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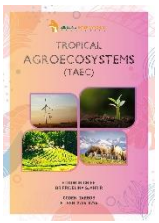

RESEARCH ARTICLE

ASSESSMENT OF GROWTH AND YIELD PARAMETERS OF MUSHROOM SPECIES (*Pleurotus Eryngii* and *Pleurotus Ostreatus*) AS INFLUENCED BY DIFFERENT SUBSTRATES

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ABSTRACT

This experiment was carried out to determine the influence of three substrates on the growth and yield of *Pleurotus eryngii* and *Pleurotus ostreatus* in 2022 at the laboratory of Faculty of Agriculture, COOU, Igbariam, Anambra State. This study was designed out as a 3×2 factorial experiment in a completely randomized design. The substrates (rice bran, corn chaff, groundnut cake) were the main factor while the mushroom species (*P. eryngii* and *P. ostreatus*) were the sub-factor. Data were collected on spawn run period, pinhead initiation, total number of fruiting bodies, maximum and minimum weight of fruiting bodies, length and width of stalk, diameter of mushroom cap, yield of first three flushes, total yield and biological efficiency. The data collected above were subjected to analysis of variance. Significant means were separated using Fisher's Least Significant Difference. The results obtained indicated that rice bran substrate gave the highest yield (10.70g), and biological efficiency (6.20%). This was followed by corn chaff while, groundnut cake had the lowest growth and yield values. The results also showed that *P. ostreatus* specie produced highest or maximum weight of fruiting bodies (4.88g), better cap diameter (3.10cm), stalk length (3.70cm), stalk width (1.20cm) and yield (40.67g) followed by *P. eryngii.*

KEYWORDS

Oyster Mushroom, *P. eryngii* and *P. ostreatus* cultivation, Substrates.

1. INTRODUCTION

Globally, food production is being threatened by many factors; such climate change due to pollution via burning of crop residues like rice straw, wheat straw and sawdust which are substrates used in mushroom production, mostly in Sub-Saharan Africa. Based on this information, there is need to intensify agricultural production to feed the growing population adequately; thereby ensuring food security and safety in a sustainable manner (Nyaera et al., 2019). Hence, Sub-Saharan African nations has to combat the food security situation with economic, technologically and scientific based approach (Nyaera et al., 2019). One of the ways to do this, is through mushroom production to enhance nutrition and food safety.

Mushroom (toadstool) is a spore-bearing, fleshy, fruiting body of a fungus. Typically, it grows above the ground, soil, or on substrate which is its food source (Wikipedia). Mushrooms are seen as a largescale parasite whose fruiting body can either be hypogenous or epigeous. The fruiting body can be seen and picked by hand (Miles, 1992). The upper part of the mushroom (fruiting body) can be seen above the ground while the remaining part (mycelium) stays underground (Bilal, 2010). And one of the most important mushroom types that can easily be grown is the oyster mushroom (Tavarwisa et al., 2021).

Oyster mushrooms (Pleurotus species: *P. eryngii, P. pulmonarius, P. djamore, P. sajor-caju, P. populinus, P. sapidus, P. cystidiosus, P. ostreatus, P. flabellatus, P. australis, P. florida, P. cirtinopileatus* and others) under agricultural wastes, have the ability to grow within a short period of time. They also require less water and space for its production (Tavarwisa et al., 2021). Oyster mushrooms are cultivated worldwide on commercial quantity due to its good taste, nutritional and inherent medicinal composistion (Tesfaw et al., 2015). Mushroom cultivation is very profitable and are grown in commercial quantities in countries like Great Britain, the USA, Europe, Asia, China, Japan, Ghana and South Africa, with China producing about 3,918,300 tons/annual making them the highest producer (Kortei et al., 2018).

It has been reported that over 85% of all oyster mushrooms production worldwide is produced in China. About, 95 percent of the total China's mushroom production is for domestic consumption (Zhang et al., 2014). Despite the benefits associated with mushroom production and consumption, Africa to a large extent, is ranked low in mushroom production and commerce (Patel and Goyal, 2012; Zhang et al., 2014). The world's production of cultivated edible mushrooms, in the last two decades, was estimated at about 7 million tonnes (Ijeoma et al., 2015). While the total market value of edible and medicinal mushrooms at that time was valued at more than US$30 billion (Ilechukwu and Okoye, 2014). Mushroom cultivation is usually affected by factors such as temperature, sterility of the substrates, and humidity; which act individually or in combination of the factors (Belletini et al., 2019).

According to mushrooms are very rich in, vitamins and minerals as well as digestible essential amino acid (Marshall et al., 2009). They also reported that it contains low water-soluble carbohydrate and less volume of high-

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quality unsaturated fats. Thus, its cultivation can lead to the production of health food, reduction of environmental pollution and manufacture of nutriceuticals; as well as providing a promising resource for promoting rapid socioeconomic development (Martinez-Ibarra et al., 2019). Mushroom cultivation can also provide opportunities for the recycling of organic matter thereby reducing pollution created by some organic substances. Also, residues and by-products of generated from cultivation of mushroom are used as organic manures to other crops after harvesting the fruiting bodies of the mushroom, which is another method for management of residues agricultural and agro-industrial sectors (Chang et al., 1989). Substrates like rice straw, wheat straw as well as sawdust can be used for cultivation of oyster mushroom hence, this study was carried out to provide an insight to which oyster species performed best on the selected substrates.

Figure 1: King Oyster (*P.eryngi*) (Source: www.danfoss.com)

Figure 2: Pearl Oyster (P. ostreatus) (Source: www.biovoices.eu)

2. Material and Methods

2.1 Mushroom Culture

The Pure culture of *P. ostreatus* and *P. eryngii* were obtained from Dilomat laboratory, Port Harcourt, Rivers State. The cultures obtained were sub-cultured on PDA medium in BOD incubator at a temperature of 25 ± 2ºC for further investigation.

2.2 Mushroom Spawn

Clean and healthy grains of sorghum were washed with clean water and soaked in water overnight. After washing, they were autoclaved and sterilized for one hour. The cooled grains were supplemented with calcium sulphate (2%) and calcium carbonate (2%) on grain dry weight basis to avoid clumping of grains. The sorghum grains were filled (300g/jar) in clean 500ml saline sterilized jar (bottle) and polyethylene bags plugged with non-absorbent cotton plugs. The bottles were usually shaken at four days interval to allow the mycelium spread properly between the grains. In two weeks, the bags were completely colonized by mushroom.

2.3 Substrate Preparation

Firstly, rice bran and sawdust compost were made. After three weeks, they were supplemented separately with rice bran, corn chaff and groundnut cake. 400g of calcium and gypsum was added to each bag. These substrates were then sterilized for three days at 121^{0}C at 12 hours per day. After this sterilization, the bags were brought out and taken to the inoculation lab and allowed to cool.

2.4 Spawning

Spawning is the process of mixing mushroom seeds in the sterilized substrate. The completely colonized fresh spawn were thoroughly mixed with the prepared substrate at a rate of 3-4% (w/w) on weight basis. Two kilograms (2 kg) of spawned substrates were filled in polyethylene bags (40cm × 30cm) and the mouth of each bag was tied with rubber band. About 8-10 small holes (1 mm dia.) were made at 10 cm part from each other for aeration.

2.5 Cropping

The spawn bags were kept in a dark growing chamber with the

temperature ranging from 20-25 ºC while the relative humidity range was 80-85%. For mycelia colonization of the substrate, spawned bags were placed vertically on a raised platform in a cropping chamber. After complete colonization of the mushroom bed, the polythene bags were cut off, removed and blocks of compact substrate were arranged on the shelves. The humidity of the growing chamber was maintained by frequently sprinkling water on the floor and walls. Pin heads started appearing after completion of spawn running, within one week and they became ready for harvest within another week.

2.6 Harvesting

At the right stage, the Oyster mushrooms were harvested. The mushroom fruiting body's size and shape were used to determine the right stage for picking or harvesting. In young mushrooms, the edge of the cap is thick, and the cap margin is enrolled, while the cap of mature mushrooms becomes flat and inward. At times, it is better to harvest all the mushrooms from a bag at once to stimulate the next crop of mushrooms to start early. Fruiting bodies were harvested in about 4-5 days after their appearance. Harvesting (picking) was done by twisting the mushroom gently so that it was pulled out without leaving any stub. This method prevents the surrounding fruit bodies from being disturbed. After the first, second and third harvesting, the mushroom continued fruiting.

2.7 Data Collection

Data were collected on growth behavior (spawn run period, pinhead initiation, number of fruiting bodies, maximum and minimum weight of fruiting bodies, length and width of stalk, diameter of mushroom cap, yield of first, second and third flushes) and yield potential (total yield and biological efficiency). The biological efficiency (BE) was calculated by given formula (Chang et al., 1989):

$$\text{Biological efficiency (BE)} = \frac{\text{Fresh weight of mushroom}}{\text{Dry weight of substrate}} \times 100$$

2.8 Data Analysis

The data collected were subjected to analysis of variance. The significant means were separated using Fisher's Least Significant Difference (FLSD) at 5% probability level.

3. Results

3.1 Spawn Run Period

The effect of substrate and mushroom variety on spawn run period is presented in Table 1. The result obtained showed that the spawn run period was not significant. However, rice bran had the highest spawn run period (38 days) while king oyster recorded the highest spawn run period (41 days). The result also showed that the interaction effect of both substrate and mushroom variety was not significant.

3.2 Pinhead Initiation

The effect of substrate and mushroom variety on pinhead initiation is also presented in Table 1. The result obtained showed that the substrate was not significant while the mushroom variety was significantly different. The rice bran had the highest pinhead formation, while king oyster had the highest pinhead formation time. The effect of substrate/mushroom variety interaction on pinhead initiation was not significant as well.

3.3 Fruiting Bodies

The effect of substrate and mushroom varieties on mushroom number of fruiting bodies were highly significant (Table 2). The substrate and mushroom varieties interaction significantly ($P<0.05$) affected the fruiting bodies number. Rice bran significantly had the highest number of fruiting bodies (15.00) while the lowest was found in the groundnut cake (0.50). Pearl oyster mushroom variety also significantly gave higher amount of fruiting bodies (7.78) than the king oyster (3.11).

3.4 Fruiting Bodies Weight

The effect of substrate and mushroom varieties on mushroom fruiting bodies weight is shown in Table 2. The result obtained indicated that all measured parameters were significantly different among the treatments. Groundnut cake had the least minimum weight (0.05g). Similarly, King oyster had the lowest minimum fruiting bodies (3.11g).

Table 1: Effect of Substrates and Mushroom Varieties on Spawn Run Period and Pinhead Initiation Maximum Mushroom Fruiting Bodies Weight. at Igbariam in 2022 Cropping Season.

Treatments	**Mushroom**	
Substrate (GM)	Spawn run period (days)	Pinhead Initiation (days)
Corn chaff	37.50	15.80
Groundnut cake	30.20	19.30
Rice bran	38.20	34.50
Mean	35.30	19.36
LSD (0.05)	NS	NS
Mushroom varieties (VAR.)		
King oyster (P. eryngi)	41.60	36.30
Pearl oyster (P. ostreatus)	29.00	3.40
Mean	35.30	19.85
LSD (0.05)	NS	17.78
Interaction		
GM x VAR	NS	NS

NS= not significant, GM= Growth media, VAR.= Varieties

3.5 Mushroom Cap Diameter

The effect of substrates and mushroom varieties on mushroom cap diameter showed that only the substrates had significant effect on mushroom cap diameter while the mushroom variety, and the interaction between the substrates and mushroom varieties were not significant on the diameter of mushroom cap (Table 3). The mushrooms produced with rice bran had the largest cap diameter followed by mushrooms grown with corn chaff. *P. ostreatus* had a relatively larger cap diameter although it was not significantly different from *P. eryngi*.

3.6 Mushroom Stalk Length and Width

The effect of substrates and mushroom varieties on the length and width of mushroom stalk is shown in Table 3. The result obtained showed that stalk length and width were significantly affected by the substrates used. Rice bran had the highest and best growth and size of mushrooms in terms of mushroom stalk length and width. *P. ostreatus* had the highest stalk length and width although it was not significant. The interaction effect for mushroom length and width was also significant.

3.7 Yield of Mushroom and Biological Efficiency

The effect of substrate, mushroom varieties and interaction between the substrates and mushroom varieties were significantly different on the three flushes of mushroom yields (Table 4). The highest mushroom yields were recorded in the first flush. Rice bran consistently had the highest yields in the three flushes while groundnut cake had the lowest. *P.ostreatus* (Pearl mushroom) also consistently had the highest yield in all three flushes.

Generally, *P.ostreatus* (Pearl mushroom) produced with rice bran significantly gave the best yield followed by *P. eryngi* (King oyster) produced with the same rice bran (Table 5). On the other hand, the two

mushroom species produced with groundnut had the poorest yield. The result obtained also indicated that rice bran substrates gave the highest biological efficiency (Table 5). The highest yield was obtained in rice bran substrates. *P. ostreatus* (Pearl oyster) has the highest biological efficiency and total yield. Ground nut cake had the lowest biological efficiency and yield. *P. eryngii* (King oyster) has the lowest biological efficiency and yield.

Table 2: Effect of Substrates and Mushroom Varieties on Mushroom Number of Fruiting Bodies and Weight of Fruiting Bodies at Igbariam in 2022 Cropping Season.

Treatments	Number of fruiting bodies	Weight of mushroom fruiting bodies (g)	
Substrate (GM)		**Minimum**	**Maximum**
Corn chaff	0.83	1.05	1.21
Groundnut cake	0.50	0.50	0.50
Rice bran	15.00	5.54	8.83
Mean	5.44	2.36	3.51
LSD $_{(0.05)}$	1.87	2.71	1.90
Mushroom varieties (VAR.)			
King oyster (*P. eryngi*)	3.11	1.21	2.22
Pearl oyster (*P. ostreatus*)	7.78	3.51	4.88
Mean	5.44	3.51	4.81
LSD $_{(0.05)}$	1.53	2.21	1.55
Interaction			
GM x VAR	**	*	**

NS = not significant, ** = significant at < 0.001, * = significant at 0.05, GM= Growth media, VAR.= Varieties.

Table 3: Effect of Substrates and Mushroom Varieties on Mushroom Cap Diameter, Stalk and Width Length at Igbariam in 2022 Cropping Season

Treatments	Mushroom growth and size (cm)		
Substrate (GM)	**Cap diameter**	**Stalk length**	**Width length**
Corn chaff	1.60	1.70	1.00
Groundnut cake	0.70	0.50	0.30
Rice bran	6.00	7.80	2.20
Mean	2.76	3.33	1.16
LSD $_{(0.05)}$	1.58	1.47	0.91
Mushroom varieties (VAR.)			
King oyster (*P. eryngi*)	2.50	3.00	1.20
Pearl oyster (*P. ostreatus*)	3.10	3.70	1.20
Mean	2.8	3.35	1.21
LSD $_{(0.05)}$	NS	NS	NS
Interaction			
GM x VAR	NS	*	*

NS = not significant, * = significant at 0.05, GM= Growth media, VAR.= Varieties.

Table 4: Effect of Substrates and Mushroom Varieties on the Yield of Mushroom at Igbariam in 2022 Cropping Season

Treatments	Mushroom yield (g)		
Substrate (GM)	**First flush**	**Second flush**	**Third flush**
Corn chaff	1.21	0.19	0.00
Groundnut cake	0.50	0.00	0.00
Rice bran	10.14	9.12	6.42
Mean	3.95	3.10	2.14
LSD $_{(0.05)}$	1.65	1.54	2.39
Mushroom varieties (VAR.)			
King oyster (*P. eryngi*)	2.22	1.41	0.07
Pearl oyster (*P. ostreatus*)	5.68	4.80	3.58
Mean	3.95	3.10	2.14
LSD $_{(0.05)}$	1.34	1.25	1.95
Interaction			
GM x VAR	**	**	*

NS = not significant, ** = significant at <0.001, * = significant at 0.05, GM= Growth media, VAR. = Varieties.

Table 5: Interaction Effect of Substrates and Mushroom Varieties on the Biological Efficiency and Total Yield of Mushroom at Igbariam in 2022 Cropping Season

		Mushroom	
Substrate	**Mushroom varieties**	**Biological efficiency (%)**	**Total yield**
Corn chaff	King oyster	0.23	1.76
	Pearl oyster	0.13	1.04
Groundnut cake	King oyster	0.07	0.50
	Pearl oyster	0.07	0.50
Rice bran	King oyster	1.28	10.70
	Pearl oyster	6.20	40.67
Mean		1.33	9.19
LSD $_{(0.05)}$		0.67	7.00

4. Discussion

The two *Pleurotus species* (*P. eryngii* and *P. ostreatus*) showed different growth and yield performances on the selected substrates used for this experiment. The results obtained showed that *P. ostreatus* had the highest growth and yield value while rice bran substrates gave the highest growth and yield compared to other substrates. Spawn run was fastest in *P. ostreatus* and *P. eryngii* took maximum time for spawn run. The pinhead formation is regarded as the second stage of mycelium growth during cultivation of mushrooms and time taken for pinheads to be formed after spawn running differed for each of the mushroom varieties. *P. ostreatus* recorded the earliest pinhead formation to *P. eryngii*.

This may be attributed to the variations in extracellular enzyme production and the prevailing mushroom growing condition since each *Pleurotus species* requires different environmental conditions of carbon dioxide (CO_2) concentration, relative humidity and temperature. These results are in agreement with the findings of who reported that *Pleurotus species* on different substrates took 2-4 weeks for fruiting bodies to be formed after inoculation of spawn (Getachew et al., 2019). Biological efficiency and the yield of *P. ostreatus* were higher than *P. eryngii*. The two Pleurotus species did not produce high biological efficiency on corn chaff and groundnut cake substrates unlike the rice bran substrates. This may be due to the variations in the chemical and nutrient composition of the substrates.

The total fresh weight was obtained in three consecutive flushes with the flushes diminishing over time. These observations agree with those of Tsegaye and Tefera who obtained 79% of total fresh weight from the first three flushes and demonstrated that regardless of the mushroom species and substrate (chemical and biological composition of the substrate) used to grow mushrooms, the pattern of gradually lessening mean yield per flush remains the same for cultivated oyster mushrooms (Tsegaye and Tefera, 2017). In this study, the first flush of mushrooms had highest yield followed by the second and third flushes. Mshandete and Cuff reported that first flush gave more yield than the second and third flushes has been attributed to the finding that the quantity of mushrooms harvested in each flush is directly proportional to the nutrients disappearing from the substrate (Mshandete and Cuff, 2008). The assimilable nutrient sources (carbon and nitrogen) in the organic waste substrate were absorbed by mycelia translocated and mobilized to supply the fruit bodies (Stamets et al., 1983).

The corn chaff and groundnut cake substrates had low growth and yield, though corn chaff substrate exhibited better growth and yield than groundnut cake substrate. This may be due to the ability of the mushrooms to degrade the substrates. The ability of mushroom species to degrade particular substrate depends on the production of enzymes necessary to degrade that substrate. A group researchers showed that although mushroom species have the ability to degrade lignocellulosic substrates, they exhibit differences regarding the production of enzymes necessary to degrade substrates and thus different abilities to grow and produce mycelium and fruit on residue substrates (Rajarathnam et al., 1998). This variation may be also due to the difference in the genetic nature of the particular *Pleurotus species*/isolates employed, pH, and temperature at which they were incubated. This corroborates with the finding of who opined that the genetic makeup of the mushroom species determine the physiology and mycelia growth/colonization of plant on different substrates (Atikpo et al., 2008).

5. Conclusion

In conclusion, rice bran substrate used in this research was the best substrate for the growth of *Pleurotus species* and the use of corn chaff and groundnut cake substrates might not be promising for the production of mushrooms.

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