

Full Length Research Paper

Correlation of stipe length, pileus width and stipe girth of oyster mushroom (*Pleurotus ostreatus*) grown in different farm substrates

Chukwurah N. F.^{1*}, Eze S. C.², Chiejina N. V.³, Onyeonagu C. C.², Okezie C. E. A.³, Ugwuoke K. I.², Ugwu F. S. O.⁴, Aruah C. B.¹, Akobueze E. U.⁴ and Nkwonta C. G.⁴

¹National Biotechnology Development Agency, Abuja, Nigeria.

²Department of Crop Science, University of Nigeria, Nsukka, Nigeria.

³Department of Plant Science and Biotechnology, University of Nigeria, Nsukka, Nigeria.

⁴South East Zonal Biotechnology Centre, University of Nigeria, Nsukka, Nigeria.

Accepted 10 April 2013

A study was performed to correlate the stipe length, pileus width and stipe girth of oyster mushroom (*Pleurotus ostreatus*) grown in different farm substrates. The experiment was laid out in a completely randomized design with eight treatments and four replications. The farm substrates (treatments) were composed of mixtures of different types of agricultural wastes with lime and water as additives to each substrate. Also single agricultural waste supplemented with lime and water was also used to prepare some farm substrates. Higher mean values of stipe length, pileus width and stipe girth were obtained from mushrooms grown in the substrates composed of two different types of agricultural wastes while lower values were obtained from those grown in the substrate composed of single agricultural waste. Highest coefficient of determination was obtained from the correlation between biological efficiency and pileus width. The changes in the stipe length, pileus width and stipe girth of the mushrooms grown in the different farm substrates depended on the type of agricultural wastes, single or mixtures of two different agricultural wastes used in preparing the farm substrates. Biological efficiency was highest (97.9%) in the substrate made from maize cob and palm kernel cake. Farm substrates that were composed of two different agricultural wastes were recommended. The use of single agricultural waste for farm substrate production is not encouraged.

Key words: *Pleurotus ostreatus*, farm substrates, sprouting, maturity, correlation.

INTRODUCTION

Oyster mushroom (*Pleurotus ostreatus*) is an edible mushroom that belongs to the family Pleurotaceae (Randive, 2012). The term mushroom applies mostly to those fungi that have stem (stipe), cap (pileus), hymenium (lamellae) and pores on the underside of the cap (Masarirambi et al., 2011). Mushroom spores (spawn) are produced on the gills and they can fall as a

fine powder from underside of the cap. The colour of spore print of most oyster mushroom is white and when cultivated produces fruiting bodies (Herlina et al., 2012).

Oyster mushroom can be cultivated in different farm substrates. They are mushrooms of wide adaptability. Royse (2002), reported that oyster mushrooms are grown from mycelium propagated on steam-sterilized cereal

*Corresponding author. E-mail: tdesalew@gmail.com.

grains. Their fast mycelia growth and multilateral enzyme system can biodegrade nearly all types of waste makes them grow on the largest varieties of wastes (Dlamini et al., 2012). Agricultural wastes make the most ideal form of materials needed for substrate production. Different farm substrates made from different types and composition of agricultural wastes produce different results. Others can also produce the same result. Agricultural wastes contain different types and amount of nutrient needed for mushroom growth. Some of the nutrients include: cellulose, hemicelluloses, nitrogen and lignin.

Most of the agricultural wastes are locally available and there is need to encourage indigenous farmers on the combination and use of these wastes for farm substrate production and mushroom cultivation. Wild edible mushrooms have been a delicacy since olden days but they cannot meet the demand of the teeming population of the world. There is need to domesticate mushrooms just as livestock domestication to meet with the increasing population of the world. The use of different agricultural wastes for production of mushroom farm substrates can make edible mushrooms available all year round. This can help to improve the economy of a nation.

Gunde and Cinerman (1995) reported that oyster mushroom has a cap spanning diameter of 5 to 25 cm at maturity. The fruiting body of oyster mushroom differs with respect to stipe length and girth, and pileus width when grown in different farm substrates (Shah et al., 2004). Information is lacking on the relationship between the fruiting bodies of oyster mushroom grown in different farm substrates composed from different types of agricultural wastes. Agricultural wastes such as maize cob, maize straw, wheat straw, palm kernel cake, cotton seed hull, saw dust, spent grain, grass families are good materials for farm substrate production. The aim of this study was to correlate the stipe length, pileus width and stipe girth of oyster mushroom (*P. ostreatus*) grown in different farm substrates.

MATERIALS AND METHODS

The materials used include: maize straw, maize cob, palm kernel cake, saw dust, spent grain, rice bran, lime and water. They were used to produce eight substrates labeled 1 to 8 used for the study. Each substrate was replicated four times. The materials were sundried for one week. The dried maize straw and maize cobs were chopped while others were ground.

Substrate 1 was a mixture of maize straw (7.5 kg), rice bran (2.0 kg), lime (0.2 kg) and water (40 L). Substrate 2 was composed of maize straw (7.5 kg), saw dust (2.0 kg), lime (0.2 kg) and water (40 L). Substrate 3 was a mixture of palm kernel cake (7.5 kg), saw dust (2.0 kg), lime (0.2 kg) and water (40 L). Substrate 4 was made up of maize cob (2.0 kg), palm kernel cake (7.5 kg), lime (0.2 kg) and water (40 L). Substrate 5 was a mixture of saw dust (7.5 kg), spent grain (2.0 kg), lime (0.2 kg), and water (40 L). Substrates 6, 7 and 8 were prepared from single agricultural waste materials as follows: maize straw (9.5 kg), maize cob (9.5 kg) and saw dust (9.5 kg), respectively. These materials were supplemented with lime (0.2

kg) and water (40 L also as additives. Substrates 1 to 5 were prepared from mixtures of two different agricultural wastes supplemented with lime and water.

Each substrate was compressed in a transparent poly bag of 50 × 27 cm (length and width). A completely randomized design was used with eight treatments and four replications. Each poly bag that contained the substrate corresponds to each replicate. The substrates were steam-sterilized at a temperature of 100°C for 7 h and allowed to cool for 48 h before inoculation in a laminar flow chamber. The inoculated substrates were transferred into an incubation room for mycelia growth. At the completion of mycelia growth (14 days after inoculation) the substrates were transferred to a growth room for fructification and data collection.

Data collection, statistical analysis and biological efficiency

Data was collected from the mushrooms in each substrate at sprouting and maturity. Stipe length (cm), stipe girth (mm) and pileus width (cm) which constituted the fruiting bodies of mushrooms were collected. The fresh weight (g) of the mushroom was recorded after each harvest. Harvesting of mushroom continued till all the nutrients in each substrate were exhausted. The dry weight of each substrate was also taken after all the harvest. The data was collected from all the mushrooms grown from each substrate and the means recorded. The stipe length (cm) and pileus width (cm) were measured with metre rule while the stipe girth (mm) was measured with micrometer screw gauge. The means of the data collected were statistically analyzed using the statistical analyses system package. Means were separated by Least Significant Difference (LSD) at 5% significant level ($P < 0.05$). The mean values obtained from the stipe length, pileus width and stipe girth was plotted against each farm substrate to show the changes in fruiting bodies of each mushroom from sprouting to maturity. Analysis of variance was done using the procedure outlined by (Obi, 2002). The total fresh weight (g) of mushrooms harvested from each substrate throughout the study period was recorded. The percentage of the total fresh weight (g) of all the harvested mushrooms was worked against the dry weight (g) of each substrate to obtain the biological efficiency.

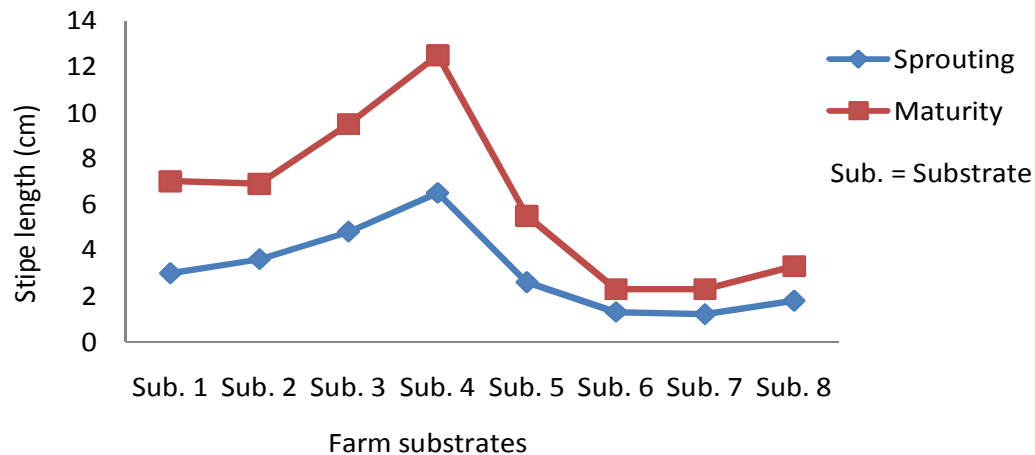
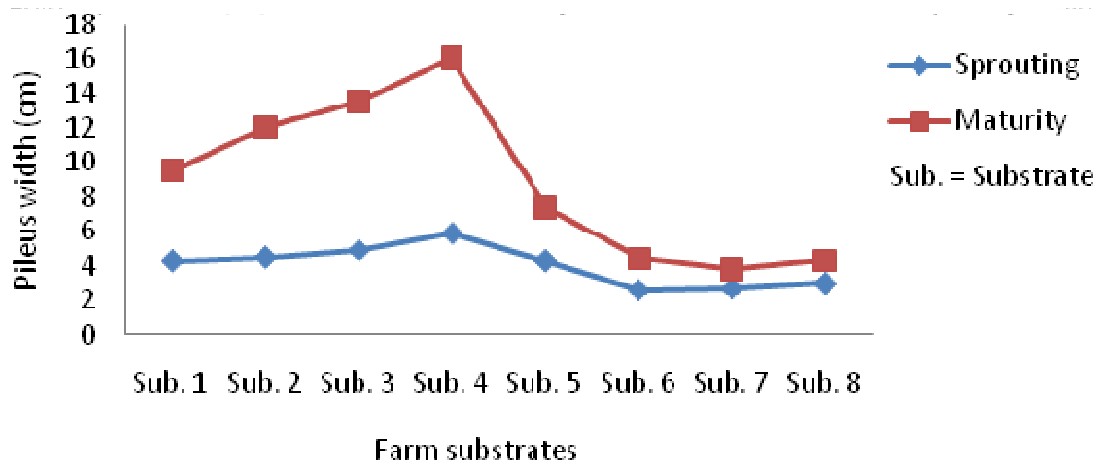
RESULTS

The different farm substrates that served as media for the oyster mushroom cultivation yielded mushrooms with different stipe lengths (cm), pileus width (cm) and stipe girth (mm) at sprouting and maturity. The performance of the fruiting bodies of the mushrooms depended on the type, mixture of two or single agricultural wastes used in preparing the farm substrates. Table 1 showed the total fresh weight (g) of the harvested mushrooms, dry weight (g) of substrate after all the harvest and biological efficiency (%). The highest fresh weight (g) was obtained from the mushroom grown in those substrates that contained maize cob, maize straw, palm kernel cake and saw dust. The mean stipe length (cm), pileus width (cm) and stipe girth (mm) measured from mushrooms grown in different farm substrates at sprouting and maturity are presented in Figures 1 to 3. This showed the changes in growth rate with respect to stipe length (cm), pileus width (cm) and stipe girth (mm) from sprouting to maturity. The correlation between the biological efficiency (%) and stipe length (cm), pileus width (cm) and stipe girth (mm) of

Table 1. Total fresh weight (g) of mushrooms in ten harvests, dry weight (g) of substrate after all the harvest and biological efficiency (%).

Substrates	Total fresh weight (g) of mushroom in ten harvests	Dry weight (g) of each substrate after all harvest	Biological efficiency (%)
Substrate 1: Maize straw + Rice bran	1408.8 ^b	3021 ^a	46.6 ^b
Substrate 2: Maize straw + Saw dust	2207.4 ^{ab}	3021 ^a	73.1 ^{ab}
Substrate 3: Palm kernel cake + Saw dust	2535.7 ^{ab}	3021 ^a	83.9 ^{ab}
Substrate 4: Maize cob + Palm kernel cake	2957.5 ^a	3021 ^a	97.9 ^a
Substrate 5: Saw dust + Spent grain	1092.6 ^b	3021 ^a	36.2 ^b
Substrate 6: Maize straw	478 ^c	3040 ^b	15.7 ^c
Substrate 7: Maize cob	488 ^c	3040 ^b	16.1 ^c
Substrate 8: Saw dust	453.1 ^c	3040 ^b	14.9 ^c
LSD 0.05	350	17	11.3

Values with the same alphabet (s) along the vertical column are not significantly different ($P > 0.05$).

**Figure 1.** Mean stipe length (cm) measured from mushrooms grown in different farm substrates at sprouting and maturity.**Figure 2.** Mean pileus width (cm) measured from mushrooms grown in different farm substrates at sprouting and maturity.

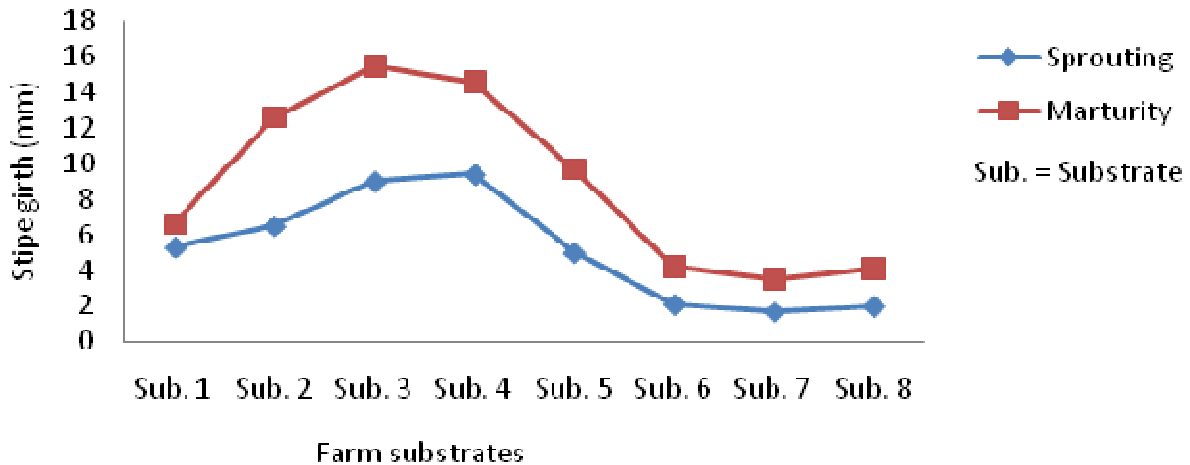


Figure 3. Mean stipe girth (mm) measured from mushrooms grown in different farm substrates at sprouting and maturity.

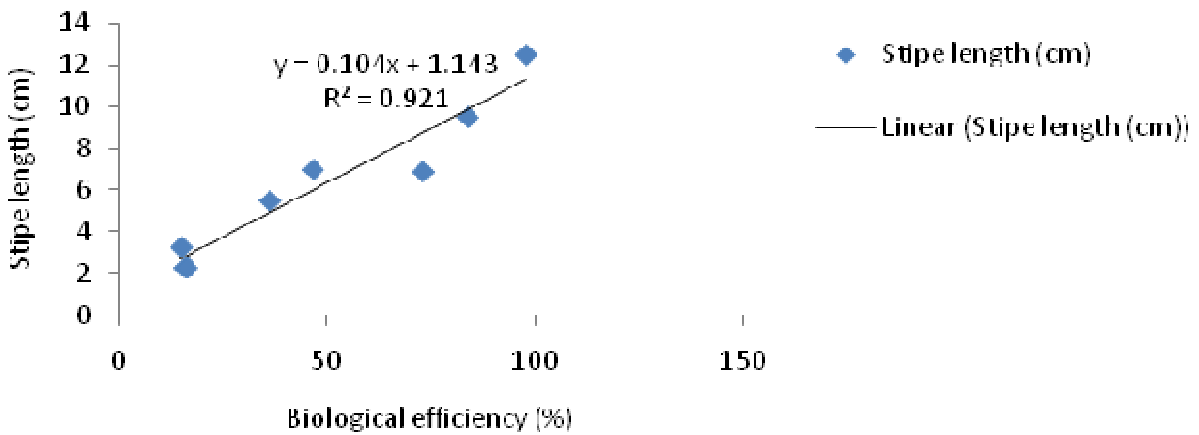


Figure 4. Correlation between biological efficiency and stipe length (cm) of oyster mushroom grown in different farm substrates.

oyster mushroom grown in different farm substrates are shown in Figures 4 to 6. This showed how the regression line fits to the data. The highest coefficient of determination R^2 (0.990) was obtained from the regression line between biological efficiency and pileus width. The highest scattered points were obtained from the correlation of biological efficiency and stipe girth.

Substrate 1, the maize straw and rice bran combination with lime as additive in the ratio of 77.3% maize straw, 20.6% rice bran and 2.06% lime produced mushrooms with stipe length, pileus width and stipe girth of average results when compared with the results of other farm substrates at sprouting and maturity (Figures 1 to 3). Substrate 2, a mixture of maize straw 77.3% saw dust 20.6% and lime 2.06% also produced stipe length, pileus width and stipe girth of average results at sprouting and maturity when compared with other farm substrates

(Figures 1 to 3). Substrates 1 and 5 were statistically the same ($P > 0.05$) with respect to the total fresh weight of the harvested mushroom (Table 1). Substrates 1, a combination of maize straw and rice bran produced similar results with substrate 5, a combination of saw dust and spent grain.

Substrate 3, a combination of palm kernel cake (77.3%), sawdust (20.6%) and lime (2.06%) produced high results with respect to stipe length, pileus width and stipe girth at sprouting and maturity (Figures 1 to 3). Substrate 4 was a combination of maize cob (20.6%), palm kernel cake (77.3%) and lime (2.06%) and it produced mushroom with the highest stipe length, pileus width and stipe girth at sprouting and maturity (Figures 1 to 3). The peak of the curve with respect to all the parameters investigated is at Substrate 4. Highest biological efficiency was obtained from the mushroom

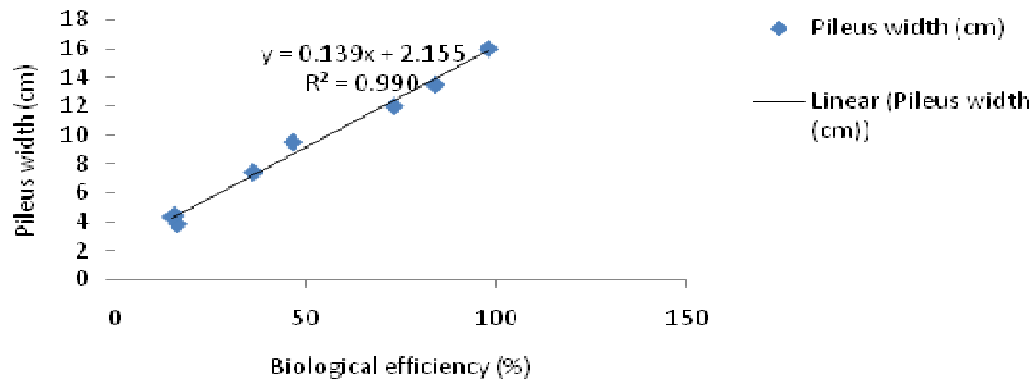


Figure 5. Correlation between biological efficiency (%) and pileus width (cm) of oyster mushroom grown in different farm substrates.

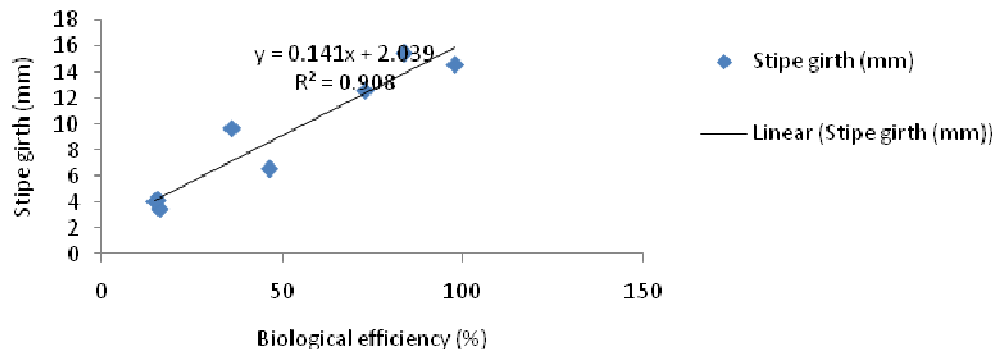


Figure 6. Correlation between biological efficiency (%) and stipe girth (mm) of oyster mushroom grown in different farm substrates.

grown in Substrate 4 (Table 1). Substrates 4 produced mushroom with the thickest fruiting body when compared with those of other farm substrates.

The substrates that were composed of single agricultural waste materials with lime produced the mushrooms with least performance. Substrates 6, 7 and 8 were made up of single agricultural waste materials. Substrate 6, a combination of maize straw (97.9%) and lime (2.1%) yielded low results with respect to fresh weight. Biological efficiency was also low in the substrates. Substrate 7, a combination of maize cob (97.9%) and lime (2.1%) yielded mushrooms with stunted stipe length, pileus width and stipe girth at sprouting and maturity. Substrate 8 composed of saw dust (97.9%) and lime (2.1%) and it yielded mushrooms with low stipe length, pileus width and stipe girth at sprouting and maturity. The similarity in performance in Substrates 6, 7 and 8 was due to the single agricultural waste material used in preparing the substrate.

The farm substrates that contained mixtures of two different types of agricultural wastes performed better than those with single agricultural waste. Also some agricultural wastes formed better farm substrates than

others. The thickness of mushrooms grown in farm substrates that were composed of two different types of agricultural wastes was more than those of single agricultural wastes. Substrates 3 and 4 produced mushrooms with the thickest fruiting bodies. The rate of absorption of nutrients in the substrates composed of two different agricultural wastes and single agricultural waste deferred. The dry weight of substrate composed from mixed agricultural wastes was lower than those of single agricultural waste. The mushroom grown in the substrates composed from mixed agricultural waste absorbed the available nutrient more efficiently than those composed from single agricultural waste. This was indicated by the higher percentage biological efficiency obtained in the substrate composed of mixed agricultural waste.

DISCUSSION

The results showed that the changes in stipe length, pileus width and stipe girth of oyster mushroom grown in different farm substrates depended on the type of

agricultural waste, single or mixture of two different agricultural wastes used in preparing the farm substrates. The different agricultural wastes used in preparing the farm substrates yielded mushrooms of different sizes while those with the same type of agricultural wastes yielded similar sized mushrooms. The highest fresh weight was obtained from the mushroom grown in the substrate composed of corn cob and palm kernel cake. The peak of the curve with respect to stipe length, pileus width and stipe girth was at this substrate (Substrate 4) indicating the best performance level of this substrate when compared with other farm substrates. High fresh weights were also obtained from mushroom grown in the substrate composed of maize straw, rice bran, spent grain and saw dust. Results further revealed that the farm substrates made up of single agricultural wastes yielded mushrooms with no significant differences ($P > 0.05$) among themselves with respect to fresh weight. Significant differences ($P < 0.05$) with respect to fresh weight existed between mushrooms grown in farm substrates that contained different types of agricultural wastes. Mixtures of two different agricultural wastes produced mushrooms that differed significantly ($P < 0.05$) with those grown in single agricultural wastes with respect to fresh weight which comprises of the fruiting bodies. The coefficient of determination R^2 showed that the regression line approximately perfectly fits to the data point with respect to biological efficiency and pileus width.

Diana et al. (2012) reported that agricultural wastes make the most ideal form of materials needed for substrate production and nearly all types of agricultural wastes are useful for mushroom production. The different agricultural wastes contain different types and amount of nutrients and minerals. Cellulose, hemicelluloses and nitrogen are the main nourishment required by oyster mushroom for growth and fructification. High values of stipe length, pileus width and stipe girth were obtained from the farm substrates that contained maize straw, maize cob, rice bran, palm kernel cake and spent grain. These substrates that gave higher values contained the required cellulose, hemicelluloses and nitrogen. This is confirmed by Viziteu (2000) who reported that higher available cellulose, hemicelluloses and nitrogen are available in maize cob than in saw dust. This is in agreement with the results obtained in this research with respect to the performance of oyster mushroom in maize cob farm substrate and that of saw dust. Buah et al. (2010) also reported that corn cob substrate had higher biological efficiency than saw dust though the difference was not different statistically. The highest biological efficiency was obtained from the substrate composed of corn cob and palm kernel cake. The least biological efficiency was obtained from single saw dust substrate. The results of this study were also in contrast to the earlier report of Ayodele and Okhuoya (2007) that mushrooms grown in saw dust substrate performed better than that of corn cob with respect to fruiting bodies.

The reason why the contrast could be that the saw dust

was prepared from trees with high cellulose and hemicelluloses. The method of corn cob preparation could also make the difference.

The performance of oyster mushroom grown in different farm substrates with respect to stipe length, pileus width and stipe girth also depended on the structure, compactness and physical properties of the substrate which in turn depended on the type of agricultural wastes used in preparing the substrates. The substrates with higher moisture retaining capacity perform better than those with lower moisture retaining capacity. The fastest growth observed in Substrates 3 and 4 from sprouting to maturity may be attributed to the type and mixture of two different agricultural wastes used in preparing the substrates. Substrates 6 to 8 which were composed of single agricultural waste had little changes in growth from sprouting to maturity as observed in the curve. The rate of nutrient absorption was poor in single farm substrate. This was indicated by the higher dry weight of the substrates obtained after all the harvest. From the foregoing therefore, farmers are enjoined to compose their farm substrates for growing mushrooms by preferably mixing two different agricultural wastes with lime and water. The use of single agricultural waste for farm substrate production is not encouraged due to poor performance of mushrooms obtained from the substrates.

ACKNOWLEDGMENTS

We acknowledge with thanks the UNESCO-HP Project for funding the research and the Director of South East Zonal Biotechnology Centre, University of Nigeria, Nsukka, Prof. C. E. A. Okezie for his effort in obtaining the fund. We are also grateful to the former Director of the South East Zonal Biotechnology Centre, Prof. J. E. Asiegbu for his assistance. The authors also acknowledge with thanks the Head of Department of Crop Science, University of Nigeria, Nsukka, Prof. K. P. Baiyeri, for making the facilities of the Department available for the work.

REFERENCES

- Ayodele SM, Okhuoya JA (2007). Cultivation studies on *Psathyrella atroumbonata* Pegler. A Nigerian edible mushroom on different agro industrial wastes. Int. J. Bot. 3:394-397.
- Buah JN, Van der GC, Puije EA, Bediako EA, Abole EA, Showemimo F (2010). The growth and yield performance of oyster mushroom (*Pleurotus ostreatus*) in different substrates. Biotechnol. 9:338-342.
- Dlamini BE, Earnshaw DM, Masarirambi MT (2012). Growth and yield response of oyster mushroom (*Pleurotus ostreatus*) grown on locally substrates. Curr. Res J. Biol. Sci. 4(5):623-629.
- Randive DS (2012). Cultivation and study of growth of oyster mushroom on different agricultural waste substrate and its nutrient analysis. Advances in Appl. Sci. Res. 3(4):1938-1949.
- Diana M, Earnshaw, Bongirikhosi E, Dlamini-Michael T, Masarirambi (2012). Growth and yield of oyster mushroom (*Pleurotus ostreatus*) grown on different substrates amended with varying levels of wheat bran. Int. J. Life Sci. 1(4):111-117.
- Gunde CN, Cinerman A (1995). Inhibitor content of *Pleurotus* fruiting

- bodies. J. Exp. Mycol. 19(1):1-6.
- Herlina N, Koesriharti, Bramanti L (2012). The effect of an organic fertilizers application on yield of white oyster mushroom (*Pleurotus florida*). Advances in Natural. Appl. Sci. 6(6):819-822.
- Masarirambi MT, Mamba MB, Earnshaw DM (2011). Effect of various substrates on growth and yield of oyster mushrooms. Asian J. Agric. Sci. 3(4):375-380.
- Obi IU (2002). Statistical methods of detecting differences between treatment means and research methodology issues in laboratory and field experiments. AP Express Publishers Limited, Nsukka (second edition). P. 117.
- Royse DJ (2002). Influence of spawn rate and commercial delayed released nutrient levels on oyster mushroom yield, size and time to production. Appl. Microbial Biotechnol. 58:527-531.
- Shah ZA, Ashraf M, Ishtiaq M (2004). Comparative study on cultivation and yield performance of oyster mushroom (*Pleurotus ostreatus*) on different substrates (wheat straw, leaves, saw dust). Pak. J. Nutr. 3:158-160.
- Viziteu G (2000). Substrate- cereal straw and corn cobs. In: mushroom growers handbook 1, Gush, R. (Ed.) P and F Publishers, USA., ISBN 10:0932551068, pp. 86-90.