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ASSESSMENT ON GROWTH AND YIELD PERFORMANCE OF MUSHROOM (*Pleurotus ostreatus)* FROM DIFFERENT BIO-WASTE IN UMUDIKE, ABIA STATE, NIGERIA

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ABSTRACT

This study was carried out to determine the growth and yield performance of Pleurotus ostreatus on different substrates of bio-waste carried out in Wood Science and Forest Based Industries Laboratory Unit, Michael Okpara University of Agriculture Umudike, Abia State. Five different substrates treatments from (Gmelina Arborea sawdust, Garcinia kola sawdust, corncob, rice straw and composite mixture) were used to grow the oyster mushroom with different substrates in Completely Randomized Design (CRD) with three replicates. The results on the growth performance of mushroom reveals cap diameter were higher than corncob, bitter kola and lower in gmelina 50.63 cm, 48.93 cm and 8.2 cm) respectively. Stipe length were higher in hard sawdust (20 cm), followed by that of rice straw (16.67 cm) and lower in soft sawdust (1.7 cm). Fruits numbers were higher in corncob (15.57), medium in rice straw (15.90) and lower in soft sawdust (1.00). Result in variation of yield weight on oyster mushroom reveals that fresh weight shows no-significant difference at p≤0.05, while yield weight variations in dry weight reveals corncob were significant at value (0.0532). Result on fruiting duration variation reveals that corncob, rice straw, soft sawdust was significant (P≤0.05) while the composite mixture was not significant at p≤0.05. Variation in harvesting duration reveals that soft sawdust, rice straw, corncobs were significantly higher than composite and hard sawdust. Result on biological efficiency reveals highes in rice straw(13.5%),corncorb(12.8%) and lowest softsawdust(0.01%). Considering all the parameters investigated; corncob and rice straw are recommended as the best substrates for the cultivation of oyster mushroom for better growth and yield performance than other bio-waste substrate medium.

Keywords: Sawdust, Bio-waste, Growth, Mushroom, Substrate, Yield Performance

INTRODUCTION

Mushrooms are very special in the scientific classification. They are neither plants nor animals, but are still organisms because they perform all the life processes of other organisms. They belong to their special group called the fungi which are microscopic. Notwithstanding, there are other members in the group that are macroscopic and mushrooms can be described as one of the macroscopic groups. According to Getachew *et al.,* (2011) mushroom is a fungus that has a stem, a cap and gills or pores on the underside of the cap. The word mushroom actually refers to the fungi that is seen with the naked eyes and that is picked by other organisms and sometimes used as food (Chang and Mills, 1992).Growing of mushroom is a prime factor for the conversion of the low value inedible wastes into a higher value commodity which can serve as medicine and food materials for humans and as a source of commercially important metabolites (Tsegaye, 2015).

Mushroom grows wild in the forest and is cultivated in the temperate and sub-tropical regions of the world. Fungi lack the most important feature of plants which makes it difficult to use energy from the sun directly through chlorophyll. They lack chlorophyll and cannot synthesize their own food. Thus, fungi depend on other organisms for food, absorbing nutrients from the organic material in which they live. Mushrooms go through two stages, the vegetative stage and the reproductive phase. The vegetative stage ceases when the hyphae fully colonize its substrate. The reproductive phase starts when the hyphae develop primordial. Mushroom is a fruit that results from fully matured primordial of the fungi (Dike *et al*., 2011).

According to Garg and Gupta (2009) plant derived from agro-industrial waste causes environmental and health problems. But the generated waste can be managed through mushroom cultivation, since mushrooms have the ability to grow on a variety of raw lignocellulosic substrates and under a wide range of temperatures (Sánchez, 2010). Oyster mushrooms are able to perform such duties, because they contain a number of non-specific lignocellulosic enzymes which have a major impact in the development and growth of the mushroom (Zhang *et al*., 2002; Kuforiji and Fasidi, 2008). The nature and nutrient constituent of the mushroom substrate also have an effect on the mycelium growth, mushroom quality and crop yield (Baldrian and Val'aˇskov'a, 2008; Kües and Liu, 2000). Mushrooms are known to decompose any complex organic material on which it grows to generate simpler compounds for its nutrition. These organic materials are usually by-products from agricultural sector, household sector and the industrial sector widely considered as wastes (Girmay *et al.,* 2011). A good substrate should consist of nitrogen supplement and carbohydrates in order to promote rapid growth of the mushroom (Ogundele *et al.,* 2014).

Muhammad *et al*.,(2005) reported that oyster mushrooms can easily and successfully be cultivated on wheat, paddy, barley, oat and gram straw, banana, sugarcane and maize leaves, empty corn cobs and millet heads, cotton waste, sticks and boll locules, sugarcane bagasse, banana pseudo-stems, saw dust, logs, straw papers, manure among others. Mushrooms are known to decompose any complex organic material on which it grows to generate simpler compounds for its nutrition. These organic materials are usually by-products from agricultural sector, household sector and the industrial sector widely considered as biodegradable wastes (Girmay *et al.,* 2016). Mushroom technology refers these organic materials as substrates. A mushroom substrate is simply any substance on which mycelium will grow such as straw, logs, enriched saw dusts and so on (Philippoussis,2009).

The process of mushroom cultivation has lots of advantages such that, it utilizes little land for production, which renders them economically beneficial viable and attractive activity for both rural farmers and semi-urban dwellers (Oyedele *et al.,* 2018). The study evaluate the growth performance and yield of different substrates from bio-waste on mushroom (*Pleurotus ostreatus)* production.

MATERIALS AND METHODS

Study Area

This work was carried out at the Wood Science and Forest Based Industry Laboratory Unit of the Department of Forestry and Environmental Management beside First Bank Plc of Michael Okpara University of

Agriculture, Umudike, Abia State. The study site lies on latitude 05°29'N and 05°47'N and longitude 07°33'E and 07°54'E with an attitude of 122m above the sea level. (ADP, 2010). The area covers about 100,000$m^2$and lies at about 8 to 10 kilometers East of Umuahia. It has a humid tropical climate with marked wet and dry seasons. The rainy season spans for eight months (from March to October) and the dry season starts from November to February. The average annual rainfall ranges from 1568.4mm to 2601.3mmwith a relative humidity of 65-85% and temperature ranges 30 ^{o} C to 23^{o} C (Agro-climatic data, 2007).

Collected of Materials

Substrates required for the experiment were collected from different sources. The mushroom spawn were sourced from Lauretta Ventures Farm Limited (LTV farms), Lagos State. The sawdust (Bitter kola and Gmelina was obtained from Umuahia Timber Market (Sawmill Unit). Similarly, rice straw and rice bran supplement were collected from Uzuakoli Rice Mill Bende Local Government Area, Abia State while corncobs were from the local farmers and corn users.

Preparation of Substrates

Corncobs were dried in an oven at a temperature of 100^{o}C while the rice straw was dried under the sun. The rice straws were beaten and chopped into pieces of about 1–1.5 cm by width and 2 – 5 cm by length according to the suggestions made by Kimenju *et al.,* (2009) and it was achieved using a machete. Fifty kilogram (50 kg) of each substrate was weighed using a weighing balance but out of it 5kg were taken from each of the substrate bags and mixed thoroughly with rice bran. Calcium carbonate ($CaCO_3$) was weighed with an electronic scale and a total of 5% (on dry weight basis) was added to each of the substrates in order to bind the mixture together. Two kilogram of rice bran was added as a supplement to the four different substrates and the amount of water used in mixing different substrates was checked with a squeezing test. Three substrate formulas including corncorb, rice straw and biter kola (sawdust) alone and in combination (composite) ratio of 50:30:20 and gmelina (sawdust) control ratio of 100 were investigated.

The substrates after thorough mixing were separated into five portions demarcated with logs of wood and covered with poly-ethylene sheets. To ensure uniform fermentation, the mixtures were turned every three (3) days. Experimental design was lied down in CRD with 5 different treatments (corncorb, rice straw, hardsawdust, composite) and softsawdust as a control in three different replicates. Then the collected data was analyzed using R statistical software at ($P \leq 0.05$).

Cultivation of Mushroom (*Pleurotus ostreatus*)

A disinfectant (Dettol) was used to clean the hands, spawn bottle and the neck of the polythene bag. The Spawns made from grains of sorghum were introduced into each polythene bag and pieces of polyvinyl chloride (PVC) pipes of 2.0 cm thick and 2.5 cm long was inserted at the neck of each polythene bag to serve as a bottle neck. The extra polypropylene was pulled through the PVC pipe and held in place with a rubber band. A piece of cotton wool was plugged at the neck of the bags. At the end of the inoculation, the substrates bags were kept in a dark room or incubation room for ramification to take place in the absence of light at temperature 25-30 ^{o} C with relative humidity of 90% on the polythene bags which was accomplished by spraying with water twice a day. The incubation period

was 49 days. Ramification is the thickening of the mycelia in the bags (colonization of the bags) which is an indication for the bags to be opened for fruiting. After complete ramification also known as full mycelia formation, ramified bags were introduced into the fruiting or incubation room. The bags were exposed to a new environmental condition temperature 17-20 ^{o} C, relative humidity 80-90% and regular spray of water (twice daily), the mycelia experiences a shock as a result of insufficient oxygen on the bags which in turn results to delay in the fruiting.

Harvesting of Mushroom

Oyster mushrooms matured within 2-3 days after primordial initiation. The matured fruiting body was identified by curial margin of the cap, as described by Asmama *et al*,(2015).the procedure for mushroom harvesting involves grasping each mushroom stalk individually and twisting the mushroom until it pullout of the substrate. As it begins fruiting, it is important to keep humidity high and temperature and constants spay of water. it may be harvested in numbers of flushes.

Data Collection

Weight of harvested mushroom (Fresh and Dry)

The fruit bodies were weighed immediately after harvesting using weighing balance for fresh weight and electronic balance for the dry weight. After recording the fresh weight, they were then dried in an oven at 80 ^{o}C for 8 hours in order to obtain the dry weight. Their mean weights were also recorded.

Weight of substrate (Before and after)

Substrates were weighed before sterilization and after fruiting and harvesting of the mushroom were done with. It was carried out using a weighing balance.

Length Measurement of stalk/stipe

The length of the stalk was measured using the ruler. Five fruits were randomly selected using simple random technique and the lengths of the stalks were measured from the tip of the stalk to the base of the caps.

Measurement of Perimeter of the cap

Five fruiting bodies were selected randomly and were measured in centimeters using meter rule from one edge of the pileus, across the stipe, to another. The average was calculated

Calculation of Mushroom Yield

This is the quantity (weight) of mushroom produced per bag of substrate per harvest time. It was weighed with weighing balance. The crop of oyster mushroom was harvested in three flushes. The yield per kilogram of substrate was calculated by dividing the total yield in kilograms taken from each treatment by the number of cropping bags fully colonized within each treatment.

Biological Efficiency

Total weight of the fruiting bodies harvested from the substrates within 60 days of fruiting was measured as total yield of the mushroom. The biological efficiency (yield of mushroom per kg substrate on dry weight basis) was calculated by the formula proposed by Chang *et al*., (1981).

Biological efficiency (B.E %) = fresh weight of mushroom/Dry weight of substrates x 100

Calculation of fruit bodies

This was done by directly counting the number of fruit bodies on each bag/ substrate.

RESULTS

Variation in the growth characteristics of oyster mushroom produced from different substrates reveals from Table 1.That cap

diameter (cm) mean of corncob has highest (58.8±10.05) and hard sawdust (57.1±10.05) rice straw (50.7±10.05), while the least was soft sawdust (8.2±8.70), result also revealed corncorb, hard sawdust, rice straw and composte significant while soft sawdust are not significant at (P≤0.05). Revealing poor environmental condition not suitable for mushroom production in control environment. Stipe length (cm) mean result reveals highest in hardsawdust(20.00±3.75) which significant at (P≤0.05) and lowest in composite(7.42±3.75) and softsawdust(1.70 3.23) which are not significant at (P≤0.05).the fruiting body is the dibble part of mushroom, the results reveals mean fruiting body is highest at corncorb(15.57±3.48) and ricestraw(14.90± 48) but lowest in softsawdust(1.00±3.01). Result reveals also that corncorb, rice straw and composite are significant while softsawdust and hardsawdust are not significant at (P≤0.05).

Table: 1 Variation in the growth characteristics of *Pleurotus ostreatus* in response to different substrate treatments

Variable	Treatments	Mean	Sdv	t value	Pr(>|t|)
Cap diameter	Softsawdust(control)	8.20 ±	8.704	0.942	0.3737
	Composite	35.90±	10.051	3.572	**0.0072**
	Corn cob	50.63±	10.051	5.038	**0.001**
	Hardsawdust	48.93±	10.051	4.869	**0.0012**
	Rice straw	42.47±	10.051	4.225	**0.0028**
Stipe length	Softsawdust(cotrol)	1.70 ±	3.248	0.523	0.6148
	Composite	7.423±	3.75	1.979	0.0831
	Corn cob	14.90±	3.75	3.973	**0.0041**
	Hardsawdust	20.00±	3.75	5.333	**0.0007**
	Rice straw	16.67±	3.75	4.444	**0.0021**
Fruit number	Softsawdust(control)	1.00 ±	3.014	0.332	0.7485
	Composite	12.67±	3.48	3.64	**0.0065**
	Corn cob	15.57±	3.48	4.473	**0.0020**
	Hardwood	6.43 ±	3.48	1.849	0.1016
	Rice straw	14.90±	3.48	4.282	**0.0026**

P values in **bold** indicates statistical significance.

Yield weight variation in Table 2 reveals that fresh weight mean shows highest in rice straw (0.09±0.07 and composite(0.08±0.07) but lowest in softsawdust (0.001±0.06). dry weight result revels highest in corncob(16. ±7.17) and lowest in softsawdust (2.79±6.21). result also revealed only corncorb is significant while other substrates treatment are not significant at (P≤0.05).

Table 2.Variation in the yield weight of *Pleurotus ostreatus* in response to different substrate treatments

Variable	Treatments	Mean	Sdv	t value	Pr(>|t|)
Fresh weight	Softsawdust(cntr)	0.0001 ±	0.05807	0.002	0.999
	Composite	0.08157±	0.06705	1.216	0.258
	Corn cob	0.0499 ±	0.06705	0.744	0.478
	Hardsawdust	0.0369 ±	0.06705	0.55	0.597
	Rice straw	0.0866 ±	0.06705	1.291	0.233
Dry weight	Softwood(cntr)	2.79 ±	6.207	0.449	0.665
	Composite	12.42 ±	7.167	1.733	0.1214
	Corn cob	16.24 ±	7.167	2.266	**0.0532**
	Hardsawdust	11.517 ±	7.167	1.607	0.1468
.	Rice straw	11.443 ±	7.167	1.597	0.1490

P values in **bold** indicate statistical significance

Fruiting duration variation in Table 3.reveals mean highest SS(42±2.92) and lowest in CC(-27±3.37), result also reveals SS is highly significant while composite are not significant at (P≤0.05).

Harvesting duration in Table 4. Result reveals highest in SS (49 ±5.96 and lowest in CC (-30 ±6.88) which shows that all the substrate are significant but SS is highly significant at(P≤0.05).

Biological efficient result in Table 5 reveals that the BE (%) was seen highest performance in rice straw(13%) and corncorb (12.8%) but lowest or poorly yield in soft sawdust (0.01%).

Table 3:Variation in the fruiting duration of *Pleurotus ostreatus*in response to different substrate treatments

Treatments	Mean	Sdv	t value	Pr(>|t|)	Remark
Soft sawdust (cntr)	42 ±	2.915	14.406	**< 0.0001**	***
Composite	-11.5 ±	3.367	-3.416	0.0861	.
Corn cob	-27 ±	3.367	-8.02	**< 0.0001**	***
Hard sawdust	-15 ±	3.367	-4.456	**0.0021**	**
Rice straw	-20.5 ±	3.367	-6.089	**0.0003**	***

P values in **bold** indicate statistical significance.

Table 4.Variation in the harvesting duration of *Pleurotus ostreatus* in response to different substrate treatments

Treatments	Mean		t value	Pr(>|t|)	Remark
Softsawdust(cntr)	49 ±	5.958	8.224	0.00003	***
Composite	-16 ±	6.88	-2.326	0.04849	*
Corn cob	-30 ±	6.88	-4.361	0.00241	**
Hardsawdust	-18 ±	6.88	-2.616	0.03083	*
Rice straw	-25 ±	6.88	-3.634	0.00665	**

P values in **bold** indicate statistical significance.

Table 5 Biological efficiency of oyster mushroom (*Pleurotus ostreatus*) on different substrates

Substrates/treatment	Total Yield of three flushes (Kg)	Biological efficiency (%)
Softsawdust(Cntr)	0.0001	0.01
Corncob	0.384	12.8
Hardsawdust	0.347	8.9
Rice straw	0.650	13.5
Composite	0.460	10.2

DISCUSSION

Higher yield were seen in corncob having effective fruiting bodies which might be due to the presence of glucose, fructose and trehalose in the substrate (Vetayasupron, 2007).Cap diameter result reveals corncob has highest(58.8cm),least was softwood(8.2cm) which reveals poor environmental condition not suitable for mushroom production. Results showed that the mushroom took the longest time for uniform mycelial colonization on Soft sawdust. This confirms the findings of Akinmusire *et al.,* (2011) who obtained the longest spawn run of *Pleurotus pulmonarius* on *sawdust* substrate. The slow growth of the mushroom on softsawdust could probably be due to the inability of the mushroom mycelia to produce appropriate enzymes that could hydrolyze and convert the waste for its vegetative growth (Stamets, 2005). .Mycelium extension rate has been reported to be related to bioavailability of nitrogen in the cultivation substrate (Philippoussis *et al.*, 2007). Softsawdust fruiting body and harvesting duration was very low which agrees with result of Shah *et al*.,(1981), the low nitrogen content (0.3%) of sawdust may have contributed to the slow growth of the mushroom mycelia on the waste. In addition, chemical analyses of sawdust showed that they contain about 8.50% hemicellulose, several reports have demonstrated that substrate decomposition by fungi is initially associated to its hemicellulose content (Philippoussis and Diamantopoulou, 2011). Mondal *et al.,* (2010) found similar result according that

lower mycelium running rate aggravates for lower yield in sawdust which might be due to presence of various kinds of polyphenolic substances, chemical extracts, low content of cellulose and low moisture holding capacity etc.

Stipe length result reveal highest at HS (21.7 cm) and the lowest was SS (1.7 cm). Similar result was reported by Chang and Quimio (1982) and (Gohl, 1993) which states the type of agricultural wastes, single or mixtures of two different agricultural wastes used in preparing the substrates may be responsible for change in the stipe length, pileus/cap width and overall yield of the mushrooms grown in the different substrates (Chukwurah ,2013) .From the overall result biological efficiency reveals that rice straw(13.5%) yielded better than other substrates and lowest in softsawdust which agrees with findings of Obodai *et al.*, (2003) who evaluated eight lignocellulosic by-products as substrates for cultivation of the Oyster mushroom such as rice straw, banana leaves, maize stover, corn husk, rice husk, fresh sawdust and rice straw gave the best yield which was also obtained from this finding. Fresh weight of mushroom result reveals rice straw (0.09kg) as the highest on mushroom weight and the least was softwood (2.8g). The dry weight of the mushroom samples raised on corn cob substrate was higher than those harvested from other substrates. There was no significant difference in the fresh weight ($F_{4,8} = 0.25$, $R^2 = -0.12$, $P = 0.632$) and dry weight ($F_{4,8} = 1.3$, $R^2 = 0.09$, $P = 0.348$) of the *Pleurotus ostreatus* mushrooms raised on the different substrates.fruiting bodies result from different substrates reveals highest in corncobs (16.6) and least in softsawdust (1.0) with the longest fruiting duration in softsawdust (45 days), these results agrees with (Oei ;2003 ;Chinda and Chinda, 2007) who observed that oyster mushroom normally complete spawn running between 14 to 28 days depending on the substrates applies and the environmental condition.

Harvesting duration result reveals softsawdust (49days), and the least harvesting period was observed in corncob (19 days), the harvesting duration (df = 4, $\chi = 27.8$, $P < 0.0001$) of *P. ostreatus* was significantly least on corn cob substrate, followed by rice straw but highly significant on softsawdust substrate.

CONCLUSION AND RECOMMENDATION

The study investigated five different types of substrates which were compared to determine the growth and yield of *P.ostreatus* for commercial mushroom production. It was observed from the results that corncob and rice straw substrate grows better yield of *Pleurotus ostreatus* than sawdust, though not all sawdust because hardsawdust(*Garcinia cola*) performed far better than that of softsawdust(*Gmelina arborea*). Corncob and rice straw showed their best performance compared to the other substrates, in terms of growth and yield of the mushroom which can therefore substitute for sawdust since it is cheaply available all year round. *Gmelina arborea* is the least performing substrate in terms of oyster mushroom growth yield and performances in this study, maybe it was due to some chemical exudates and absorption capacity on the substrate which may affect growth formation of mycelium. Therefore, mushroom cultivation may become one of the most profitable agribusiness that could produce food products from different substrates and help to dispose them in an environmental friendly manner and enhances sustainability.

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