Effect of Spent Mushroom Substrate on Yield, Nutritive Value and Proximate Composition of *Ipomoea Batatas*

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Abstract- A field experiment was conducted to evaluate the effect of spent mushroom substrate (SMS) on nutrient value, growth and yield of Ipomea batatas (sweet potato). SMS was applied at five levels namely 0ton/ha^{-1}(control) 20ton/ha^{-1}, 40tons/ha^{-1}, 60tons/ha^{-1} and 80tons/ha^{-1}. Treatments were laid out in a Randomized Complete Block Design (RCBD) in three replicates. The experimental plot was cleared, raised beds prepared and SMS were applied soon after seed beds preparation. Sweet potato vines (3cm) were planted two weeks after treatments. Vine survival rate, vine length, tuber weight and tuber length were determined. Harvested tubers were later subjected to proximate and nutrient analysis in the laboratory. Result obtained from the study shows that application of spent mushroom substrate (SMS) enhanced sweet potato vine survival rate, encourage higher vine length and tuber weight significantly (P>0.05). Similarly, higher percentage crude protein, fat and crude fiber content were recorded across various treatment levels, but variability in carbohydrate content across the various levels of the substrate did not differ significantly (p<0.05). Calcium, Nitrogen and Phosphorous content recorded across the levels of the applied mushroom substrate were higher than values obtained at the control experiment, indicating ability of the substrate to enhance absorption and deposition of the essential nutrient in sweet potato.

Indexed Terms- Sweet Potato, Mushroom, Substrate, Proximate, Evaluation

I. INTRODUCTION

Ipomoea batatas, a member of convovulaceae family, is a perennial plant, usually grown as an annual crop in the tropics. Though Potato leaves are eaten as green vegetables, tubers are the most utilized part of the crop. The major nutritional components of sweet potato tubers are, carbohydrates, protein, fat and fat-soluble vitamins. Yellow skin cultivars in addition contain carotene (Allen *et al.*, 2012). Sweet potato tuber is known to possess anti-diabetic, anti-oxidant and anti-proliferative properties (beneficial to human health) due to presence of valuable nutritional and mineral components (Jaarsveld *et al.*, 2005; Abubaka *et al.*, 2010).

There is a growing interest in the cultivation of sweet potato to complement the steady decline in yam production due to declining soil fertility, inadequate staking material and high labour cost. With an energy value of 86kcal including 6% in the form of protein, sweet potato food products provide sufficient amount of protein for a suitable, calorific diet (Katayamu *et al.*, 2004).

Nitrogen, potassium and phosphorus as macro nutrients are important for the cultivation and growth of sweet potato. Intensified agricultural activities in various parts of the tropics are closely associated with gradual and continuous degradation of the physical and biological properties of the soil leading to increased risk of soil erosion and fertility decline. Though dependence on inorganic fertilizer has been associated with increase productivity of various crops, its negative effects, is linked with high production cost and continuous use can degrade soil components. Organic manure on the other hand has the ability to continue improving soil physical, chemical and biological properties, thus enhancing soil quality and productivity (Andrew *et al.*, 2004). It has capacity to increase friction between particles thus improving soil strength and soil aggregate stability has been documented (Omovbude *et al.*, 2019). Several organic materials have been employed in the production of crops and their usefulness in enhancing the yield of several crops have been reported.

Spent Mushroom Substrate is an ideal soil enrichment material as it contains important nutrients needed for crop production. It is a bulky waste product of the mushroom industry. Depending on the Mushroom species cultivated, the Spent Mushroom Substrate (SMS) contain minerals in varying proportion because they are made of different substrate ingredients and varying preparation method. Spent Mushroom Substrate (SMS) contains about 14% protein and abundance of vitamins and micro elements such as Fe, Ca, Zn and Mg and have been used to enhance yield of crops (Hui *et al.*, 2007).

The study determined the relevance of this important organic material (SMS) in enhancing yield, nutritive value and mineral composition of sweet potato.

II. MATERIALS AND METHOD

Study was conducted at Teaching Research Farm of Federal College of Education (Technical) Omoku, Rivers State, South-South Nigeria. Temperature ranges between 25^0C and 28^0C, while relative humidity fluctuates between 90% and 100% for most of the year and rarely drops below 60%. Local farmers cultivate plantain, sweet potato, cassava, yam, vegetables etc. Soil is predominantly alluvial, with inland tropical rainforest mangroves towards the coast.

Experimental plot was cleared, stumped and mapped out with the use of cutlass, measuring tape, ranging pole, peg and lining rope. Entire experimental was laid out in 15×22m, plot on beds measuring1×1m. A total of fifteen, (15) experimental plots were prepared. Spent Mushroom Substrates (SMS) were applied at five levels (0, 20, 40, 60 and 80ha^{-1}) and laid out in a randomized complete block design (RCBD) in three replicates. Sweet potato vines were planted 40×70cm apart two weeks after treatment. Weeding was done manually at two weeks interval until vine spread was complete. Vine sprouting rate, length, tuber yield, proximate and chemical composition of the tuber were measured.

Vine survival rate was determined by direct counting of sprouted vines and subtracting it from total planted vines. Measuring tape was used to determine vine length. Tuber weight was measured using graduated weighing machine.

Proximate analysis was used to determine chemical composition of flour obtained by slicing, drying and grinding harvested tuber.

Moisture content was determined using a moisture meter using standard procedure of drying the sample at 100^0c for 10 minutes.

Ash content determination was based on principle of complete incineration of organic component of food and the left behind component is inorganic of ash.

Protein content in flour samples is was determined using modified Kedjhal method.

Fat content was calculated thus % fat content

$$= \frac{\text{Weight of extract}}{\text{Weight of sample}} \times \frac{100}{1}$$

Total carbohydrate content of each sample was determined by difference. These were done by subtracting the percentage of moisture, ash, protein and fat obtained from 100%; % carbohydrate = 100% - (Moisture + ash + % protein + fat)

Mineral contents of sweet potato were determined by atomic absorption spectrometry and flame photometry according to standard methods **(**Oyedeji *et al*., 2016; Bello and Anobeme, 2015; Ezigbo *et al*., 2013; Association of Official Analytical Chemists, 2005).

III. RESULTS AND DISCUSSION

Table I Effect of Spent Mushroom Substrate (SMS) on vine survival, shoot length and tuber yield

SMS Trts. Rates tons/ha^{-1}	Vine Survival Rate	Shoot length (cm)			Tuber yield tons
		3WAP	4WAP	5WAP	
0	6	9.7	13.3	23.3	90.6
2	6.5	10.3	14.30	26.3	7.2
4	6.7	12.0	19.30	46.3	10.10
6	8.0	12.3	22.30	53.7	10.53
8	10.5	15.7	36	62.3	20.5

- Vine Survival Rate: Increasing levels of spent mushroom substrates (SMS) produced a linear increase in sweet potato vine survival rate (table I). Mean vine survival rate of 6.0. and 6.5 was observed at the control experiment and 2kg/m^2 (lowest) SMS application rate whereas, at medium (6kg/m^2) and highest SMS (8kg/m^2) treatment rate recorded a mean vine survival rate of 8.0 and 10.5. Analysis of variance (ANOVA) result indicated a significant difference ($p<0.5$) among the observed means.

- Vine Length: A linear increment was observed in mean vine length with application of increasing rates of the spent mushroom substrate (SMS) 3, 4 and 5 WAP (Table I). For instance, vine length at control experiment (0kg) 3, 4 and 5 WAP were 9.7, 13. 3, and 23.3cm. The lowest SMS (2kg/m^2) treatment recorded a mean vine length 10.3, 14.30 and 26.30 across 3, 4, and 5 WAP whereas at the highest SMS treatment (8kg/m^2) mean vine length of 1.57, 3.6 and 6.2cm respectively was recorded across 3, 4 and 5 WAP.

- Tuber Weight: In tuber weight a linear response trend was also observed across the various treatment rates. Whereas the control experiment (0kg/m^2) recorded a mean tuber weight of 0.6kg. The lowest (2kg/m^2) and highest (8kg/m^2) SMS treatments recorded a mean tuber weight of 0.72kg and 2.5kg respectively. Analysis of variance×× (ANOVA) conducted indicated a significant increase across the observed means ($P \leq 0.5$).

Table II Effect of SMS treatment on mineral composition of Sweet potato tuber

SMS Trts. Rates tons/ha^{-1}	N	P	K	Ca	C	mg
0	0.24	128.91	70.5	46.31	17.62	20.53
2	0.27	128.30	81.7	44.84	17.48	21.74
4	0.32	123.81	78.7	48.43	17.43	23.03
6	0.36	140.25	82.8	50.09	16.95	25.03
8	0.40	161.51	65.4	53.92	18.26	24.14
LSD	0.03	6.91	8.69	4.99	2.14	1.99
SE	0.08	3.79	4.78	1.58	0.68	0.633
CV%	5.7	2.8	6.0	5.6	6.7	4.8
Vr	35.03	48.12	4.34	4.86	0.75	8.16
Fr	<0.01	<0.001	0.027	0.019	0.48	0<0.27

Analysis conducted to determine the mineral composition of Spent Mushroom Substrate used as soil amendment material showed that N, P, K content of the SMS were 2.87, 278,56 and 485.03 while mean value of Ca, C, and Mg content of the substrate were 268.54, 8,44 and 143.83 respectively. In addition to improvement in shoot growth and tuber yield, application of SMS was found to enhance mineral content of sweet potato tuber. Result obtained from this study shows that application of increasing level of SMS produced linear increase in the composition of N, P, K Ca, and Mg. At 0kg, mean Nitrogen and Phosphorus content of sampled sweet potato tubers were 0.24 and 123.22mg/100g respectively; but at 2kg/m^2 SMS treatment, the N and P levels increase to 0.27 and 127.62mg/100g respectively. This observed linear increase in the percentage composition of Nitrogen and phosphorus were maintained across SMS treatment rates of 2–80tons/ha^{-1}. Highest SMS application rate (80tons ha^{-1}) recorded 0.39mg/100g nitrogen content, with phosphorus value of the tubers rising to 159.27mg/100g.

Again, application of increasing levels of SMS produced a linear increase in potassium and calcium levels of sampled tubers. At 0tons ha^{-1} SMS treatment level, potassium content of sweet potato tuber was 69.09mg/100g, but at 20tons ha^{-1}(lowest) SMS treatment and highest (80tons ha^{-1}) SMS treatment, mean potassium content obtained was 73.63 and 85.61mg/100g respectively. Similarly, Ca content at 0kg/m^2 treatment was 43.76mg/100g but 2kg/m^{2}SMS, treatment recorded mean calcium level of 45.86mg/100g. Across 4, 6 and 80tons ha^{-1} SMS application, mean calcium level obtained was 46.37mg/100, 48.56mg/100g and 50.63mg/100g respectively. However, magnesium level of the tuber was 20.64, 21.94, 22.86, 23.72 and 23.79mg/100g across the respective 0, 2, 4, 6 and 8kg/m^2 SMS application. Carbon content across various SMS treatment levels decreased with rising levels of the SMS with control experiment recording highest carbon content of 18.38mg/100g, but across 2, 4, 6, and 8kg/m^2 SMS treatment Carbon value obtained was 17.64, 16.74, 16.44 and 15.82mg/100g respectively. (Table 2.).

Table III Effect of SMS on proximate composition of sweet potato

SMS tons/ha	Moisture Content	Dry Matter	Ash Content	Crude Protein	Crude Fibre	Fat	Carbohydrate
0	10.38	89.36	1.6	1.46	0.78	0.78	85.29
2	9.84	90.28	28.4	1.77	0.72	1.05	85.17
4	10.37	89.84	1.6	2.11	0.52	1.30	84.08
6	10.26	89.82	1.8	2.29	0.87	1.36	83.78
8	9.69	90.29	1.8	2.49	0.88	1.59	83.62
LSD	0.30	0.22	37.76	0.22	0.19	0.39	0.95
SE	0.13	0.12	20.76	0.12	0.10	0.21	0.52
CV%	1.6	0.1	294.9	6.2	14.0	17.9	0.6
Vr	10.55	29.31	0.99	31.48	5.77	6.19	6.70
Fr	<0.01	<.001	0.45	<.001	0.01	0.09	0.07

- Percentage moisture content: Result obtained from the study shows that % moisture content of sweet potato flour did not differ across treatments. Percentage moisture content of the potato flour at control experiment (0tons ha$^-$) was 10.44% whereas, mean percentage moisture content at lowest (2kg) and highest (80tons ha$^-$) spent mushroom substrate treatment, were 9.84 and 9.76% respectively. Similarly, dry matter content of the sweet potato tuber was 89.56% at 0kg treatment, 90.16% at 2kg treatment and 90.24% at highest (8kg) SMS application level. Ash level of the tuber was 1.68% at control, but at lowest (2kg) SMS treatment the percentage ash dropped to 1.55%; however increasing application of organic matter (SMS) produced a linear increase in percentage ash level. At the highest SMS treatment level, as a percentage ash content of 1.85% was eventually recorded.

Crude protein level at the control experiment (0kg) was 1.53% but at 2kg SMS treatment, the percentage protein level rose to 1.67% showing an increase of 0.14%. At 8kg SMS application the percentage protein level was 2.40%. However, the percentage increase in protein level between 20tons ha$^-$ and 80tons ha$^-$ SMS treatment was 0.77%.

- Crude Fibre: Percentage crude fibre across the treatments did not vary widely as shown in table 3 below. Percentage crude fibre across the treatments varied with application of increasing levels of SMS. At the control experiment (0tons ha$^-$) treatment 0.86% percentage crude fibre was recorded, at 2kg SMS level the percentage CF level declined to 0.79% whereas as the levels of the spent mushroom substrate increased to 8kg/m^2(highest) SMS level percentage CF of 0.88% was recorded.

- Fat Content: At the control experiment (0tons/ha$^-$) treatment 0.89 percentage fat was observed but with application of 20tons ha$^-$SMS the fat level of the sweet potato tuber rose to 1.05%. This linear increase was observed across the various levels of the SMS treatment, with 8kg treatment level recording a higher fat content of 1.45%.

- Carbohydrate Content: Carbohydrate (CHO) value of sweet potato at 0kg SMS application level was

84.61%. Highest and lowest CHO content of 85.11 and 83.64 were recorded at lowest (2kg) and highest (8kg) SMS treatments respectively, showing a reduction in percentage CHO concentration with application of increasing levels of the organic matter (SMS).

IV. DISCUSSION

- Vine length and tuber yield: Sweet potato is an important staple food crop that is widely cultivated in the humid tropics. In Nigeria it is cultivated during around March and April and harvested between July and September. Planting of the crop in the heart of the dry seasons of November through February is not common except along the flood plain of River Niger and Sombrero rivers where vines are planted following receding flood.

High temperature and high intensity of sunshine is a major setback to vine survival, shoot growth and yield during dry season cultivation. The linear increase in vine survival rate observed in this study and the subsequent shoot length increase indicates the potency of the spent mushroom substrate (SMS) to support cultivation of the crop in the dry seasons. Spent mushroom substrate has the ability to absorb and retain moisture that is released to the crop gradually, hence the significant increase in vine survival rate and shoot length. Moisture is vital to plant growth and any organic manure that can absorb and retain water can enhance vine survival and growth during the dry seasons. Therefore the observed increase in sweet potato vine survival rate in this study can be associated with the potential of the mushroom substrate to retain and gradually release moisture and nutrient to the crop. To collaborate this finding Omovbude *et al* (2019) reported an increase in maize plant height following use of spent mushroom substrate in combination with poultry dropping as soil amendment material. Enhancement in maize height was associated with synergy in nutrient supply between the organic materials. Ability of SMS to enhance sweet potato shoot length in this study could rightly be associated with the ability of the organic manure to provide slow-release of basic plant nutrients coupled with relatively high phosphorus value of the substrate (Omovbude *et al.,* 2019).

- Tuber yield: Spent mushroom substrate used in this study has high value of NPK and calcium such that the recorded linear increase in tuber yield could be associated with high k and Ca value of the organic manure. This is supported by Muoneke and Ukpe (2010) who reported increased tuber yield with SMS application of 100kg/h^{-1} at 8 WAP. In sweet potato, application of potassium (k) has been identified as a key factor, in the enhancement of tuberization (Hahn 1977) whereas phosphorus and nitrogen help to support vegetative and photosynthetic ability through increasing leaf area and shoot growth.

- Mineral composition: Mineral content of food products is indicative of nutritive value and relevance of the food product to support vital metabolic processes in human body: The rising level of nitrogen with increasing application of spent mushroom substrate depicts the potency of the organic manure to enhance nitrogen constituent of sweet potato in the study. Mean nitrogen value of 0.24 recorded at the control experiment, 0.27mg/100g observed at 2kg SMS treatment and sustained rise to 0.39 mg\100g at the highest SMS treatment depicts the potency of organic material to enhance nitrogen intake in sweet potato tuber.

Phosphorus content of 123.22mg/100g and mean value of 159.27mg/100g recorded at the control (0g) and highest SMS (8kg/m^2) treatment respectively is indicative of the ability of mushroom substrate to promote absorption and retention of phosphorus in sweet potato tuber. Potassium value for sweet potato tuber increased from 69.09 mg in the control to 73.63mg at lowest SMS (2kg/m^2) treatment level and at the highest SMS (8kg/m^2) the K level rose to 85.61. Earlier Ukom *et al* (2009) reported that application of increasing levels of nitrogen fertilizer significantly increased mineral contents of sweet potato tuber with exception of phosphorus. Concentration of phosphorus obtained in this study is quite higher than values of between 20.00–27.50 mg/100g obtained across various varieties of sweet potato sampled by Ukom *et al* (2009).

Again the observed increase in magnesium and calcium value of the sweet potato tuber across the treatments agrees with Ukom *et al* (2009). Generally, the observed increase in the value of, Nitrogen, Phosphorus, Potassium, Calcium and Magnesium following SMS treatment can be a useful indices to measure ability of the organic material to promote absorption and deposition of essential minerals in sweet potato tuber and can serve as research guide in the production and consumption of SMS treated sweet potato tuber with a view of enhancing nutritional needs of consumers.

- Moisture Content: Variability in moisture content of 10.44, 9.84 and 9.76 (dry matter basis) obtained at the control experiment (0tons ha^{-1}), lowest (2kg\m^2) and highest (8kg\m^2) SMS treatment respectively in this study is within the range of 8.9-10.25% documented for cassava flour (Isirima *et al.,* 2019) but less than 10.78–12.22% recommended for effective storage of cassava tuber (Maziya *et al.,* 2005). Moisture is one of the greatest challenges in the effective storage of root and tuber crops and their products. Any root or tuber crop whose moisture level is between 12-9% is able to possess a stable property that will enhance shelf-life during storage.

- Dry Matter (DM): Dry matter content of sweet potato at 0tons ha^{-1} and 80tons ha^{-1} SMS treatment were 89.56 and 90.24% respectively. Though variability in percentage dry matter content did not differ significantly across treatments, recorded values were quite related to mean values (30-39%) obtained by Ukom *et al* (2009). Higher dry matter generally is an indication of higher biomass quality. However, variability in dry matter among crop species most times is related to genotypic variability and environmental factors. Higher percentage ash values across SMS treatment suggest the ability of the organic manure to encourage ash deposition in the tuber. Ash value of 1.68% at control treatment and 1.85% obtained at the highest (80tons ha^{-2}) SMS treatment are low but are within values reported by Ukom *et al* (2009). The result of this study indicates that SMS treatment increase ash value of sampled sweet potato product linearly.

Linear increase in percentage crude protein observed in this study describes the potency of SMS in enhancing protein content of sweet potato tuber. Mean protein content of 1.53% recorded at 0 tons ha^{-} and 2.44% obtained at 8kg\m^2 SMS treatment is comparable to 4.7-6.3g/100g (dry weight basis) earlier reported by Marczak *et al* (2014). USDA National Nutrient Database for Standard Reference (2007) recommended daily energy and protein requirement for men and women as 2700kcal and 2000kcal with a protein value of 8.3%. This can be obtained with the consumption of SMS treated sweet potato tubers considering the rising value in protein accumulation potential of the food product.

- Crude Fiber: Increase in percentage crude fiber with the application of SMS reported in this study agrees with the findings of Igbokwe *et al* (2005) who reported that use of non-synthetic input enhanced crude fiber content of sweet potato than utilization of synthetic fertilizer. In a separate study Ukom *et al* (2009) reported a decline in fiber content with application of increasing level of nitrogen fertilizer.

- Fat: Though fat levels of 0.89% for control experiment and 1.45% documented at the highest SMS treatment in this study are low, they are comparable to 1.10 – 2.0% reported in Ukom *et al* (2009). The chemistry, synthetic pathways and biological roles of edible fats and oils are complex. Fats occur in our body as tricylglycerol (triglycerides) which are major storage forms of energy that need to be broken down by lipase to forms that the body can absorb and utilize in the blood stream.

- Carbohydrates*:* Carbohydrates is a major component of sweet potato tuber. High content of carbohydrate across sweet potato samples makes it a vital source of dietary energy but there was no observed significant difference in percentage carbohydrate content across SMS treated plots, an indication that SMS did not influence accumulation of this vital energy resource in sweet potato tuber.

CONCLUSION

The study has shown clearly the capacity of spent mushroom substrate to enhance growth, yield and nutrient value of sweet potato. To this end sweet potato farmers are advice to adopt the use of spent mushroom substrate in sweet potato cultivation as it will enhance both tuber development and nutrient value of harvested tubers.

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