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Impact of Co-compost Pellets on Growth and Yield of *Ipomoea batatas* and *Eleusine coracana*

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Introduction

Excessive and continuous application of inorganic fertilizers for decades in Sri Lanka has converted the agricultural lands in to drastic issues (Chandrajith *et al*., 2011). Further, some scholars argue that the adverse effects of these inorganic fertilizers can be corrected to some extent by adopting new agricultural technological practices such as shifting from conventional chemical intensive agriculture towards the use of organic inputs viz. manure, compost powder, compost pellets, liquid organic fertilizers or biofertilizers and the inclusion of legumes in the cropping systems. Municipal Solid Waste (MSW) compost being the most available organic input in Sri Lanka is supposed to have a potential to be used as an agricultural resource.

Improper solid and liquid waste management cause severe human health and environmental issues. As a part of the solid waste management, MSW can be used for composting process. Compost made using MSW is progressively used as a soil conditioner and as a fertilizer. Further, co-composting of organic fractions of MSW with Dewatered Fecal Sludge (DFS) is a diverse and a cheap source for nutrient recovery (Cofie *et al*., 2009) which has a high potential as an agricultural resource in Sri Lanka while elevating deficient MSW management. Pelletized co-compost, as a value added product has been introduced and tested as an organic fertilizer which increase some desirable properties such as easy storage and handling, disintegration time and controlled nutrient release (Nikiema *et al*., 2014).

Biochar has long been used as a soil amendment. It can provide many benefits which contribute to soil fertility with long lasting effects such as increased soil pH, Cation Exchange Capacity (CEC), water holding capacity, and reduced bulk density. Biomass waste materials can easily be used as feedstock for biochar production. Empty Fruit Bunches of oil palm (EFB), is a rising problem in Sri Lanka due to its high production rate and low utilization. It can potentially be used to produce biochar.

Fertilizer application depth and dosages affect the transformation, accumulation, availability of nutrients in soil and Nutrient Use Efficiencies (NUEs). For successful crop production, it is important to incorporate correct doses of fertilizers at optimum fertilization depth (Jiang *et al*., 2017). Hence, an experiment was conducted to explore the possibility of utilization of oil palm EFB as biochar with co-compost in pellet form to amend sandy loam soil and to evaluate its performance on plant growth and yield of *Ipomoea batatas*. Parallel to this, two experiments were conducted to investigate the response of growth and yield of *Eleusine coracana* to different dosages and application depths of co-compost powder and pellets under poly-house conditions.

Methodology

***Ipomoea batatas* Experiment**

The field experiment was conducted at the Sustainable Agriculture Research and Development Centre, Makandura, Gonawila (NWP), in Sri Lanka situated in IL1a Agro Ecological Zone where maximum and minimum temperatures are 35.6 ^{0}C and 20.8 ^{0}C respectively. Soil type is sandy loamy which consists of alluvial soil as a top layer. Co-compost pellets requirement per plot was calculated using the Nitrogen requirement of sweet potato as recommended by Department of Agriculture (DOA), Sri Lanka. *Ipomoea batatas* variety 'Wariyapola Red' cuttings were planted in ridge and furrow method at a spacing of 90 cm x 20 cm. Fifteen vines were planted in a plot size of 4.8 m^2. The experimental design was Randomized Complete Block Design (RCBD) with four blocks and seven treatments as given in Table 1. Biochar was produced with oil palm EFBs by pyrolysis method (Parmar *et al*., 2014).

Table 1. Tested fertilizer combinations - *Ipomoea batatas Experiment*

Code	Treatment		Application Rate kg/ ha		
			Urea	TSP	MOP
T_1	Inorganic fertilizer (Control)	*Basal dressing*	162.5	50	25
		Top dressing	162.5	50	25
T_2	DFS+MSW Co-compost pellet 100 % available Nitrogen		12650		
T_3	DFS+MSW Co-compost pellet 30 % available Nitrogen		42133		
T_4	DFS+MSW+Biochar Co-compost pellet 100 % available Nitrogen		13599		
T_5	DFS+MSW+Biochar Co-compost pellet 30 % available Nitrogen		45366		
T_6	DFS+MSW+Inorganic Co-compost Pellet		1875		
T_7	DFS+MSW+Biochar+Inorganic Co-compost Pellet		1875		

DFS- Dewatered Fecal sludge; MSW- Municipal Solid Waste; TSP- Triple superphosphate; MOP- Muriate of Potash

Vegetative and yield data were collected from randomly selected six vines from each treatment from each block. Vine length, vine girth, number of branches, leaf area, shoot and root dry weights were taken as vegetative parameters. Fresh and dry weight of tubers and marketable and non-marketable yield were taken as yield parameters from six vines which were selected previously. Soil samples were taken at monthly intervals and soil pH and Electrical Conductivity (EC) were measured.

Eleusine coracana Experiments

Two experiments were conducted in a poly-house at the Faculty of Agriculture and Plantation Management, Wayamba university of Sri Lanka using finger millet variety called 'Oshadha'. Nine treatments with nine replicates were arranged in Latin Square Design (LSD) for each experiment. Twenty one days old seedlings were transplanted into pots. Irrigation and other cultural practices were performed according to DOA recommendation.

Dosage response experiment:

Eight different dosages of co-compost pellets based on available Nitrogen (Table 2) were applied as treatments with inorganic fertilizer recommended for finger millets by the DOA, Sri Lanka as the control.

Application depth experiment:

Co-compost powder and pellets were applied at four different soil depths; surface application, 10 cm shallow incorporation, bottom layer application and complete soil mixture over inorganic fertilizer recommended for finger millets by the DOA, Sri Lanka as the control (Table 2).

Plant height, number of leaves, leaf area as vegetative parameters and number of days to 50 % flowering, weight of ears, overall yield as reproductive parameters were recorded from 81plants in both experiments. Soil pH and soil EC were measured as soil parameters.

The data were analysed by one-way ANOVA using SAS Statistical software (version 9.4). Significant differences among the means were assessed with the least significant difference (LSD) test at a 0.05 probability level.

Table 2. Tested treatments combinations - *Eleusine coracana* experiments

Treatments of the dosage response experiment		Treatments of the application depth experiment	
Code	**Treatments**	**Code**	**Treatments**
T_1	DFS+MSW co-compost pellet with N-10%	T_1	Inorganic fertilizer (Control)
T_2	DFS+MSW co-compost pellet with N-30%	T_2	Surface application with DFS+MSW co-compost pellet
T_3	DFS+MSW co-compost pellet with N-50%	T_3	10 cm shallow incorporation with DFS+MSW co-compost pellet
T_4	DFS+MSW co-compost pellet with N-70%	T_4	Bottom layer application with DFS+MSW co-compost pellet
T_5	DFS+MSW co-compost pellet with N-90%	T_5	Complete soil mixture with DFS+MSW co-compost pellet
T_6	DFS+MSW co-compost pellet with N-110%	T_6	Surface application with DFS+MSW co-compost powder
T_7	DFS+MSW co-compost pellet with N-130%	T_7	10 cm shallow incorporation with DFS+MSW co-compost powder
T_8	DFS+MSW co-compost pellet with N-150%	T_8	Bottom layer application with DFS+MSW co-compost powder
T_9	Inorganic fertilizer (Control)	T_9	Complete soil mixture with DFS+MSW co-compost powder

DFS- Dewatered Fecal sludge; MSW- Municipal Solid Waste; N- Nitrogen

Results and Discussion

Ipomoea batatas Experiment

Mean values of vegetative and yield parameters are given in Table 3. There was no significant ($p > 0.05$) difference of vine length among all treatments except T_1 and T_3. The highest vine length was recorded in T_3 (70.917 cm) while the lowest was recorded in T_1 (56.583 cm). Addition of DFS+MSW co-compost pellets (T_3) tend to increase the vine length suggesting that the presence of DFS+MSW and 30% Nitrogen combination favour better vein development compared to other treatment combinations. There was no significant difference ($p > 0.05$) of vine girth, number of branches and leaf area among all treatments (Table 3.). The significantly ($p < 0.05$) highest mean value of the shoot dry weight was recorded in T_5 while the lowest was recorded in T_1 (control) indicating the addition of biochar into DFS+MSW co-compost pellets (T_5) tend to increase the shoot dry weight. The significantly ($p < 0.05$) highest mean value of the root dry weight was recorded in T_3 while the lowest was recorded in T_1 (control). Among the tested fertilizer combinations, T5: DFS+MSW+Biochar Co-compost pellet with 30 % available Nitrogen recorded a significantly ($p < 0.05$) higher yield and it was 32.39 % higher than yield obtained by the recommended inorganic fertilizer recommended for *Ipomoea batatas* by the DOA, Sri Lanka (Control).

Table 3. Mean values of vegetative and reproductive parameters

Treatment	Vine length (cm)	Vine girth (cm)	Number of branches	Leaf area (cm³)	Dry weight of shoots (g)	Dry weight of roots (g)	Marketable yield (g/plot)	Non-marketable yield (g/plot)	Total Yield (g/plot)	Dry weight of tubers (g/plot)
T1	56.583^{b}	3.953^{a}	8.209^{a}	7.154^{a}	43.613^{d}	1.1405^{c}	2924.5^{bc}	1091.0^{b}	4015.5^{dc}	328.13^{b}
T2	63.625^{ab}	4.113^{a}	9.292^{a}	7.358^{a}	58.750^{bcd}	1.2940^{bc}	2848.8^{bc}	1077.0^{b}	3925.8^{dc}	379.17^{ab}
T3	70.917^{a}	4.457^{a}	10.292^{a}	7.495^{a}	72.310^{ab}	2.8868^{a}	4175.0^{a}	1154.5^{b}	5329.5^{ab}	464.89^{a}
T4	60.583^{ab}	4.230^{a}	10.000^{a}	7.485^{a}	67.467^{abc}	1.7800^{abc}	3126.0^{b}	902.5^{b}	4028.5^{dc}	363.36^{ab}
T5	68.958^{ab}	4.421^{a}	10.417^{a}	7.529^{a}	78.214^{a}	2.4513^{a}	4188.8^{a}	1750.8^{a}	5939.6^{a}	378.83^{ab}
T6	65.792^{ab}	3.867^{a}	9.792^{a}	7.661^{a}	76.999^{ab}	2.4368^{ab}	2592.5^{bc}	789.8^{b}	3382.3^{d}	380.14^{ab}
T7	63.833^{ab}	4.054^{a}	9.708^{a}	7.425^{a}	52.212^{cd}	2.0095^{abc}	3298.3^{b}	1322.3^{ab}	4620.6^{bc}	317.34^{b}
P	0.5373	0.1620	0.1956	0.1433	0.0105	0.0181	0.0030	0.0008	0.0006	0.0961

Means in a column with the same letters are not significantly different at the 0.05 probability level. p-significant probability value

Eleusine coracana Experiments

In dosage response experiments, a significantly ($p < 0.05$) higher yield was recorded in the treatment with N-150 % and it recorded 65 % total average yield increment compared to the control (Table 4.). Dosage increments of DFS-MSW co-compost pellets incorporated into soil, doesn't increase the vegetative growth, yet, the yield performances were increased. However, there was a gradual increment in soil pH and EC with the dosage. The results revealed that depth of co-compost application did not have any effect on growth and yield of finger millet or soil pH. Significantly ($p < 0.05$) higher yield could be obtained in the DFS-MSW co-compost powder form than pellet form (Table 5). A grain increment of 49% was recorded in powder form over the pellet form. However, application of DFS-MSW co-compost recorded a significantly ($p < 0.05$) higher growth and yield performance compared to inorganic fertilizer. Further, co-compost ensued a significant improvement of soil pH over inorganic fertilizer.

Table 4. Mean values of vegetative and reproductive parameters - Dosage response experiment

Treatment	Leave/ plant	Plant height (cm)	LAI	Shoot DW/ plant (g)	Root DW/ plant (g)	Day to 50% flowering	Ears weight (g m^{-2})	Yield (g m^{-2})	100 seed weight (g)
T_1	20.22^{e}	24.91^{h}	49.76^{f}	17.60^{d}	1.85^{f}	34.44^{d}	8.43^{f}	7.43^{e}	0.25^{a}
T_2	21.56^{de}	27.68^{g}	50.41^{ef}	18.96^{b}	2.48^{e}	38.89^{c}	11.06^{e}	9.81^{d}	0.26^{a}
T_3	22.56^{cd}	31.92^{c}	52.31^{e}	19.31^{b}	3.15^{d}	39.67^{bc}	13.05^{d}	12.46^{bc}	0.27^{a}
T_4	23.56^{cd}	33.05^{e}	61.70^{d}	19.83^{a}	3.97^{c}	39.89^{abc}	14.46^{cd}	13.20^{b}	0.27^{a}
T_5	24^{c}	35.55^{d}	66.24^{c}	19.98^{a}	4.66^{b}	40.67^{abc}	12.99^{d}	11.20^{cd}	0.27^{a}
T_6	27^{b}	41.76^{c}	69.71^{b}	20.10^{a}	4.92^{a}	40.33^{abc}	15.33^{c}	14.24^{b}	0.28^{a}
T_7	28.89^{b}	44.26^{b}	70.24^{b}	20.17^{a}	4.98^{a}	40.33^{abc}	18.00^{b}	14.07^{b}	0.30^{a}
T_8	32^{a}	48.00^{a}	80.69^{a}	20.10^{a}	4.96^{a}	41.11^{ab}	21.30^{a}	18.91^{a}	0.31^{a}
T_9	20^{e}	27.27^{g}	46.37g	18.42c	1.78f	41.78^{a}	9.31^{f}	7.67^{e}	0.25^{a}
p	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.118

Means in a column with the same letters are not significantly different at the 0.05 probability level. p-significant probability

Table 5. Mean values of vegetative and reproductive parameters - Form and depth of application experiment

Treatment	Leave/ plant	Plant height (cm)	LAI	Shoot DW/ plant (g)	Root DW/ plant (g)	Day to 50% flowering	Ears weight (g m^{-2})	Yield (g m^{-2})	100 seed weight (g)
T_1	11^{a}	70.69^{e}	65.68^{a}	15.31^{c}	3.76^{a}	58^{a}	13.92^{d}	11.04^{e}	0.26^{a}
T_2	12^{a}	72.42^{de}	71.53^{a}	15.56^{c}	5.29^{a}	59.67^{a}	16.26^{d}	13.21^{ed}	0.27^{a}
T_3	12^{a}	76.33^{dec}	67.22^{a}	16.03^{c}	4.39^{a}	60.67^{a}	18.19^{dc}	14^{ed}	0.27^{a}
T_4	12^{a}	74.38^{dec}	64.829^{a}	16.23^{c}	4.6^{a}	58.56^{a}	18.25^{dc}	14.72^{ed}	0.28^{a}
T_5	12^{a}	78.67^{bdec}	71.35^{a}	16.91^{bc}	4.84^{a}	59.33^{a}	21.25^{dc}	16.53^{ed}	0.30^{a}
T_6	12^{a}	90.69^{a}	69.67^{a}	18.36^{bc}	3.98^{a}	58.67^{a}	22.29^{bc}	19.14^{bc}	0.28^{a}
T_7	13^{a}	88.31b^{a}	71.92^{a}	22.35^{ba}	4.43^{a}	60.11^{a}	26.87^{ba}	21.78^{ba}	0.27^{a}
T_8	13^{a}	81.38b^{dac}	72.75^{a}	25.52^{a}	5.18^{a}	59.44^{a}	28.84^{a}	24.45^{a}	0.27^{a}
T_9	12^{a}	83.8b^{ac}	70.198^{a}	18.51b^{c}	5.82^{a}	60.44^{a}	22.85^{bac}	20.29^{bac}	0.27^{a}
P	0.1551	0.0091	0.2866	0.0115	0.9356	0.7214	0.0007	0.0002	0.0561

Means in a column with the same letters are not significantly different at the 0.05 probability level. p-significant probability

Conclusions and Outlook

The fertilizer application rate of 16.8 tons/ha can be recommended with MSW+DFS + Inorganic pellet for Wariyapola Red sweet potato cultivation in sandy loam soils of intermediate zone. Further, DFS+MSW co-compost pellets with 150 % available Nitrogen at 10 cm depth fertilization can be recommended for finger millet considering the convenience and cost of application. As this is a short-term study, further studies are necessary to determine the optimum pellets application rate and asses the response of other field crops in different soils and different environmental conditions.

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