Growth responses of *Corchorus olitorius* Lin. (Jute) to the application of SMC as an organic fertilizer

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Abstract: This study was carried out in a green house with the aim of assessing the response of jute plant to the spent mushroom compost (SMC) application as a organic fertilizer. The potted vegetable (jute) studied were planted in pots and harvested after ten weeks of cultivation and it was observed that the vegetable planted on 20% SMC soil had the best growth followed by 30%, 50%, 0% and 100% SMC respectively (in terms of plant height, leaf number, stem girth, and leaf area). The results obtained for biological efficiencies (B.E.) showed that 20% SMC had the best above and below ground biomass with B.E. of 30.5% and 32.8% followed by 30% SMC (24.8% and 23.4% B.E.) and 10% SMC (15.9% and13.9%), the least B.E. was 2.5 and 11% above ground and 3.3% and 14.2 below ground of the 0 and 100% SMC plants respectively. Moreover, the SMC was able to improve mineral composition of this vegetable. It was observed that, phosphorus and potassium were the best mineral elements of vegetable and mineral elements (iron, magnesium, calcium, phosphorus and potassium) were observed to increase as the concentration of the SMC in the soil increased to 100%.However, zinc decreased with SMC treatment, while manganese concentrations increased to 30% SMC. SMC application was found to increase the soil pH by ±2. The pH values of the soil treated with SMC increased significantly with the SMC percentages in the soil. It was found to have increased from 4.8 to 6.7 and 7.0 in the potted plant with the highest yield.

[Jonathan SG, Oyetunji OJ, Olawuyi OJ and Asemoloye. **Growth responses of *Corchorus olitorius* Lin. (Jute) to the application of SMC as an organic fertilizer.** *Academ Arena* 2012;4(9):48-56] (ISSN 1553-992X). http://www.sciencepub.net/academia. 6

Keywords: *Corchorus olitorius,* , biological efficiency, SMC, biomass., organic fertilizer

1. Introduction

Growing of mushrooms on large scale values have been providing employment for several people in the developed and developing countries of the world (Gbolagade, 2005; Ahlawat *et al.,* 2007; Aina *et al*.,2012a;Jonathan and Adeoyo, 2011). Edible fungi have been widely reported of providing high protein diets and other essential proximate for mushroom consumers (Gbolagade *et al.*, 2006; Aina *et al*.,2012a; Jonathan *et al*., 2012a). Likewise, mushrooms have been also implicated of possessing important exo-polysaccharides and other secondary metabolites that could be responsible for their high medicinal potentiality (Gbolagade,2006; Zakaria *et al*.,2006;Aina *et al*., 2012b;Oluranti *et al*.,2012). It has been widely reported that commercial mushroom cultivation activities are environmentally friendly events that utilized agro industrial wastes such as substrates from farm land, horticulture, poultry, brewery etc. for its cultivation (Bayer,1996;Jonathan and Adeoyo, 2011; Omarini,2010;Jonathan *et al*., 2012b).

Despite numerous benefit of mushroom cultivation, disposal of spent mushroom compost (SMC) also known as spent mushroom substrates (SMS) have been known of constituting nuisance pollutants to our environment. These problems may include foul odour arising from the piling up of SMS after various flushes of mushrooms have been harvested. Dumping of SMS indiscriminately may also lead to diseases outbreak or unwarranted health risk especially when these were disposed at a close range to where people live. It has been reported that unwanted SMC disposal may serve as contamination to ground water sources in villages and rural area (Beyer, 1996).

SMC have been reported of containing nutrients which could be used for the growth of useful photosynthetic plants (Fasidi *et al.,* 2008 and Gbolagade *et al*., 2006). It can also supply nutrients and increase the water-holding capacity of the soil. (Polat *et al*., 2004), Chang *et al*. (1999) explained that the SMC is entangled with innumerable mushroom threads (collectively referred to as mycelia) which could have modified the substrate biochemically by production of enzymes.

Uncontrolled disposal of SMC may pose a problem to the environment, therefore, there is a need to convert this waste into harmless substances (waste to wealth)which will be useful for agricultural use or to products that will be environmentally friendly. The demand for organic residues and compost has also increased several folds considering the ill effects of synthetic pesticides and fertilizers. The low soil pH level is one of the most common limiting factors for plant development, and there is need to increase it using compost (Chang *et al*., 1981;

Chefeetz *et al*., 2000; Howat, 2003; Jonathan *et al*., 2012c).

Kabata *et al*. (2000), explained that, critical aspects of soil fertility management include pH, secondary nutrients and micronutrients. Also, many of our agricultural lands have been over utilized by inadequate farming practice, and these results in nutrient depletion of soils (Jonathan *et al*., 2011). Therefore, there is a need to look for an alternative source of organic fertilizers that will boost the growth and production of vegetables by the local farmers .

Corchorus olitorius Linn. (Tiliaceae), called jews mallow or jute mallow in English and "ewedu"among the Yoruba people of south western Nigeria is an annual herb with a slender stem. It is an important green leafy vegetable in many countries including Egypt, Sudan, India, Bangladesh, Malaysia, as well as Japan, the Caribbean and Cyprus (Samra *et al*., 2007). *Corchorus olitorius* is a vegetable eaten in both dry and semi-arid regions and in the humid areas of Africa. The plant is also known for its fibre product, the jute (Schippers, 2000). The plant prefers light (sandy), medium (loamy) and heavy (clay) soils. It is extremely consumed as a health vegetable, because it contains abundant β-carotene and other carotenoids, vitamins B1, B2, C and E, and minerals. The vegetable also has varying proportion of dietary fibre and protein required for health (Schipper, 2000).

Nutritionally, *C. olitorius* on the average contain 85-87g H_2O, 5.6 g protein, 0.7 g oil, 5 g carbohydrate, 1.5 g fiber 250-266 mg Ca, 4.8 mg Fe, 1.5 mg 300010 vitamin A, 0.1 mg thiamine, 0.3 mg riboflavin, 1.5 mg nicotinamide, and 53-100 mg ascorbic acid per 100 g (Ndovu and Afolayan ,2008). In West African countries including Ghana, Nigeria and Sierra Leone, the vegetable is cultivated for the stem bark which is used in the production of fibre (Jute) and for its mucilaginous leaves which are also used as food vegetable (Zakaria *et al*., 2006). The leaf extract of the plant is also employed in folklore medicine in the treatment of gonorrhea, pain, fever and tumor (Ndlovu and Afolayan, 2008). The crop is an excellent source of vitamin A and C, fiber, minerals including calcium, and iron. It is reportedly consumed as healthy, vegetable in Japan because of its rich contents of carotenoids, vitamin B_1, B_2, C and E, and minerals (Ndovu *et al*., 2008). Its leaves and roots are eaten as herbal medicine in South East Asia (Ndovu *et al*., 2008). In Nigerian , the Yorubas commonly used it in a stew known as ewedu, a condiment to other starch-based foods such as amala(Jonathan *et al.,*2012d). The Hausa people of Nigeria and their Fulani neighbours call it *rama*. They use it to produce soup (*taushe*) or boil the leaves and mix it with *kuli-kuli* (groundnut cake) to form a dish known as *kwado* in Hausa. The Hausa peasant farmers cultivate it beside their corn-stalk constructed homesteads or among their main crops in their farms. The Hausa and Fulani peoples also use jute leaves to treat some diseases.

The composition of *Corchorus olitorius* leaves per 100 g fresh edible portion is: water 80.4 g (74.2–91.1), energy 243 kJ (58 kcal), protein 4.5 g, fat 0.3 g, carbohydrate 12.4 g, fibre 2.0 g, Ca 360 mg, P 122 mg, Fe 7.2 mg, β-carotene 6410 μg, thiamin 0.15 mg, riboflavin 0.53 mg, niacin 1.2 mg, ascorbic acid 80 mg (Samra *et al*., 2007). This composition is in line with other dark green leafy vegetables, but the dry matter content of fresh Jew's mallow leaves is higher than average. The composition and especially the micronutrient content are strongly influenced by external factors such as soil fertility and fertilization. Nitrogen fertilizer greatly improves the micronutrient content, e.g. Fe, P, Ca, carotene and vitamin C.

The mucilaginous polysaccharide in the leaves is rich in uronic acid (65%) and consists of rhamnose, galactose, glucose, galacturonic acid and glucuronic acid in a molar ratio of 1.0:0.2:0.2:0.9:1.7 in addition to 3.7% acetyl groups.

Jute fibres are obtained from baste. The use is limited to coarse fabrics, because the length: diameter ratio of jute filaments is only 100–120, much below the minimum of 1000 required for fine spinning quality. Individual fibre cells are (0.5–)2–2.5(–6.5) mm long, with a diameter of (9–)15–20(–33) μm. The length of the fibre cells decreases from the top to the bottom of the stem, whereas the width increases. The lumen width varies greatly throughout the length of the fibre cell, with the lumen sometimes closing up. Fibre cells are cemented together into filaments of up to 250 mm long.

The tensile strength, elongation at break, and Young's modulus of jute fibre are 187–775 N/mm², 1.4–3.1% and 3000–55,000 N/mm², respectively.

Jute has a low ignition temperature of 193°C, posing a considerable fire hazard in warehouses. Jute fibre contains 45–84% α-cellulose, 12–26% hemicelluloses, 5–26% lignin, 0.2% pectin and 1–8% ash. Jute fibre may be treated with a strong alkali ('woollenization'), resulting in a reduced fibre length, a softer feel and a crimp or waviness, giving the fibre a wool-like appearance. The woody central core is of medium durability under exposed conditions. The fibres in the central core are 0.5–0.8 mm long and 29–42 μm wide.

Corchorus olitorius leaves contain antioxidative phenolic compounds, of which 5-caffeoylquinic acid is the most important. Some ionone glucosides have also been isolated from the leaves; they showed inhibitory activity on histamine release from rat peritoneal exudate cells induced by antigen-antibody reaction. The seeds are poisonous to mammals and insects. They contain cardiac glycosides.

Inorganic fertilizers are mostly being used for production of organic food but their prices are beyond the reach of many local farmers in the developing countries like Nigeria (Jonathan *et al.*, 2011). Organic farms need to be supplied with Nitrogen through sources such SMC (Chefetz *et al.*, 2000). SMC has many attributes aiding its exploitation in place of inorganic farm yard manure (FYM) in raising organic field crops and environment management (Ahlawat *et al.,*2007). Therefore the objectives of this work were to convert the mushroom waste (SMC) to a valuable product, to determine the dose of SMC that will best support the vegetable yield and to determine the effect of SMC on the pH of the soil.

2. Materials and methods

2.1 Collection of samples

Cultivated soil samples used for this experiment were collected from the Botanical Nursery of the Department of Botany, University of Ibadan while the **SMC** was collected from Beehay Mushroom Ventures dumping ground, at Ibadan, Nigeria, after it has been disposed for 7days. Treated seeds of the pumpkin were collected from Tobol Agro Care, Ibadan.

2.2 Experimental Set up

The experiment was carried out in the greenhouse as a pot experiment. The pots were arranged in a completely randomized design with three replicates. Corresponding rates in percentage of SMC was applied to 5kg of soil inside a basin, and mixed together with bare hand and then packed inside thick polythene bags. SMC was applied to the experimental soil in the following fashion like the one developed by Onal and Topcoglu (2003), and Jonathan *et al*. (2012c)

Six different levels of SMC of oyster mushroom were chosen, that is, 0% (Control), 10%, 20%, 30%, 50%, 100% were supplemented with 5grams of cultivated soil in green house. This was done between the months of August to November 2011.

- Treatments with no SMC i.e. Control (0% SMC)
- 0.5kg of SMC /5kg of Soil (10% SMC)
- 1kg of SMC /5kg of Soil (20% SMC)
- 1.5kg of SMC /5kg of Soil (30% SMC)
- 2.5kg of SMC /5kg of Soil (50 % SMC)
- Treatment with only SMC (Control (100% SMC)

All pots were arranged on the shelves in the greenhouse under controlled climatic conditions. Pots were maintained around field capacity by daily watering with 100mil of water. The vegetable seeds were planted directly on the pots based on the SMC treatment and each treatment was replicated trice and the pots were labelled.

2.3 Growth Analysis

Sampling for growth analysis started two weeks after sowing the vegetable seeds. Growth parameter measurements were carried out at weekly intervals. Each potted plant was labelled according to the SMC treatment and the same label was chosen from each pot every week. Parameters such as plant length, plant diameter (girth), number of node, leaf length, leaf diameter and total number of leaves plus the dead leaves were taken. These were done for 12 weeks for *T. occidentalis* and 10 weeks for others.

Plant height was determined by placing a thread from the ground level to the tip of the terminal bud and the length of the thread measured with a ruler to determine- the height and plant diameter was determined by the use of electronic calliper (Hand veneer calliper) by placing it 1cm above the ground level. Number of leaf and node were recorded by counting while the leaf Length, diameter and Leaf area was determined using the leaf Area Meters LI-COR (LI-3000C)

2.4Biomass analysis

The studied jute plants were harvested after 10weeks of planting. The shoots and roots of the same SMC treatments were packed in an envelope and were taken to the laboratory immediately after harvest for quantitative measurement. The fresh weight was recorded and dry weight was recorded after air-dried for 2 weeks using a digital Weighing balance (Ohaus Scout).

2.5 Nutrient analyses

The plant's nutrient analyses were carried at the soil laboratory of The Department of Agronomy, University of Ibadan. Organic carbon, organic matters, % nitrogen, phosphorus, potassium were determined using official methods of the Association of Analytical Chemists (AOAC, 2005). Total N were determined by Kjeldahl method. Plant tissues were ground and digested in aqua regia (1:3 HNO_3/HCl). In wet ashed leaf samples total P were determined by molibdophosphoric yellow colour method, total K, Ca, Mg, Fe, and were determined by atomic absorption spectrophotometry (FAAS) under optimised measurement conditions.

2.6 pH Determination

The pH of the soil sample used for this experiment was first determined before mixing it with different percentages of SMC. After the addition of SMC, the PH of the mixture were taken in the next five weeks in other to allow the soil to adjust its pH as a result of the SMC addition as suggested by Herald, (2010) and Jonathan *et al.,* (2012c).

2.6 Yield and biological efficiency

The Biological Efficiency (B.E.) of the vegetables was calculated using the field dry weight (above and below ground biomass) of the harvested plant. These were calculated using the following formula like that of Jonathan *et al*. (2012c)

BE= FDW / TFDW ÷ 100% where
BE = Biological Efficiency
FDW = Field Dry Weight of the plant and
TFDW = Total Dry Weight of the plant

2.7 Statistical analysis

Data obtained were analysed using analysis of variance (ANOVA). Test of significance were carried out using Duncan Multiple Range Test (DMRT).

3. Results and Discussion

3.1 Growth assesement

Table 1: Influence of different levels of SMC application on the growth of *C. olitorius*

Parameters	SMC	NUMBER OF WEEKS								
(Cm)	(%)	2	3	4	5	6	7	8	9	10	MEAN
Leaf No.	**0**	4	10	12	14	16	18	21	24	24	15.9d
	10	2	9	12	14	16	21	23	28	29	17.1c
	20	3	9	12	16	21	28	31	39	41	22.2a
	30	2	8	11	15	17	21	23	32	34	18.1b
	50	3	8	11	13	16	21	23	29	29	17c
	100	2	6	9	12	13	15	16	17	18	12e
Plant length	**0**	6.7	21.5	29.9	37.7	40.1	45.6	48.2	55.7	57.4	38.1e
	10	3.3	19	26.7	36.8	45.7	54	58.5	65.7	67	41.9d
	20	5.4	26.5	37.3	44.7	54.9	69.2	73.3	87.8	88.9	54.2a
	30	5.8	21.6	30.6	37.6	47	60.2	64.5	72.4	72.7	45.8b
	50	4.2	15	26.9	38.1	49.3	59	61.8	68.4	69.7	43.6c
	100	3.1	4.7	6.2	8.4	11.8	15.3	18.8	28.3	30.3	14.1f
No of nodes	**0**	2	6	7	8	10	12	13	16	16	10d
	10	1	6	8	9	11	13	15	18	19	11.1c
	20	2	6	8	11	14	18	20	25	26	14.4a
	30	1	6	8	10	11	14	15	21	22	12b
	50	2	6	8	9	10	14	15	18	18	11.1c
	100	1	4	6	8	9	11	11	12	13	8.3e
girth	**0**	0.3	-	0.7	-	1.1	-	3.1	-	4.5	1.9e
	10	0.3	-	0.9	-	1.5	-	3.4	-	5.3	2.3d
	20	0.4	-	1	-	2.5	-	5.3	-	7.6	3.4a
	30	0.4	-	0.7	-	2.1	-	4.6	-	6.6	2.9b
	50	0.3	-	0.6	-	1.8	-	3.9	-	6.6	2.6c
	100	0.2	-	0.4	-	1.1	-	2.1	-	3.5	1.5f
Mean leaf area	**0**	3.9	13.5	22.1	29.2	33.2	42.2	45.0	58.2	63.7	34.6e
(cm^2)	**10**	5.76	14.3	21.5	30.8	38.25	50.4	57.6	91.1	100.0	45.5c
	20	2.6	6.7	12.0	24.1	39.6	62.5	62.5	136.1	142.8	54.3a
	30	2.64.8	8.6	14.6	20.5	30.4	53.6	64.4	102.2	117.0	51.4b
	50	1.7	4.2	6.1	10.6	13.8	41.0	51.5	91.8	100.7	35.7d
	100	0.6	3.1	4.6	6.1	7.8	9.9	12.0	22.4	27.8	10.5f

Means with different letters in the same row each are significantly different by Duncan's multiple range test($P<0.05$).

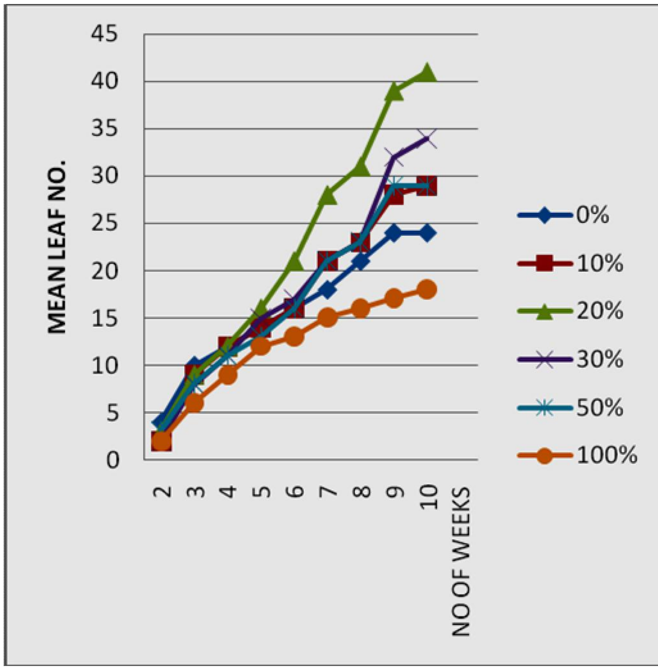

Figure 1: The Impact of SMC on the growth of *C. olitorius* (leaf numbers).

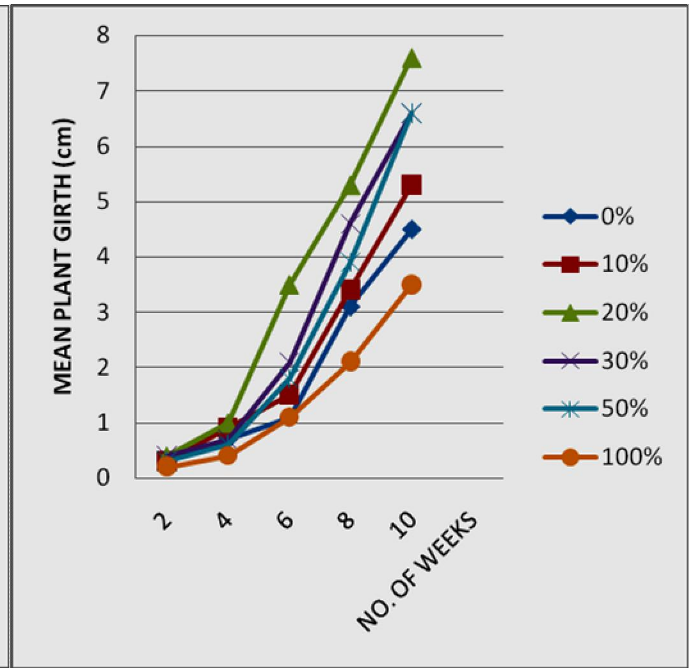

Figure 2: The effect of SMC on the growth of *C. olitorius* (girth)

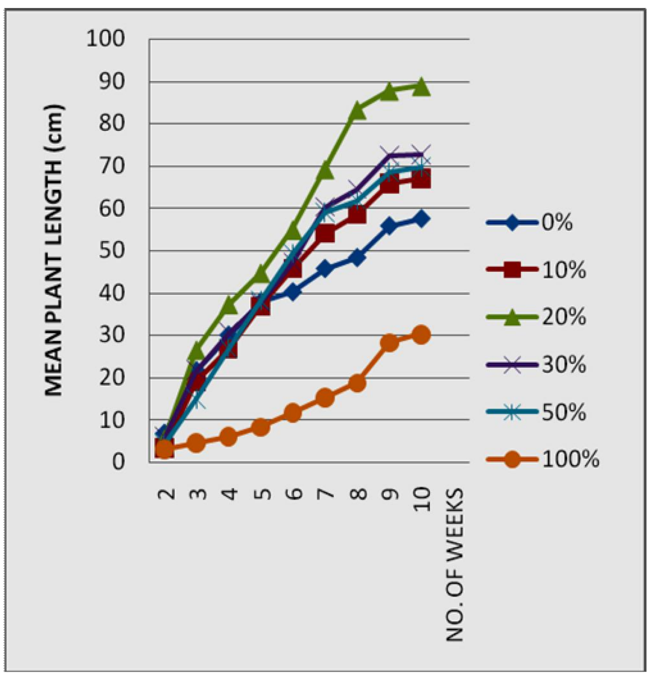

Figure 3: The effect of SMC on the growth of *C. olitorius* (plant length).

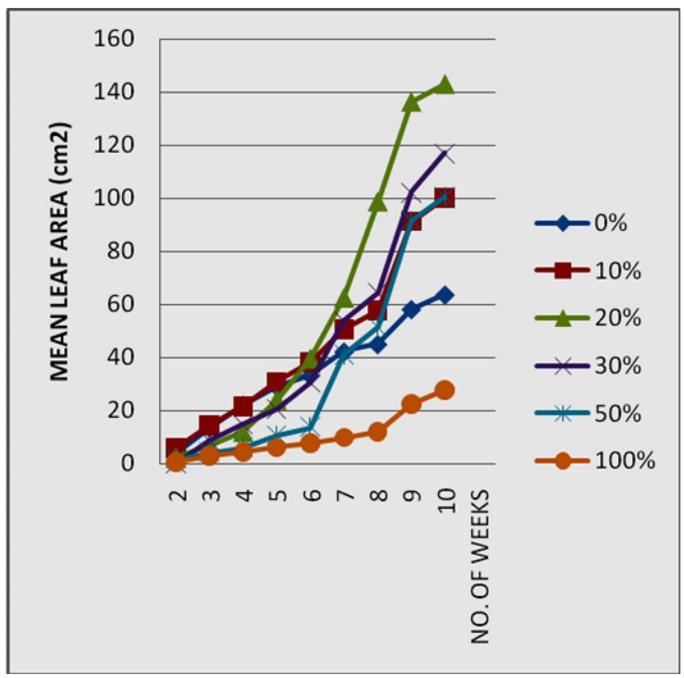

Figure 4: The Effect of SMC on the Growth of *C. olitorius* leaf area (cm^2)

Parameters recorded for the growth assessment of *A. hybridus* were presented onTable 1 and onFigures 1-4. Rally It was generally observed that application of different concentration of SMC has direct growth promoting effect on the test vegetable.This could be noticed in terms of leaf number (Fig.1), plant length (Fig.2), Stem diameter or girth (Fig 3), number of nodes(Table 1), and leaf area (Fig 4). From Table 1, *Corchorus olitorius* planted on 20% SMC soil also had the best growth (with mean leaf area of 54.3cm^2, mean plant length of 54.2cm and mean girth diameter of 3.4cm) followed by 30% SMC plants (with mean leaf area of 51.4cm^2, mean plant length of 45.8cm and mean girth diameter of 2.9cm) and 10% SMC treatment (mean leaf area of 45.5cm^2, mean plant length of 43.6cm and mean girth diameter of 2.3cm). The least growth was recorded for *Corchorus olitorius* planted on 0% SMC (with mean leaf area of cm^2, mean plant length of 38.1cm and mean girth diameter of 1.9cm) and 100% SMC plants (with mean leaf area of 10.5cm^2, mean plant length of 14.1cm and mean girth diameter of 1.5cm). Similar observation of SMC treatment on *Telfairia occidentalis* were reported by Jonathan *et al*.(2012c).

3.2 Results of biomass analysis.

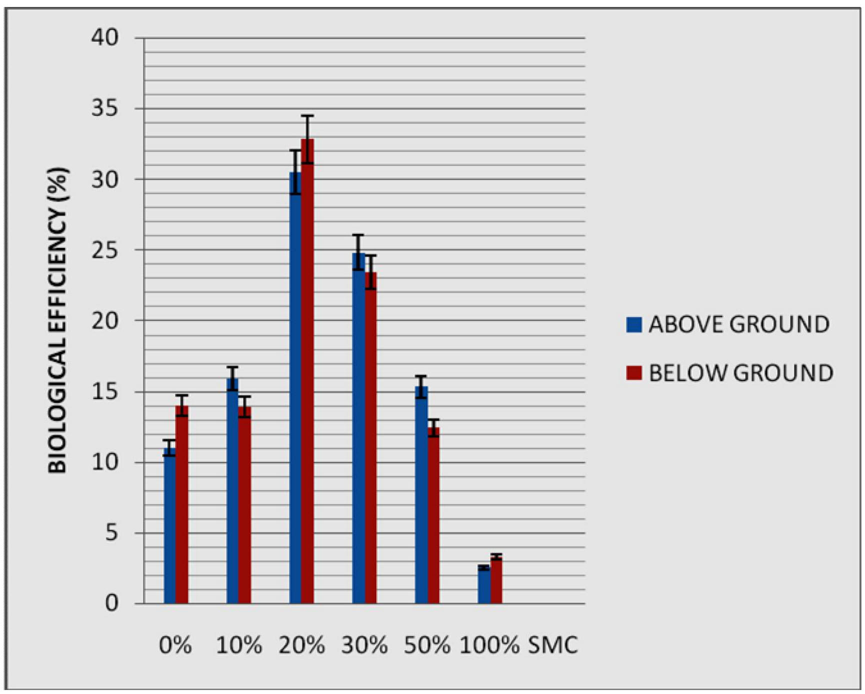

Figure 5 : Effect of SMC on Biological Efficiency of *C. olitorius.* (Error bars with percentages 5% value) Biological efficiency B.E. (%) =Fresh or Dry Biomass (g) divided by Total Biomass (g) ×100.

Data on the biomass analysis of the studied *C. olitoriusis* was presented on Table 2. The treatments were significantly greater than the control except in 100 SMC . The best field dry mass was 30.5% of the plants cultivated on 20% SMC, followed by 30% SMC with BE. of 24.8% and 10% SMC with B.E of 15.5%. The least B.E recorded for above ground biomass of the plant was 10.4 and 2.5% of the 0 and 100% SMC plants respectively. Also, the results obtained for B.E of the below ground biomass of the *Corchorus olitorius* showed that 20% SMC was the best with B.E. of 32.8% followed by 30% SMC with B.E. of 23.4% and 10% SMC with B.E of 13.9%, the least B.E was 14.2 and 3.3% of the 0 and 100% SMC plants respectively. This result is in agreement with the suggestion of Ndovu *et al*. (2008) that the average dry weight of *C. olitorius* ranged between 30 and 40g.

3.3 Nutrient analyses

Table 2: Effect of SMC application on the mineral composition of *Corchorus olitorius* (mg/100g)

	NUTRIENTS								
SMC	**Fe**	**Mg**	**Ca**	**Na**	**K**	**P**	**Zn**	**Mn**	**%Ash**
Control (0%)	10.3a	17.1a	11.1a	4.7a	188.1a	120.0a	0.7a	0.12e	4.6a
10%	12.7b	18.4b	12.2b	5.9b	196.1b	122.5b	0.6b	0.11d	5.3b
20%	13.1c	19.1c	13.4c	6.2c	199.6b	128.3c	0.4c	0.10d	5.8c
30%	14.5c	19.7d	33.7c	6.8d	202.1b	128.6c	0.3d	0.9c	6.1d
50%	16.1d	20.4e	15.6d	7.4e	211.4c	129.1d	0.31d	0.8b	6.7e
Control (100%)	17.6e	21.1f	17.5e	8.7f	222.3d	130.2e	0.2e	0.76a	3.6f

Each value is the mean for three replicates. Means with different letters in the same row on each growth parameters are significantly different (P <0.05).

Table 2, showed the mineral contents of *C. olitorius* grown in soil treated with different level of SMC. The results of the nutrients content revealed similar trend with nutrient content of other vegetables that are treated with SMC. Most of the minerals such as iron, magnesium, calcium, phosphorus and potassium increased as the concentration of the SMC in the soil increased to 100% while zinc concentration decreases with SMC treatment. Manganese concentrations increased to 30% SMC at the highest level and, then decreases to 100%SMC level. The pH values of the soil treated with SMC increases significantly with the SMC percentages in the soil. The ash content of the plant was also found to be influenced by the addition of SMC. It increases from 0%SMC i.e. 4.6 to 30%SMC i.e. 6.7 as the highest level and then Decreases to 100%SMC i.e. 3.6

Table 3. The effect of SMC addition on the pumpkin soil pH

	No of Weeks							
% SMC	**0**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	4.8	-	-	5.1	5.2	5.3	5.3	5.2
10	-	-	-	6.2	6.3	6.3	6.2	6.4
20	-	-	-	6.4	6.5	6.6	6.7	6.7
30	-	-	-	6.9	6.7	6.8	7.1	7.0
50	-	-	-	6.5	6.6	6.7	6.7	6.6
100	-	-	-	6.9	6.9	7.2	7.8	7.8

The initial pH of the soil was recorded at 0 day to be 4.8 after the addition of SMC, it was observed that the SMC was able to raised the pH of the soil from 4.8 recorded from week 0 to 6.4 in 10%SMC soil, 6.7 in 20% SMC where the highest yield was recorded, 7.0 and 6.6 in 30 and 50% SMC respectively. However, planting *C. olitorius* on the SMC alone was found to increase the pH to 7.8

4.0 Conclusion:

This study showed that the different concentration of spent mushroom compost (SMC) of *Pleurotus ostreatus* in the soil has a direct effect of on the growth, yield and nutrient contents of *C. olitorius.* All plants cultivated on soil treated with SMC showed yield different from those of the control, This was in accordance with the report of American Mushroom Institute(2003) that SMC alone was not good for planting.

This study made it clear that 20% and or 30% level of SMC in soil best suppoted the growth of *C. olitorius*. It was also observed that application of SMC at these rate raises the nutrient content of the plant used in this study.

We hereby recommend the use of SMC as an organic ameliorant in the cultivation of jute vegetable (*C. olitorius*) at the rate of 30%.

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8/8/2012