Effect of MSW-FS Co-compost Pellet and Powder Forms with Different Nitrogen Enrichment Levels and Inorganic Fertilizers on Growth and Yield of Radish (*Raphanus sativus* L.) Variety Big Ball

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ABSTRACT

Municipal solid waste and faecal sludge are major issue in urban areas in Sri Lanka. Co–compost production is the best solution to avoid this condition. An experiment was conducted to investigate the effect of municipal solid waste – faecal sludge co-compost pellets and powder fertilizers with different nitrogen enrichment levels and inorganic fertilizers on growth and yield of radish (*Raphanus sativus* L.). The variety Big Ball was tested with four nitrogen enrichment levels and three forms combinations. Treatments were 5% nitrogen co-compost powder, 10% nitrogen co-compost powder, 15% nitrogen co-compost powder, 20% nitrogen co-compost powder, 5% nitrogen co-compost pellets, 10% nitrogen co-compost pellets, 15% nitrogen co-compost pellets, 20% nitrogen co-compost pellets and inorganic fertilizers. This two factor factorial experiment was laid out in Completely Randomized Block Design in four replicates. Enrichment levels among treatments were not significantly different in vegetative and yield parameters. Higher vegetative parameters were shown by pellets form treatments. No significant differences were observed in yield among pellet and powder form while highest mean value recorded in pellet form.

KEYWORDS: Municipal solid waste co-compost, Nitrogen level, Radish

INTRODUCTION

Radishes are cool–season, fast maturing, easy–to–grow annual or biannual herbaceous plants that are grown for their roots. Garden radishes are extremely popular in home gardens because they can be grown almost anywhere there is sun (Decoteau, 2000). It is used both as raw and cooked (Chadha and Kalloo, 1993). Radish is low in calories and is a good source of vitamin C (Decoteau, 2000). World production of radish root is estimated at seven million tons per year, about 2% of the total world production of vegetables (Kopta and Pokluda, 2013). In Sri Lanka during 2013/2014 *Maha* season the extent of radish cultivation was 1,122 ha and the production was 10,446 mt (Anon, 2014). Radishes grow on wide range of soils. For irrigated plantings, sandy loams are generally best, while heavier soils are generally used for dry land crops. Since plant growth is rapid, a fertile soil is needed (Swiader *et al.*, 1992).

Several chemical fertilizers have high acid content like sulfuric and hydrochloric acid. It results in the destruction of the nitrogen-fixing bacteria, which is helpful in supplying the nitrogen to a growing plant. Repeated applications may result in buildup of toxic chemicals such as arsenic, cadmium, and uranium in the soil. These toxic chemicals can eventually make their way into fruits and vegetables and may harmful for the human consumption (Anon, 2015).

Compost is one of the common organic fertilizers and it is the product of a controlled aerobic decomposition of organic matter. It is a stable, dark brown, soil-like material that contains important plant nutrients like nitrogen, potassium and phosphorus, but in unequal proportions. It can also contain a range of beneficial minerals and rich in humus and microorganisms beneficial for plant growth. Compost improves moisture, drainage, water holding capacity, buffering capacity and reduces erosion. And it supplies significant quantities of organic matter (Rouse *et al.*, 2008). Compost nutrient ratio is often unknown and the overall percentage is lower than chemical fertilizers. Further, organic fertilizers do not release nutrients immediately. Therefore, soon after application of organic fertilizer plants may show deficiencies during the first phase of its life cycle. Considerable amount of land, time and labour are needed to produce compost (Anon, 2015). Generally compost is very low in nutrients and is about 1% of nitrogen (N), phosphorous 0.5% and 1% of potassium (Anon, 2009).

Nitrogen is the most important plant nutrient, responsible for shoot and leaf growth. Plants require large amounts of N for normal growth, hence they respond most rapidly to applications of nitrogen. Nitrogen is necessary for chlorophyll synthesis and as a part of the chlorophyll molecule, is involved in photosynthesis. Nitrogen is a component of vitamins and energy systems in the plant. It is also an essential component of amino acids, which form plant proteins (Gupta, 2003).

Hence ground raw compost is enriched with ammonium sulphate ($[NH_4]_2SO_4$) to increase the N content in the compost (Nikiema *et al.*, 2014).

The bulkiness of compost makes it difficult for farmers to store and transport (Nikiema *et al.*, 2013). Loose form of compost is responsible for most of the difficulties pertaining to packaging, handling, storing (need more space to store), transporting (high cost) and marketing. Further, the loose or powder form of the compost product generates dust at the point of applications making uncomfortable conditions for the farmers.

Pelletization can be considered to be a possible solution to these challenges. This pellet foam fertilizer contributes to facilitate their broadcasting and application. Granular compost is the effective way for decreasing the amounts of soil and nutrient losses from agricultural fields, which may contribute to sustainable agriculture (Siriwattananon and Mihara, 2008).

The quantity of solid waste generated has increased rapidly during the last few decades due to industrialization and urbanization. The accelerated growth of urban population with unplanned urbanization, increasing economic activities and lack of training in modern solid waste management practices in the developing countries complicates the efforts to improve solid waste services. Municipal solid waste (MSW) management is an important part of the urban infrastructure in developing countries that ensures the protection of environment and human health. Composting of MSW reduces the volume of the wastes, kills pathogens that may be present, decreases germination of weeds in agricultural fields and destroys malodorous compounds (Jakobsen, 1995).

The faecal sludge (FS) is relatively high in N content and the MSW is relatively high in organic carbon and has good bulking quality. Both these waste materials can be used together to produce co-compost. It is very meaningful option in waste management in long term and can provide valuable alternative nutrient source.

This study was carried out to identify the suitable co-composting form and nitrogen enrichment level for radish cultivation.

MATERIALS AND METHODS

Location

The study was carried out at the Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura situated in the low country intermediate zone (IL_{1a}), at an elevation of 30 m above mean sea level. Soil was moderately well drained and characterized by soft lateritic sub soil. The experiment was conducted from December 2015 to March 2016. During the period of study, total rainfall, average relative humidity, soil temperature, average day temperature and night temperature in the site were 85.5 mm, 80%, 28.5 °C, 32.7 °C and 23.2 °C respectively.

Treatments

Two formulation types i.e. powder and pellet form and four nitrogen enrichment levels of co-compost and inorganic fertilizer (Table 1) recommendation by Department of Agriculture (DOA) were used as treatments.

Application rates were determined according to the nitrogen requirement (Anon, 2006) of radish and N content in each treatment (Table 2). Nitrogen enrichment was done by adding $(NH_4)_2SO_4$.

Table 1. Treatments used in the experiments

Treatment	Description
T_1	5% Nitrogen co-compost powder
T_2	10% Nitrogen co-compost powder
T_3	15% Nitrogen co-compost powder
T_4	20% Nitrogen co-compost powder
T_5	5% Nitrogen co-compost pellets
T_6	10% Nitrogen co-compost pellets
T_7	15% Nitrogen co-compost pellets
T_8	20% Nitrogen co-compost pellets
T_9	Inorganic fertilizers

Layout of Experiment

Treatments were arranged in Completely Randomized Block Design (RCBD) with four replicates, each having nine treatments (Table 1).

Crop Establishment and Maintenance

Land was ploughed to 15-20 cm depth and 36 raised beds (1.3×0.6 m) were prepared with 24 planting holes in each bed. Between row and within row spacing was 30 cm and 10 cm respectively. Seeds of the radish variety Big ball were sown at the rate of three seeds per hill. Thinning out was done at eight days after sowing to keep one seedling per hill. Co-compost fertilizers were applied during land preparation 15 days before sowing (DBS). Basal dressings of inorganic fertilizers were applied two days before sowing. Top Dressing by Co-compost and inorganic fertilizers were applied 21 days after sowing (DAS; Table 2). Irrigation, weeding and other cultural practices were done according to DOA recommendations.

Data Recording

Data were collected from ten randomly selected plants from each treatment in each replicate for vegetative parameters. Five plants were randomly selected from each treatment in each replicate for yield parameters.

Vegetative Parameters

Plant height was measured from base of the plant to the distal end of the longest leaf. Number of leaves was determined by counting all unfolded leaves without yellowish and dead leaves. Canopy diameter was measured at widest point of canopy.

Yield Parameters

Total plant weight, root weight, leaf weight were measured by top loading balance. Root length was measured and root circumference was measured at widest point. Leaf and root dry weight were obtained by oven drying at 80 °C for 72 hours.

Statistical Analysis

The data generated from the experiment were statistically analyzed using SAS statistical package (Version 9.2).

Table 2. Fertilizer application schedule and rates (kg/ha)

Fertilizer	BD	TD (21 DAS)
T_1	833	833
T_2	410	410
T_3	282	282
T_4	205	205
T_5	833	833
T_6	410	410
T_7	282	282
T_8	205	205
T_9		
Urea	90	90
TSP	110	-
MOP	65	65

BD- Basal dressing, TD- Top dressing, DAS- Days after sowing; T_1 - 5% Nitrogen co-compost powder, T_2 - 10% Nitrogen co-compost powder, T_3 - 15% Nitrogen co-compost powder, T_4 - 20% Nitrogen co-compost powder, T_5 - 5% Nitrogen co-compost pellets, T_6 - 10% Nitrogen co-compost pellets, T_7 - 15% Nitrogen co-compost pellets, T_8 - 20% Nitrogen co-compost pellets, T_9 - Inorganic fertilizers

RESULTS AND DISCUSSION

According to the analysis of results, different MSW-FS co-compost enrichment levels did not show significant effect on vegetative and yield parameters. Radish was harvested at the end of vegetative growth just before flowering. Therefore, growth, development and yield production of radish mainly depended on the availability of N in soil as the same quantity of nitrogen was applied. All co-compost treatments with enrichment levels were not significantly different for vegetative parameters and yield. Hence, further statistical analysis was done to compare compost formulation types. Therefore, only formulation type was considered as a factor.

Vegetative Parameters

The plant height was significantly higher in pellet form throughout the vegetative growth period (Table 3). It ranged from 21.47 cm to 32.25 cm. Differences in plant height among treatments were significant at all stages of measurements (Table 3).

Plant height is an indicator of vegetative growth that is directly influenced by plant production management strategies (Baloch *et al.*, 2014).

Table 3. Effect of fertilizers on plant height

Type of forms	Plant height (cm)		
	20 DAS	30 DAS	40 DAS
Inorganic	12.50±2.4[c]	20.92±3.1[c]	25.57±5.7[c]
Pellet	21.47±3.6[a]	28.44±5.4[a]	32.25±5.7[a]
Powder	19.72±4.4[b]	26.55±7.8[b]	30.40±7.4[b]

Means with the same superscript letters are not significant at the $p<0.05$ level; DAS-Days after sowing

Canopy diameter was significantly high in pellet form throughout the vegetative growth (Table 4). It ranged from 23.38 g to 37.83 g. No significant differences were observed in canopy diameter at 20 DAS among pellet and powder form while there was a significant difference between pellet and inorganic form (Table 4). Significantly high canopy diameter at 30 DAS was recorded in pellet form (39.23 cm) while it was significantly low in inorganic form (31.55 cm). Pellet form recorded the widest canopy diameter at 40 DAS (44.69 cm) while inorganic form recorded the lowest value (39.71 cm) which was significantly different.

Table 4. Effect of fertilizers on canopy diameter

Type of forms	Canopy diameter (cm)		
	20 DAS	30 DAS	40 DAS
Inorganic	15.36±3.4[b]	31.55±6.8[c]	39.71±7.8[b]
Pellet	23.38±6.3[a]	39.23±8.5[a]	44.63±9.2[a]
Powder	23.10±6.7[a]	36.87±10.4[b]	42.69± 11.9[ab]

Means with the same superscript letters are not significant at the $p<0.05$ level; DAS-Days after sowing

Number of leaves was significantly high in pellet form throughout the vegetative growth (Table 5). It ranged from 8.19 to 16.52. No significant differences were observed in number of leaves at 20 DAS and 40 DAS among inorganic fertilizer and powder form while there was a significant difference between pellets and powder form (Table 5).

Pelletized form of MSW co-compost is releasing nutrient in the soil at a slower rate than the powder form. Hence the nutrient retention in soil will be higher with MSW co-compost pellets as well as the leaching will be minimized. Consequently the vegetative growth may have higher significant effect by pelletized form of MSW co-compost (Siriwattananon and Mihara, 2008).

Table 5. Effect of fertilizers on number of leaves

Type of forms	Number of leaves		
	20 DAS	30 DAS	40 DAS
Inorganic	7.43[b]	11.32[ab]	16.35[b]
Pellets	8.19[a]	11.87[a]	16.52[a]
Powder	7.74[b]	11.14[b]	14.65[b]

Means with the same superscript letters are not significant at the $p<0.05$ level; DAS- Days after sowing

Yield parameters

No significant effects were observed for total biomass among pellets and powder form while there was a significant difference between inorganic fertilizer with others (Table 6). Lower fertility status of soil provided by inorganic fertilizer has not supported vegetative growth and root development of plant (Baloch *et al.*, 2014).

Table 6. Effect of fertilizers on total biomass

Type of forms	Total biomass (g/plant)	Total biomass (kg/m²)
Inorganic	58.58±32.08[b]	2.11
Pellets	176.96±53.57[a]	6.37
Powder	211.06±84.06[a]	7.59

Means with the same superscript letters are not significant at the $p<0.05$ level

Significant differences were observed in tuber length, tuber circumference, tuber weight, tuber dry weight, leaf fresh weight and leaf dry weight between inorganic fertilizer and pellet form. Powder form was having significant differences with inorganic fertilizer for tuber circumference, tuber weight, tuber dry weight, leaf fresh weight and leaf dry weight while differences between pellet and powder forms were not significant. There was no significant difference in tuber length among powder form and inorganic fertilizer (Table 7 and Table 8). The total biomass is a parameter that is directly influenced by number, weight of leaves, tuber length, diameter, and tuber weight per plant (Pervez *et al.*, 2004). An increase in tuber length might be due to effect of environment, soil texture, on time and balanced fertilizing practices. More numbers along with greater size of leaves per plant might also be one of the growth characteristics that influenced on the size of tubers (Asghar *et al.*, 2006).

Table 7. Effect of fertilizers on tuber length, tuber circumference and tuber dry weight

Type of forms	Tuber length (cm)	Tuber circumference (cm)	Tuber Dry weight (g)
Inorganic	14.47±1.9[b]	9.02 ± 2.3[b]	1.87 ±0.83[b]
Pellets	18.42±5.1[a]	12.95 ± 4.0[a]	6.5 ± 1.8[a]
Powder	15.14±3.8[b]	14.27 ± 4.6[a]	7.53±3.57[a]

Means with the same superscript letters are not significant at the $p<0.05$ level

Table 8. Effect of fertilizers on leaf weight, tuber weight

Type of forms	Leaf weight (g)		Tuber weight (kg/m²)
	Fresh weight	Dry weight	
Inorganic	75.11±27.1[b]	7.6±4.5[b]	0.60±0.3[b]
Pellets	167.55±52.6[a]	11.27±3.5[a]	2.44±0.7[a]
Powder	201.61±71.9[a]	13.51±4.4[a]	3.11±1.6[a]

Means with the same superscript letters are not significant at the $p<0.05$ level

During the experimental period drought condition and hot weather prevailed in the field. For tuber initiation and bulking, day and night temperature difference is of paramount important factor. Due to the prevailed weather condition temperature difference between day and night was decreased causing negative effect for tuber initiation and bulking. In addition respiration and transpiration were at high rate due to high solar radiation. Therefore, high energy losses occurred with experimental plants. Unusual ratio between leaf weight and tuber weight of plants can be attributed to the above mentioned yield production mechanism (De Costa, 2000).

CONCLUSIONS

Results revealed that MSW-FS co-compost was having a superior effect on growth, development and yield of radish variety Big Ball under these experimental conditions. Enrichment of MSW-FS co-compost with Nitrogen by adding $(NH_4)_2SO_4$ does not have any significant effect on radish plant growth and yield. Municipal solid waste-FS co-compost pellets were having significant effect on vegetative parameters of the plant compared to powder form. There was no significant difference between pellet and powder forms of co-compost in relation to the radish yield. Organic fertilizer was superior than inorganic fertilizer under these experimental conditions. No significant differences among pellet and powder form were observed for yield. Pellet form can be suggested as most suitable for cultivation due to easy handling, transporting and broadcasting. However, pellet or powder form can be used for cultivation according to farmer's resource availability and willingness.

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