible for the falling pH values and increasing electrical conductivity (Sanchez, 2000). Similar results obtain in the experiment reveal that treatment of adding biochar showed higher pH values than treatments without biochar. Similar results obtain by Jien and Wang in 2013 reveal that biochar has a property of nutrient retention. However, in this experiment there were no evidences to confirm the improvement of plant performance with biochar.

Positive effects of biochar due to the adsorption, retention and slow release of nutrients could be more prominent in relatively longer periods. (Trupiano *et al.*2017). Hence within the short period of this experiment such performance of biochar could not be observed.

CONCLUSION

Application of 10 % MSW co-compost level improving the medium characters and the plant growth parameters. However, colour quality improvement cannot be observed with that treatment. In order to determine the suitable co-compost media, experiments should be carried out throughout the usual production cycle of the plant.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Mr.K.H.M.I Karunarathne, Instructor, ICT center, Wayamba University of Sri Lanka, for the help given in statistical analysis. All the staff members of Mike Flora (Pvt) Ltd. Nawala, Koswatta and all the staff members of the Faculty of Agriculture and Plantation Management also gratefully acknowledged for their support during research period.

REFERENCES

Anon. (2012). Data Base of Solid Waste in Sri Lanka. Ministry of environment and renewable energy.16-18

Anon. (2017). International biochar Initiative data base, Biochar use in Soils. Available from: http://www.biochar-international.org (Accessed 21 May 2017).

Hoornweg, D. and Bhada-Tata, P. (2012) What a waste - A Global Review of Solid Waste Management. Urban Development Series Knowledge papers. World Bank, 15, vi

Jianjun, C., Dennis, B.M., Richard J.H., and Kelly C.E. (2003), Cultural Guidelines for Commercial Production of Interiorscape Aglaonema.

Jien, S.H. and Wang, C.S. (2013). Effects of biochar on soil properties and erosion potential in a highly weathered soil. Catena, **110**, 225-233.

John, H. (2017) The effects of nitrate on plant growth. Available from: http://www.saps.org. (Accessed 21 May 2017).

Papasavvasa, A., Triantafyllidisb, V., Zervoudakisa, G., Kapotisa, G., Samarasc, Y and Salahasa G. (2008). Correlation of Spad-502 meter readings with physiological parameters and leaf nitrate content in Beta vulgaris. *Journal of*

Environmental Protection and Ecology 9, **2**, 351–356.

Sánchez, M. A., Roig A., Paredes C. and Bernal M.P. (2001), Nitrogen transformation during organic waste composting by the Rutgers system and its effects on pH, EC and maturity of the composting mixture. Bioresourse Technology, **78**, 301-308.

Trupiano, D., Cocozza, C., Baronti, S., Amendola, C., Vaccari, F.P., Lustrato, G., Lonardo, S.D., Fantasma, F., Tognetti, R. and Scippa, G.S. (2017) The effect of biochar and its combination with compost on lettuce *(Lactuca sativa*) Growth,Soil properties, and soil microbial Activity and abundance. Hindawi International Journal of Agronomy, **2017,** Article ID 3158207.