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# Supplementation of spent mushroom compost (SMC) of *Pleurotus ostreatus* (Jackuin Ex. Fr.) Kummer as a soil amendment for the growth of *Amaranthus hybridus* Lin. a Nigerian green vegetable

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## ABSTRACT

In this study the stimulatory effect of spent mushroom compost (SMC) as an organic ameliorant for the growth of *Amaranthus hybridus* in greenhouse experiment was examined. This vegetable was grown in experimental pots and were harvested after ten weeks of planting. The results obtained showed that the vegetables planted on 20% SMC soil had the best growth in respect to plant height (cm), leaf number, stem girth (cm), and leaf area ($cm^2$), followed by 30% and 50%,The two control 0% and 100% SMC generally supported poor growth of *Amaranthus hybridus*. The biological efficiencies (B.E.) of the vegetable was calculated using the field dry weight (FDW) of the plant and the results obtained showed that 30% SMC had the best above and below ground biomass with B.E. of 34.0% and 31.0% followed by 30% SMC (26.0% and 22.1% B.E.) and 10% SMC (23.0% and120.0%), the least B.E. was 1.7 and 1.2% of the 0 and 100% SMC plants respectively. Moreover, observation on the mineral analyses of this vegetable revealed that the plant had calcium and sodium as the highest mineral compositions. Most of the minerals such as iron, magnesium, calcium, phosphorus and potassium increased as the concentration of the SMC in the soil increases to 100% while zinc decreased with SMC treatment. The pH values of the soil treated with SMC increased significantly with the introduction of SMC. PH increased from 4.8 to 6.7 and 7.2 in the potted plant with the highest yield that is, 20 and 30%. 

## KEYWORDS

*Amaranthus hybridus*;
Amendment;
Yield;
SMC;
pH.

## INTRODUCTION

Jonathan *et al*[14] defined SMC as the leftover of wastes after different flushes of mushrooms have been harvested. It is a by-product of the mushroom industry, after mushroom cropping, the compost and casing layer have no further use as a growing medium and are removed Fasidi *et al*[9]. According to reports in literatures[9-13],there are two types of spent mushroom compost; these are fresh SMC and weathered SMC. The fresh SMC is the one that was applied to plants immediately they were removed from mushroom farms[11,12].

The weathered SMC are those that undergo further decomposition for several weeks before their utilization by farmers as soil conditioner[9,14]. After mushroom crops are harvested, millions of tonnes of "spent" (used) mushroom substrate become available for other uses. Many beneficial uses for spent mushroom substrate are currently being evaluated internationally. These uses vary with the mushroom species[6,7].

The important question in this day of limited natural resources and concerns over human health and the environment is, "What use or value does this residual material from mushroom production have?"[6]. Mushrooms are cultivated on natural materials which are taken from different agricultural wastes, woodlands, animal husbandry, and manufacturing industries[1-4]. As SMC contains a considerable amount of nutrients and is generally not phytotoxic, it has been used as a soil amendment[1,14].

Chang[5] reported that the spent substrate that is left after the mushroom had been harvested is entangled with innumerable mushroom threads (collectively referred to as mycelia) and the substrate would have been biochemically modified by the mushroom enzymes into a simpler and more readily digestible form, which is thus more palatable to livestock, when used as a livestock feed supplement. Additionally, it will significantly have been enriched with protein, by virtue of the remains of the protein-rich mycelia, left after harvesting the mushroom fruiting bodies. The residue could also be utilised as organic garden mulch, which is good for the soil[5].

The spent substrate from mushrooms has been analysed and found to be nutritionally rich with respect to its N:P:K contents and high cation exchange capacity[1,3,6,9]. Therefore, it has the ability to replace inorganic Farm Yard Manure for the purpose of raising horticultural and cereal crops, as feeding material for vermicomposting, for plants diseases management, preparation of organic-mineral fertilizer and bioremediation of the contaminated soils[8,9,14].

A good advantage of using SMC as organic compost is that, if used properly, it can improve plant growth in poor or marginal soils[7,12,16,17]. This is because mushroom compost amended into those soils will improve the structure of clay soils, reduce surface crusting and compaction and therefore improve drainage, increase beneficial soil microbial activity, and provide nutrients to plants which can reduce the need for fertilizer[14,15]. Scientists have discovered that, when using mushroom compost, it is best to mix the compost with garden soil and then spread around the plants[3,9,14]. This will provide a slow release of organic fertilizer (2-1-1, pH 6.8) and will assist with moisture retention[16].

*Amaranthus hybridus* commonly called African spinach; is known to people from South Eastern Nigeria as 'inene' and it belongs to the family Amaranthacae. It tolerates varying soil and climatic conditions but altitudes of over 1500ft are unsuitable[17]. is widely grown in West Africa, Indonesia and Malaysia[8]. *Amaranthus hybridus* is an annual plant, it is spineless and up to 80m high with grooves. The leaves are green and variable in shape and size.

In order to increase the soil fertility, farmers are prone to use fertilizers which can be organic or inorganic. It is very important to note that the prices of inorganic fertilizers are beyond the reach of many local farmers in the developing countries like Nigeria[12]. Although inorganic farm yard manure is mostly being used for production of organic food but its poor availability might contributed to the restricted production of organic crops at a large scale. In this country, many of our agricultural lands have been over utilized by inadequate farming practice, thereby resulting in nutrient depletion of soils[14]. There is a need to look for an alternative source of organic fertilizers which will boost the growth and production of vegetables by the local farmers[14]. In addition to providing a balanced nitrogen and carbon source for plant growth, the SMC will be further degraded in the soil humus. This is very important in maintaining soil structure, good aeration, water holding capacity, and also relevant to maximizing crop productivity[9].

The demand for organic residues and compost has also increased several folds considering the ill effects of synthetic pesticides and fertilizers. The research work carried out around the world has proved that spent mushroom substrate possesses the quality of a good organic manure for raising healthy crops of cereals, fruits, vegetables and ornamental plants, in addition to its ability of reclaiming the contaminated soil.

SMS has many of the requisite attributes still left with for its exploitation in place of FYM in raising organic field crops and environment management[1]. The re-use of SMC in crop production by its recycling as an ingredient of growing mixes would provide an environmentally safe disposition. The objective of the present study is therefore to use SMC as an organic ameliorant for the growth of *Amaranthus hybridus*

## MATERIALS AND METHODS

### 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 *A. hybridus* were collected from Tobol Agro Care, Ibadan.

### Experimental set up

This was done as a pot experiment and it was carried out in the greenhouse. Six different levels of SMC of oyster mushroom were chosen, that is, 0% (Control), 10%, 20%, 30%, 50% and 100% supplemented with 5grams of cultivated soil in green house. The cultivated soil and SMC properties are shown in TABLE 2 and 3 respectively. This experiment was done between the months of August to November 2011. The SMC and 5grams of soil were missed together in a basin using bare hand (in different percentages) and bagged in polythene bags; these were done in triplicates and are arranged on the shelves in a completely randomised design fashion. SMC was applied to the experimental soil in the following fashion like the one developed by Onal and Topcoglu[15].

- SMC0 %: no SMC application (Control)
- SMC10 %: 0.5kg of SMC /5kg of Soil
- SMC20 %: 1kg of SMC /5kg of Soil
- SMC30 %: 1.5kg of SMC /5kg of Soil
- SMC 50 %: 2.5kg of SMC /5kg of Soil
- SMC 100 %: Only SMC (Control)

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 distilled water.

The vegetable seeds were planted as broadcast on the pots based on the SMC treatment and each treatment was replicated trice and the pots were labelled. The seeds germinated after four days and they were thinned to one after two weeks of emergence to one plant per pot.

### 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 10 weeks.

The basic procedures taken for analysis of growth were as follows.

1. 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.
2. Plant diameter was determined by the use of electronic calliper (Hand veneer calliper) by placing it 1cm above the ground level
3. Number of leaf and node were recorded by counting
4. Leaf Length, diameter and Leaf area was determined using the leaf Area Meters LI-COR (LI-3000C)

### Biomass analysis

The studied vegetable plants were harvested after 14weeks of planting. The shoots and roots of different SMC treatments were taken to the laboratory immediately after harvesting for quantitative measurement and were air-dried for 2 weeks. Field dry weight was measured using a digital Weighing balance (Ohaus Scout). The Field Dry Weight of the plant parts were measured after the water content of the plant has been eliminated.

### Nutrient analysis

Organic carbon, organic matters, % Nitrogen, Phosphorus, Potassium were determined using official methods of the Association of Analytical Chemists[2]. Total nitrogen was 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.

### PH determination

The pH of the soil sample used for this study was first determined before mixing it with different percentages of SMC. After the addition of SMC, the pH of the mixture were observed again after five weeks in other to allow the soil to adjust its pH as a result of the SMC Harald[7].

To determine the PH of a pot, soil samples (about 20g) were taken from the top 20 cm with a trowel into a clean container selected at five random spots in the area of the pot. The soil samples were mix together to get an average reading. Soil pH test kit and the glass electrode pH meter called Eutech EcoTestr pH 2 were used in taking the readings. The Soil sample was scoop up loose with a clean, dry plastic jar, stones and any clumps of soil was crushed to prevent breaking the delicate tester's glass electrode bulb.

The soil sample was then mixed with distilled water (1:1 ratio) in a clean jar to form an emulsion; the jar was tightly caped and shacked vigorously for some few times. The mixed sample was allowed to stand for 5 – 10 minutes so that the salts in the soil can dissolve in the distilled water. EcoTestr was switched on after the cap has been removed and the electrode bulb was submerged fully into the wet soil slurry.

The reading was taken after it stabilized. The HOLD button was pressed to freeze the reading for recording and pressed again to release the reading. This was repeated two more times for higher accuracies.

### Yield and biological efficiency

The Biological Efficiency (B.E.) of the vegetables ware were calculated using the formula of Chang *et al*[7]

**BE= FDW / TFDW ÷ 100%**

Where BE = Biological Efficiency
FDW = Field Dry Weight of the plant and
TFDW = Total Dry Weight of the plant.

### Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA)while the means were separated using Duncan's multiple range test (DMRT) (P <0.05).

## RESULTS AND DISCUSSION

**TABLE 1: Effect of different levels of SMC application on the growth of *A.hybridus***

| Paramer | SMC | NUMBER OF WEEKS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| (Cm) | (%) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | MEAN |
| Leaf No. | 0 | 6 | 10 | 12 | 14 | 16 | 20 | 21 | 24 | 25 | 16.4e |
| | 10 | 3 | 9 | 17 | 19 | 22 | 26 | 28 | 33 | 33 | 21.1c |
| | 20 | 5 | 12 | 22 | 26 | 28 | 33 | 35 | 41 | 41 | 27a |
| | 30 | 5 | 9 | 21 | 24 | 25 | 29 | 31 | 35 | 35 | 23.7b |
| | 50 | 3 | 7 | 14 | 18 | 19 | 24 | 26 | 32 | 32 | 19.4d |
| | 100 | 2 | 5 | 7 | 10 | 14 | 17 | 18 | 21 | 23 | 13f |
| Plant Length | 0 | 5.8 | 15.5 | 15.7 | 15.9 | 21.3 | 22.6 | 17.9 | 26.2 | 27.1 | 18.7e |
| | 10 | 3.6 | 7.4 | 15.8 | 22.1 | 23.3 | 26.6 | 30.3 | 44 | 44.6 | 24.2c |
| | 20 | 4.3 | 10 | 24.3 | 26.7 | 30.9 | 45 | 48.1 | 54.8 | 56.1 | 33.4a |
| | 30 | 5.3 | 9.2 | 18.8 | 23.6 | 25.8 | 31 | 36.6 | 46.6 | 46.6 | 27.1b |
| | 50 | 4.5 | 10.8 | 16.8 | 22 | 23.3 | 25 | 26 | 30.2 | 36.2 | 21.6d |
| | 100 | 3 | 6.8 | 12.4 | 14.1 | 16.5 | 18.2 | 20.1 | 22.2 | 30 | 15.9f |
| No of Nodes | 0 | 4 | 6 | 7 | 8 | 9 | 11 | 12 | 13.5 | 15 | 9.5d |
| | 10 | 2 | 6 | 9 | 10 | 12 | 14 | 16 | 19 | 19 | 11.9c |
| | 20 | 3 | 7 | 13 | 15 | 16 | 20 | 21 | 25 | 26 | 16.2a |
| | 30 | 3 | 5 | 13 | 15 | 16 | 18 | 19 | 22 | 22 | 14.8b |
| | 50 | 2 | 4 | 9 | 11 | 12 | 15 | 16 | 20 | 20 | 12.1c |
| | 100 | 1 | 3 | 4 | 6 | 8 | 10 | 11 | 14 | 15 | 8e |

| Paramer | SMC | NUMBER OF WEEKS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (Cm) | (%) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | MEAN |
| Girth | 0 | 0.5 | - | 0.6 | - | 0.6 | - | 1.9 | - | 3.1 | 1.3d |
| | 10 | 0.6 | - | 0.8 | - | 1.1 | - | 2.4 | - | 3.8 | 1.7c |
| | 20 | 1 | - | 1.7 | - | 2.7 | - | 4.3 | - | 6.2 | 3.2a |
| | 30 | 0.8 | - | 1.4 | - | 1.9 | - | 3 | - | 4.4 | 2.3b |
| | 50 | 0.7 | - | 0.9 | - | 1.2 | - | 2.5 | - | 3.8 | 1.8c |
| | 100 | 0.3 | - | 0.5 | - | 0.7 | - | 1.7 | - | 2.4 | 1.1e |
| Mean Leaf Area ($cm^2$) | 0 | 5.1 | 9.2 | 12.2 | 15.9 | 30.8 | 56.2 | 63.8 | 85.1 | 91.8 | 41.1e |
| | 10 | 6.3 | 14.7 | 17.8 | 23.4 | 39.5 | 64.4 | 75 | 93.6 | 106.5 | 49.0c |
| | 20 | 10.1 | 29.1 | 36.0 | 43.6 | 56.2 | 100.7 | 104.4 | 131.2 | 137.7 | 72.1a |
| | 30 | 6.5 | 19.7 | 23 | 26.9 | 29.8 | 69.6 | 77.4 | 98.6 | 103.6 | 50.6b |
| | 50 | 6.6 | 19.1 | 24.1 | 31.2 | 35.2 | 61.5 | 69.0 | 85.8 | 89.8 | 46.9d |
| | 100 | 1.9 | 5.1 | 8.2 | 12.0 | 15.6 | 27.4 | 33.2 | 50.0 | 54.4 | 23.1f |

**Values are mean of 3 replicates. Means with different letters in the same row on each growth parameters are significantly different ($P < 0.05$)**

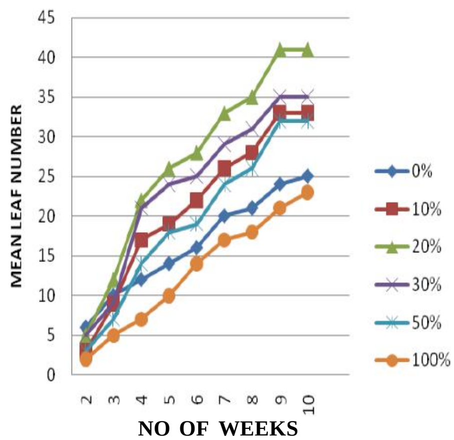


**Figure 1 : The impact of SMC on the growth of *A. hybridus* (Leaf numbers)**

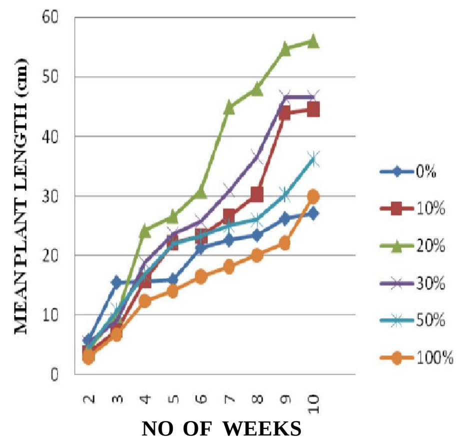


**Figure 2 : The effect of SMC on the growth of *A. hybridus* (Plant length)**

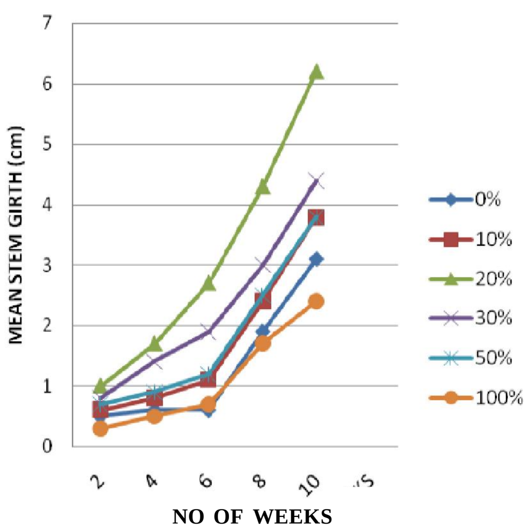


**Figure 3 : The effect of SMC on the growth of *A. hybridus* (Stem girth)**

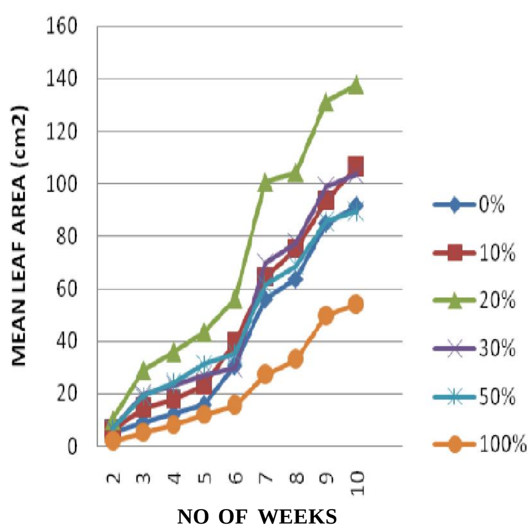


**Figure 4 : The effect of SMC on the growth of *A. hybridus* leaf area ($cm^2$)**

Parameters recorded for the growth analyses of *A. hybridus* were recorded in Figures 1, 2, 3 and 4 above. The results on SMC application showed that the application of SMC has a direct growth promoting effect on the growth of the vegetable in terms of leaf number (Figure 1), Plant Length (Figure 2), stem diameter or Girth (Figure 3), number of nodes, and leaf area (Figure 4).

The result obtained from the growth analysis of *A. hybridus* showed that the vegetable planted on 20% SMC soil had the best growth (with mean leaf area of 72.1cm$^2$, mean plant length of 33.4cm and mean girth diameter of 3.2cm) followed by 30% SMC plants (with mean leaf area of 50.6cm$^2$, mean plant length of 27.1cm and mean girth diameter of 2.3cm) and 10% SMC plants (mean leaf area of 41.1cm$^2$, mean plant length of 24.2cm and mean girth diameter of 1.9cm). The least growth was recorded for *A. hybridus* planted on 0% SMC (with mean leaf area of cm$^2$, mean plant length of 18.7cm and mean girth diameter of 1.3cm) and 100% SMC (with mean leaf area of 23.1cm$^2$, mean plant length of 15.9cm and mean girth diameter of 1.1cm).

**TABLE 2 : Mean biomass analysis of *A. hybridus***

| *A.* hybridus | ABOVE GROUND (g) | BELLOW GROUND(g) |
|---|---|---|
| (% SMC) | FDW B.E. | FDW B.E |
| | 5.2 | 1.7 |
| 0% | 5.0e | 7.5d |
| | 24.4 | 4.6 |
| 10% | 23.3c | 20.4c |
| | 35.8 | 7 |
| 20% | 34.3a | 31.0a |
| | 27.4 | 5.7 |
| 30% | 26.2b | 25.2b |
| | 8.4 | 2.4 |
| 50% | 8.0d | 10.6e |
| | 3.3 | 1.2 |
| 100% | 3.2f | 5.3f |
| Total Field Dry Weight | 104.5 | 22.6 |

**Values are mean of 3 replicates. Means with different letters in the same row on each B.E are significantly different (P <0.05). B.E = Biological Efficiency. FDW = Field Dry Weight**

## Results from the biomass analysis

## Nutrient analisys

The Biological Efficiencies (B.E.) of the vegetables was calculated using the dried above and below biomass of the plant. The result gotten showed that the best off ground biomass recorded for *A. hybridus* was 26.2% of the plants cultivated on 20% SMC, followed by 30% SMC with B.E. of 26.2% and 10% SMC with B.E of 23.3%, the least B.E recorded for above ground biomass of the plant was 5 and 0.03% of the 0 and 100% SMC plants respectively. Also the results gotten for B.E of the bellow ground biomass of the test plant showed that 20% SMC was the best with B.E. of 31% followed by 30% SMC with B.E. of 25.2% and 10% SMC with B.E of 20.4%, the least B.E was 7.5 and 5.3% of the 0 and 100% SMC plants respectively.

**TABLE 3 : Effect of SMC application on the mineral composition of *A. hubridus* (mg/100g)**

| | NUTRIENTS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SMC | Fe | Mg | Ca | Na | K | P | Zn | Mn | %Ash |
| Control (0%) | 1.8a | 10.4a | 44.8a | 24.4a | 8.1a | 6.0a | 1.16a | 0.11e | 5.5a |
| 10% | 2.5b | 11.4b | 46.1b | 25.9b | 9.1b | 7.5b | 1.07b | 0.2d | 6.3b |
| 20% | 3.1c | 12.1c | 53.4c | 26.2c | 9.6b | 8.3c | 1.05c | 0.3d | 6.8c |
| 30% | 3.5c | 12.7d | 53.7c | 31.8d | 10.1b | 8.6c | 1.03d | 0.9c | 7.1d |
| 50% | 4.1d | 13.4e | 55.6d | 36.4e | 11.4c | 10.1d | 1.03d | 0.8b | 6.7e |
| Control (100%) | 5.6e | 16.1f | 67.5e | 38.7f | 12.3d | 19.2e | 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 3 shows the mineral contents of *A. hybridus* grown in soil treated with different level of SMC. The result of the nutrients content showed that the plant had calcium and sodium as the highest mineral components while manganese are zinc are the least. Similar trend of SMC effect on nutrient content of the other vegetables was also observed. Most of the minerals such as iron, magnesium, calcium, phosphorus and potassium increase as the concentration of the SMC in the soil increases to 100% while zinc concentration decreases with SMC treatment manganese concentrations increases to 30%SMC as the highest level and then decreases to 100%SMC level.

From TABLE 4, the initial pH 4.8 of the soil was recorded at 0 day. After the addition of SMC, it was observed that the pH of increased from 4.8 recorded from week 0 to 5.5 in 10%SMC soil, 6.7 in 20%SMC, 7.2 and 6.6 in 30 and 50% SMC respectively. However, planting *A. Hybridus* on the SMC alone was found to increase the pH to 7.9

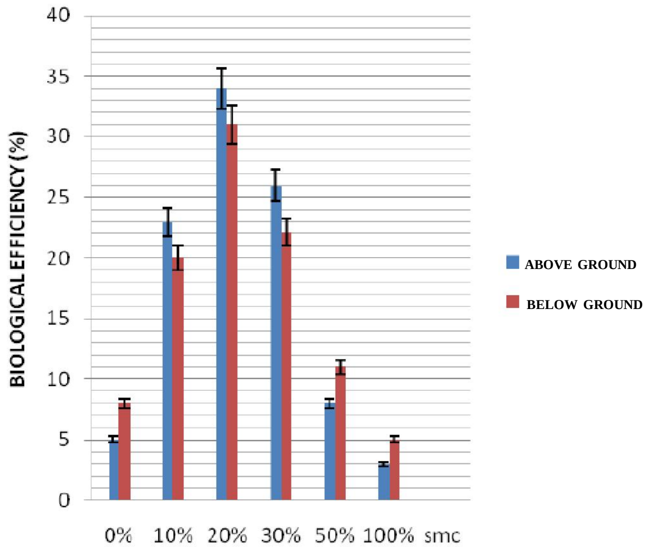


**Figure 5: Effect of SMC on biological efficiency of *A. hybridus.* (Error bars with standard)**

**TABLE 4 : The effect of SMC addition on the *A.hybridus* soil pH**

| | No of Weeks | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| % SMC | 0 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 0 | 4.8 | - | - | 5.0 | 4.5 | 4.7 | 5.1 | 5.2 |
| 10 | - | - | - | 5.1 | 5.4 | 5.4 | 5.6 | 5.5 |
| 20 | - | - | - | 6.2 | 6.5 | 6.6 | 6.6 | 6.7 |
| 30 | - | - | - | 6.4 | 6.7 | 7.0 | 7.1 | 7.2 |
| 50 | - | - | - | 6.1 | 6.5 | 6.7 | 6.7 | 6.6 |
| 100 | - | - | - | 7.0 | 7.5 | 7.8 | 7.8 | 7.9 |

**Each value is the mean for three replicates**

## 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 yield and nutrient compositions of *A. hybriduss.* All the vegetables cultivated on soil treated with SMC showed yield different from those of the control, this establish the fact that SMC has effects on the growth of the vegetable.

This study revealed that 20% and or 30% of SMC in soil best supported *A. hybridus* growth. It was also observed that application of SMC at these rates raises the nutrient content of the plant used.

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