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Suitability of Selected Indigenous Wood Wastes on Yield and Biological Efficiency of Edible Mushroom (*Pleurotus florida*)

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ABSTRACT A cultivation scheme model for edible mushroom (*Pleurotus florida*) was prepared by keeping in view the agro-climatic conditions. The scheme model was adopted for successful cultivation of mushroom. Wood species: *Brachystegia eurycoma*, *Nauclea diderichii*, *Anogeissus leiocarpus* and *Triplochiton scleroxylon* were used as substrates to discover their potentials in the production of an edible mushroom. Each of the treatment was repeated five times. The samples were inoculated with mushroom seeds (spawn) of *Pleurotus florida*. The yield of the mushroom, its mycelia growth, diameter of the pileus, length of stipe and mushroom height was good. The analysis of variance carried out on yield parameters and biological efficiency exhibited significant difference ($P \leq 0.05$). The highest yield (g) was produced in *Brachystegia eurycoma*, followed by *Nauclea diderichii*, *Triplochyton scleroxylon* and *Anogeissus leiocarpus* with mean yield of 88.38±6.88, 69.82±3.06g, 48.72±1.97g and 34.20±3.91g respectively. The regression analysis between mushroom yield parameters and biological efficiency displayed a very strong positive linear relationship (R^2 =0.90).

INTRODUCTION

Fungi plays important ecological role in forest ecosystems that affect the health, diversity, productivity, and development of its biotic societies. Such roles include mycorrhizal associations with vascular plants, decomposers of coarse organic material, pathogens of commercial tree species, and food resources for wildlife (Marcot 2002). Fungi are eukaryotic and heterotrophic organisms that cause diseases, recycle nutrients in the ecosystem. They are often associated with food spoilage, food processing, as food and antibiotics like in the case of edible mushrooms (Agrios 2005; Trudell and Ammirati 2019). Mushrooms are important components of the ecosystem. They are often referred to as macro-fungi with distinctive fruiting bodies (Chang and Miles 1992). They are hunted for food and medicines apart from their ecological roles as decomposers and for bioremediations. Mushrooms have been used for treating cancer, cholesterol reduction, stress, insomnia, asthma, allergies and diabetes (Bahl 1983). They are high in proteins therefore are used as protein supplements in the underdeveloped world Wani et al. (2010). It has been estimated fungi comprises of about 90 percent biomass of all living things in forest soils. They are the important agents for the decomposition of waste matter, and are an essential component of the soil food chains (Rhodes 2012). They provide nourishment for the other organisms that live in the soil. Fungi are the only organisms on Earth that can decompose wood. The mycelium of fungi releases strong extracellular enzymes and acids that are able to decompose lignin and cellulose which are essential components of plant wood fiber. Their digestive enzymes break down the dead wood and recycle it into nutrients that plants can utilize. Wood decay fungi play an integral role in forest nutrition cycling. Van der Wal et al. (2015) reported that fungi also decompose oak stumps. Mushrooms colonize with unique fungal communities on freshly cut trees, young and in old stumps. White-rot fungi digest lignin by the secretion of enzymes and give a bleached look to wood due to undissolved cellulose. They are effective in degrading a wide range of organic matter by releasing extra-cellular lignin-modifying enzymes. These enzymes have low substrate-specificity and can decompose various molecules that are similar to lignin.

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Different types of mushrooms necessitates different type of substrates and availability of various types of materials may be dependent on which type is used Shah et al. (2004). Other fungi*; Bjerkandera adusta, Pleurotus ostreatus, Trametes versicolor, Agaricus bisporus Lentinula edodes, Irpex lacteus, Pleurotus tuber-regium, Pleurotus pulmonarius* destroy toxic or insoluble substances, that is, persistent xenobiotic compound (Singh et al. 2014; Adenipekun and Lawal 2012). Many above-ground fruiting mushrooms such as chanterelles, matsutake, boletes, morels, truffles, ganoderma (reishi), and others are good for food, medicinal use and are of recreational value (Pilz and Molina 2002). Recently a simulation-based decision-support model was developed to assess the effects of forest management intensity on mushroom occurrence and production (Kucuker and Baskent 2017). Edible mushrooms are eaten as food and give nice flavor, have economic and ecological values, and are used as medicine. The fungal genus Pleurotus has been studied intensely. It is cultivated in many different parts of the world (Sanchez 2010). It was also studied that cultivation of *Pleurotus species* on agricultural residues provides high value products with nutritional and medicinal properties. Mushroom production also gives economic benefits to farmers in the form of value-added products (Nurudeen et al. 2013). The objective of this study is to assess the suitability of different wood wastes for growth potential and biological efficiency of edible mushroom (*Pleurotus florida*).

MATERIAL AND METHODS

Study Condition

This experiment was conducted at the Pathology Laboratory, Department of Forest Conservation and Protection, Forestry Research Institute of Nigeria, Jericho, Ibadan, Oyo State, Nigeria, located between Latitude 7° 23' 20" to 7 °23' 40" North and longitude 3° 51' 23" to 3° 51' 52" East. The spawn used in this study was obtained from the pathology laboratory of Forestry Research Institute of Nigeria. The sawdust of *Brachystegia eurycoma*, *Anogeissus leiocarpus Nauclea diderichii*, and *Triplochiton scleroxylon* was taken from sawmill in Bodija Ibadan Oyo state. The sawdust was later mixed with 5 percent wheat bran and 1 percent lime ($CaCo_3$). About 1 percent sugar was added to the substrates to enhance the mushroom growth. Then each treatment was mixed with water to moisten the substrates. The polythene bags of size 15 x 35cm were filled with substrate of 500g weight. Then bags containing the treated substrates were sterilized in an autoclave at 121°C for 2 hours. After sterilization, the substrate bags were allowed to cool down. After that, the substrate bags were inoculated with spawn (mushroom seed). The spawn was mixed at the rate of 2 percent of the wet weight of substrate used. After inoculation, the bags were kept in a dark room where the temperature and humidity were kept around 28±2°C and 80 90 percent with sufficient ventilation for next 3-4 weeks (Quimio et al. 1990). The mycelia maturity was completed within 25 days. The polythene bags were torn-off from the tips by following the ramification of the bags. Fruit bodies emerged in 4-5 days after opening the polythene bags. The bags were not removed till the harvest of the 4th flush, which was completed within 37 days after spawning. A small layer of substrate was scrapped off from all the sides of the bags after each harvest. Each treatment was replicated five times.

Yield and Biological Efficiency

Parameters such as length of stipe, diameter and height of Pileus were measured with the aid of meter rule (cm). Total fruiting bodies harvested weight was measured as total yield (g) of the mushroom. The biological efficiency (yield of mushroom per gram of substrate on wet and dry basis) was estimated according to the following formula by Chang et al. (1981)

$$\text{B.E. \%} = \frac{\text{Fresh weight of mushroom}}{\text{Dry weight substrate}} \times 100$$

Data Analysis

The data obtained in this study was evaluated using analysis of variance in Completely Randomized Design (CRD) and descriptive statistics with the help of Statistical Packages for Social Sciences (SPSS) version 16.

RESULTS AND DISCUSSION

The mean mycelia running (%) as shown by different indigenous wood waste is presented in Table 1. This study was conducted at the Pathology Laboratory, Department of Forest Conservation and Protection, Forestry Research Institute of Nigeria, Jericho, Ibadan, Oyo State, Nigeria and it is located between Latitude 7° 23' 20" to 7 °23' 40" North and longitude 3° 51' 23" to 3° 51' 52" East. The result showed that for week 1 *Brachystegia eurycoma* had the highest running followed by *Nauclea diderichii*, *Anogeissus leiocarpus* and *Triplochiton scleroxylon* with the values of 42.5 percent, 30 percent, 26.6 percent and 22.2 percent respectively. For week 2, the values ranged from 48.9 percent to 71.25 percent with highest in *Brachystegia eurycoma* and lowest in *Anogeissus leiocarpus*. During the 3rd week, mean mycelia running (%) ranged from 72.12 to 85.42 percent with the highest in *Brachystegia eurycoma* and lowest in *Anogeissus leiocarpus*. All four wood wastes attained 100 percent running on fourth week. The mycelia performance shown by wood waste suggests that *Pleurotus florida* utilized the substrates maximum and the ramification rate is independent of supplement composition (Nurudeen et al. 2012). The mean length of stipe (cm), diameter of pileus (cm) and mushroom height (cm) obtained (Tables 2, 3 and 4) showed that all parameter values obtained were good and sizable with high market value. The length of stipe ranged from 5.6-7.1 cm while the mean mushroom height ranged from 7.1 to 9.0 cm and diameter of pileus ranged from 5.7 to 7.2 cm. This result is in accordance with the findings of Nurudeen et al. (2013), who reported that high performance of mushroom growth shows that substrates supported the growth of mushrooms. Farming and wood wastes are good growth medium for *Pleurotus spp*. The order of fruitification was as follows: *Brachystegia eurycoma* fruited first followed by sawdust from *Nauclea diderichii*, *Triplochiton scleroxylon* and *Anogeissus leiocarpus* respectively (Philippoussis et al. 2001). *Brachystegia eurycoma* were able to fruit first may be due to variation in nutrients composition of the wood wastes which are essential for the development of fruit bodies (Zhang et al. 2014). Meanwhile, *Nauclea diderichii* and *Brachystegia eurycoma* were able to fruit till fourth flush while *Triplochiton scleroxylon and Anogeissus leiocarpus* stopped maturing at the third flush. This shows that the fungus (*Pleurotus florida*) used the substrates in changing supplements present in different

Table 1: The mean mycelia growth (%) exhibited by different substrates on weekly basis

Substrate	*Week 1*	*Week 2*	*Week 3*	*Week 4*
Brachystegia eurycoma	42.50	71.21	85.42	100
Nauclea diderichii	30.00	58.28	79.14	100
Anogeissus leiocarpus	26.60	48.90	72.12	100
Triplochiton scleroxylon	22.22	51.67	78.51	100

Means of five replicates

Table 2: The mean length of stipe (cm) per flush

Substrate	*Flush 1*	*Flush 2*	*Flush 3*	*Flush 4*
Brachystegia eurycoma	6.4	7.1	6.7	6.8
Nauclea diderichii	6.2	6.3	6.1	6.5
Anogeissus leiocarpus	5.6	6.3	5.8	-
Triplochiton scleroxylon	6. 0	6.5	6.1	-

Mean of five replicates

Table 3: The mean diameter of pileus (cm)

Substrate	*Flush 1*	*Flush 2*	*Flush 3*	*Flush 4*
Brachystegia eurycoma	7.0	6.4	6.3	7.1
Nauclea diderichii	6.3	6.0	5.7	7.2
Anogeissus leiocarpus	6.0	6.0	5.8	-
Triplochiton scleroxylon	6.0	6.2	5.9	-

Mean of five replicates

Table 4: The mean mushroom height (cm)

Substrate	*Flush 1*	*Flush 2*	*Flush 3*	*Flush 4*
Brachystegia eurycoma	8.2	9.3	8.4	9.6
Nauclea diderichii	7.4	8.4	8.1	9.0
Anogeissus leiocarpus	7.1	7.2	7.4	-
Triplochiton scleroxylon	7.4	8.0	7.6	-

wood wastes (Kehinde and Awoyemi 2009). Similar findings were reported by other scientists in their studies that low fruiting body of *Pleurotus* spp could be due to supplement deficiency. The analysis of variance for mushroom yield (g) and biological efficiency (%) exhibited significant difference ($P \leq 0.05$) in all four wood wastes. The follow up procedure using Duncan multiple range test showed that *Brachystegia eurycoma* had the maximum yield (Tables 5 and 6) followed by *Nauclea diderichii, Triplochiton scleroxylon* and *Anogeissus leiocarpus* with mean yield values of 88.38±6.88, 69.82±3.06, 48.72±1.97 and 34.20± 3.91 respectively. This result shows that the wood wastes used supported mushroom growth. Similar findings were reported to address the effect of different supplement on the yield of *Pleurotus florida.* They observed that supplements such as lime and wheat-bran increase yield of mushroom and also aids in sporophore emergence of mushrooms grown on *Gmelina arborea* sawdust (Biswas et al. 2011). The biological efficiency (%) exhibited by different wood wastes showed that *Brachystegia eurycoma* had the

Table 5: The DMRT values for the yield (g) of the fruiting body of *P. florida* in different substrates

Substrate	*Mean*	*±Standard error*	*Duncan rating*
Brachyestegia eurycoma	88.38	6.88	a
Nauclea diderichii	69.82	3.06	b
Anogeissus leiocarpus	34.20	3.91	d
Triplochiton scleroxylon	48.72	1.97	c

Mean carrying the same alphabet are not significantly different from each other ($p \leq 0.05$)

Table 6: The DMRT values for the biological efficiency (%) as exhibited by different substrates

Substrate	*Mean*	*±Standard error*	*Duncan rating*
Brachyestegia eurycoma	61.30	1.57	a
Nauclea diderichii	54.16	1.44	b
Anogeisus lewcarpus	29.76	2.20	d
Triplochiton scleroxylon	47.04	2.73	c

Mean carrying the same alphabet are not significantly different from each other ($p \leq 0.05$)

highest B.E value followed by *Nauclea diderichii*, *Triplochiton scleroxylon* and *Anogeissus leiocarpus* with values of 61.30±1.57, 54.16±1.44, 47.04±2.73 and 29.76±2.20 (%) respectively. This result suggests that B.E is a function of yield. Higher the mushroom yields higher will be the biological efficiency. The regression equation for the relationship between mushroom yield and biological efficiency is presented in (Fig. 1). Similar results were reported that cultivation of oyster mushroom on similar by-products have manifested variable levels of B.E. They observed that these variations are mostly related to spawn rate, supplement added to the substrate and fungal species used (Mane et al. 2007).

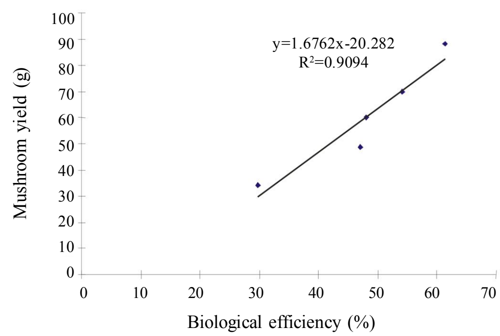

Fig. 1. Regression equation for the relationship between ushroom yield (g) and biological efficiency (%)

CONCLUSION

In this study, the researchers tried to establish growth and biological efficiency (%) of oyster mushroom *(Pleurotus florida)* cultivated on different wood wastes. They found that the mycelia growth is independent of genetic combination of the substrates because the entire wood wastes attained 100 percent ramification on the fourth week.

Consequently, the overall diameter of pileus, length of stipe and mushroom height produced was an indication that the mushrooms reached a good sizable stage that is marketable with good profit for the farmers. Biological efficiency and mushroom yield were reported to be significantly different ($P \leq 0.05$) in all the four wood wastes. However, the relationship between biological efficiency and mushroom yield shows that biological efficiency is a function of mushroom yield. The overall performance of the all wood wastes supported the sporophore emergence and thus resulted in mushroom yield in different levels. Commercial production of oyster mushrooms is largely depends upon availability and utilization of cheap agricultural and lignocellulosic waste materials. The substrates used in this study are considered practical and economically feasible due to their availability throughout the year at little or no cost in large quantities.

RECOMMENDATIONS

The researchers recommend that utilization of wood wastes for the production of oyster mushrooms could be more economically and ecologically beneficial. The usage of sawdust as medium for mushroom cultivation will assist in reducing environmental pollution produced by high amount of lignocellulosic wastes. The researchers further recommend that Mushroom cultivation is the need for improved protein, job creation and poverty alleviation. So, awareness should be spread among the farmers about the nutritional and health benefit of mushroom. This will boost mushroom cultivation and consumption. Moreover, edible mushrooms should be incorporated to diet to enhance the overall health and well-being of the populace.

The following recommendations are for improved research:

- A phytochemical screening on different wood species used for mushroom cultivation;
- Proximate analysis on mushroom grown on different substrate to determine their nutritive content;
- More indigenous wood species should be tested as substrate for mushroom cultivation

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