ISSN 1682-296X (Print)
ISSN 1682-2978 (Online)

Bio Technology

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Biotechnology 9 (3): 338-342, 2010
ISSN 1682-296X

The Growth and Yield Performance of Oyster Mushroom (*Pleurotus ostreatus*) on Different Substrates

[1]J.N. Buah, [1]G.C. Van der Puije, [1]E.A. Bediako, [1]E.A. Abole and [2]F. Showemimo
[1]Deaprtment of Crop Science, School of Agriculture, University of Cape Coast, Ghana
[2]Faculty of Agriculture, Amedu Bello University, Zaria, Nigeria

Abstract: The research was carried out to investigate the cultivation of oyster mushroom (*Pleurotus ostreatus*) on different substrates. The steps involved in the cultivation were composting the substrates, bagging the substrates, sterilizing the bagged compost, spawning, incubation and cropping. The experiment was laid out in a completely randomized design with five treatments and six replications. Pinhead formation was faster (12 days), on the substrate made from grounded corn cob and the fruiting bodies formed in 27 days. The average number of fruiting bodies on the corn cob substrate was 28. Similarly, the fresh weight and dry weight of the fruiting bodies were all high for corncob substrate. These were in line with the figures of the biological efficiency which was higher for the corn cob substrate.

Key words: Biological efficiency, substrate, *Pleurotus ostreatus,* mycelia, sawdust, corn cob

INTRODUCTION

Mushroom cultivation is a profitable agribusiness and Oyster mushroom (*Pleurotus ostreatus*) is an edible mushroom having an excellent taste and flavour. It belongs to the class Basidiomycetes, subclass Hollobasidiomycetidae, order Agricales. It grows wild in the forest and is cultivated in the temperate and sub tropical regions of the world (Shah *et al*., 1981).

The technology of artificial mushroom cultivation is a recent innovation, which stemmed from the realization that the incorporation of non-conventional crops in existing agricultural systems can help in improving the social as well as the economic status of small farmers.

Mushrooms are a source of virility and are used in the preparation of many continental dishes. They have anticancerous, anticholesterol and antitumorous properties and are useful against diabetes, ulcer and lung diseases (Quimio, 1976). Mushrooms are a good source of protein, vitamins and minerals (Khan *et al*., 1981). Mushrooms contain about 85-95% water, 3% Protein, 4% Carbohydrates, 0.1% fats, 1% minerals and vitamins (Tewari, 1986). They also contain appreciable amounts of potassium, phosphorus, copper and iron but have low levels of calcium (Anderson and Feller, 1942). Mushroom protein is intermediate between that of animals and vegetables (Kurtzman, 1976). Oyster mushroom has no starch, low sugar content and high amount of fibre, hence it serves as the least fattening food (Osei, 1996).

In Ghana, wild mushroom has been a delicacy for many years. It is regarded as meat substitute especially by the rural population of Ghana (Atikpo *et al*., 2008). With changes in the climatic patterns, it is becoming difficult harvesting wild mushrooms. The alternative then, is to grow mushrooms domestically. In Ghana, Oyster mushrooms have become the most popular for commercial production.

The growth of oyster mushroom requires high humidity (80-90%) and high temperature (25-30°C) for the vegetative growth called spawn running and lower temperature (18-25°C) for fruit body formation (Viziteu, 2000).

Like other mushrooms, oyster mushroom can be grown on various agricultural waste with the use of different technologies. In Ghana, the main substrate for the production of mushroom is sawdust. Sawdust is a mixture of shavings from many trees and depending on the type of tree and the amount of lignin present, the growth of the spawn can be inhibited. Moreover, with the increasing expansion in the poultry industry, there is high demand for sawdust, thus making it difficult and expensive for commercial mushroom growers to get the sawdust. One farm produce that is easily available in Ghana at all times is the corn cob. During the main harvesting period, corn cobs are in abundance and farmers dispose of them by burning. If grounded corn cob can support the growth of oyster mushroom, then it would serve as a cheap source of substrate for mushroom growers.

Corresponding Author: John N. Buah, Department of Crop Science, School of Agriculture, University of Cape Coast, Cape Coast, Ghana

The grounded form of corncob is very firm and retains good amount of moisture to make it a plausible alternative to sawdust.

This study therefore sought to evaluate the potential of grounded corn cob substrate as medium for the cultivation of oyster mushroom.

MATERIALS AND METHODS

The research was conducted at the Technology Village of the School of Agriculture, University of Cape Coast from April 2008 to June 2008. The materials used and the methods applied are given below. The substrates used for the cultivation of the oyster mushroom were;

- 50% Sawdust + 50% grounded corncob
- 60% Sawdust + 40% grounded corncob
- 100% Grounded Corncob
- 100% Sawdust (control)
- 40% Sawdust + 60% corncob

The substrates were each mixed with 1.2 kg of wheat bran and were soaked in water for 24 h to moisten them thoroughly and were staled on a steep cemented floor to allow for the draining of excess moisture from the substrates to obtain 65-75% moisture level. Lime was mixed at the rate of 5% (on dry weight basis). The substrates were then fermented by covering with polythene sheet. To ensure uniform fermentation, the mixtures were turned every four days. In all a total of seven turnings were carried out and the various composts were ready for bagging after 28 days. The various composts were again mixed with 13.2 kg of wheat bran and 0.1 kg of quicklime. Water was added during the mixing to make the compost dump.

The composted substrates were then packed into heat resistant polythene bags at 1kg per bag and each substrate was replicated 10 times. The bottom ends of the bags were folded to enable them stand without any form of support. An empty bottle was used to compress the compost as more was added to a final weight of 1 kg. A PVC pipe of 2.0 cm thick and 2.5 cm long was inserted at the neck of each 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. The bags were then autoclaved at 121°C and 15-20 lbs pressure and allowed to cool.

Before inoculation, 70% alcohol was used to disinfect the hands and the spawn bottles. The spawn bottles were then shaken to loosen the grains. The bags were then inoculated for spawn running under complete darkness at controlled temperature of 25°C. Mushroom cultivation has two important phases; spawn running and fructification, while temperature and humidity are two vital factors involved in both phases. The humidity of the bags was accomplished by spraying with water twice a day. The incubation period was about 45 days. The thickening of the mycelia in the bags (colonization of the bags) was an indication for the bags to be opened for fruiting.

The experiment was laid out in a completely randomized design.

Time was recorded in days for the completion of growth of mycelium on substrates, mycelium length and girth, appearance of pinheads, maturation of fruiting bodies in different treatments were also recorded.

Height, was measured in centimeters using meter rule from the base to the stipe of the pileus.

The number of fruiting bodies was counted for each treatment and the mean calculated.

Diameter of pileus: This was measured in centimeters using meter rule from one edge of the pileus, across the stipe, to another.

Fresh and dry weight: The fruitbodies were weighed immediately after harvest using electronic balance. After recording the weight, they were then dried in an oven at 80°C for 24 h. Their mean weights were also recorded. The data collected were subjected to statistical analysis using Analysis of Variance (ANOVA) on Genstat version 9 (Hilbe, 2007).

Data was also recorded for yield (number of fruiting bodies) and biological efficiency of substrates. The total biological efficiency was worked out against the dry weight on each substrate.

RESULTS

Spawn running is an important phase of mushroom cultivation since it has a bearing on how fast the substrate will be colonized by the mycelia. In this study, it was observed hat spawn running took lesser days, 15.67 days on the 100% corn cob and 16.51 days on the 100% sawdust substrate (Table 1). The number of days for 100% corn cob and 100% sawdust were not significantly different but the two (pure sawdust and pure corn cob) were significantly different from all the sawdust and corn cob combinations.

The days for pinehead formation were also lesser, 21.35 days for the 100% corn cob substrate compared to 22.14 days for the 100% sawdust. They were however not statistically different. More fruiting bodies 28.11 were counted on the 100% corn cob substrate and this was

Table 1: Days for completion of spawn running, fruiting bodies formation and pinehead formation of mushroom on different susbstrates

Treatments	Days for completion of spawn running	Days for pinehead formation	Days for fruiting body formation (after pinhead formation)	Average No. of fruiting bodies
Sd+Ccb (50+50%)	17.42±1.05	23.15±1.70	27.27±2.01	20.41±1.15
Sd+Ccb (40+60%)	17.33±1.05	23.24±1.62	35.00±2.20	20.00±1.00
Sd+Ccb (60+40%)	18.63±1.04	24.26±1.01	28.33±1.09	18.77±1.84
Sd (100%)	16.51±2.20	22.14±1.56	26.41±1.86	22.55±2.31
Ccb (100%)	15.67±0.50	21.35±1.70	27.00±1.22	28.11±2.01

Sd: Sawdust, Ccb: Corncob

Table 2: Average mycelia length and girth, diameter, fresh and dry weight of fruiting bodies of mushroom on different substrates

Treatments	Length of mycelia (cm)	Girth of mycelia (cm)	Diameter of fruiting boby (cm)	Fresh weight of fruiting body (g)	Dry weight of fruiting body (g)
Sd+Ccb (50+50%)	6.00	1.53	6.5	19.0	5.0
Sd+Ccb (40+60%)	5.00	1.18	5.0	9.4	3.0
Sd+Ccb (60+40%)	5.37	1.32	5.3	10.0	4.0
Sd 100%	12.57	1.18	8.0	24.0	9.0
Ccb 100%	14.86	2.08	8.0	30.0	10.0

Table 3: Biological efficiency, weight and average yield on different substrates

Treatments substrate (g)	Weight of each three flushes (g)	Average yield in three flushes (g)	Biological efficiency (%)
Sd+Ccb (50+50%)	1000	791.90±30.80	79.19±5.01
Sd+Ccb (40+60%)	1000	772.00±4.11	77.20±5.20
Sd+Ccb (60+40%)	1000	684.00±10.91	68.40±4.61
Sd 100%	1000	856.90±4.83	85.69±5.28
Ccb 100%	1000	912.14±8.76	91.21±6.01

higher than all the other substrates. The substrate with the 60% sawdust produced the least number of fruiting bodies.

Mushroom cultivated on the 100% corn cob substrate performed better in terms of dry weight, fresh weight, mycelia length and girth, compared to the 100% sawdust (Table 2). The fresh weight of fruiting bodies on the 100% corn cob was 30 g and this was significantly different compared to the 24 g which was obtained on the 100% sawdust. The sawdust and corn cob combinations in the ratio of 40% sawdust + 60% corn cob and 60% sawdust + 40% corn cob recorded the least fresh weight for the fruiting bodies. The fresh weight values for the corn cob and sawdust combinations were all significantly lower than those obtained from the 100% corn cob and sawdust.

In terms of girth of mycelia, those grown on the 100% corn cob were better, 2.08 cm. Unlike the fresh weight and dry weight, almost all the various combinations of sawdust and corn cob gave a mycelium girth that was higher than that achieved on the 100% sawdust substrate.

The biological efficiency was worked out against the dry weight of each substrate and it was found that the 100% corn cob had higher biological efficiency of 91.21% compared to the 100% sawdust which had 85.69% but the difference was not different statistically (Table 3). They were however significantly higher than all the combinations of sawdust and corn cob. The least biological efficiency was on the 60% sawdust + 40% corn cob.

DISCUSSION

The observation that the mushroom grew successfully on the different substrates indicates the potential of mushroom in the bioconversion of these materials (Ayodele and Okhuoya, 2007). Stamets (2005) have also stated that many wood decomposing mushrooms can be grown on non-wood based substrates such as cereal straw, corn cobs and banana leaves.

The spawn running, pinehead formation and fruiting bodies formation are the most important phases in the cultivation of mushroom. It is evident from that spawn running took 2-3 weeks after inoculation as shown in Table 1. These results agree with Tan (1981) and Shah *et al.* (2004) who also had their spawn running over the same number of days even though they used cotton waste and wheat, leaves and sawdust even though Shah *et al.* (1981) had achieved spawn run in 16.67 days on wheat straw.

Pinhead formation is the second stage of mycelia growth in the cultivation of mushroom. Generally, the pine heads were formed over a six-day period for all the treatment. This observation is collaborated by Vetayasuporn (2007) who reported that *Pleurotus ostreatus* completed spawn running in 17-20 days on different substrates and the time for pinehead formation was between 6 to 7 days. This observation has also been collaborated by Shah *et al.* (2004) when he cultivated oyster mushroom on different substrates consisting of a combination of wheat straw, sawdust and leaves.

Fruiting bodies appeared earlier on the sawdust and delayed in those mushrooms cultivated on the 40% sawdust and 60% corncob combination. The fruiting bodies appeared approximately four weeks after the formation of pine heads. In the study of Quimio (1976) and Shah *et al*. (2004), fruiting body formation took between 3-6 weeks after pinehead formation and this agrees with the findings of this study. Onuha (2007), also worked on mushroom cultivation on different substrates and observed that the mushrooms grown on sawdust produced the least number of fruiting bodies compared to those on a mixture of topsoil and poultry manure. On the contrary, Shah *et al*. (1981), recorded fewer days than what we recorded in this study for the formation of fruiting bodies on sawdust. It is however not known if the sawdust used by Shah *et al*. (1981) was a mixture of wood shavings or from one type of wood.

In terms of girth of mycelia, diameter of fruiting bodies, fresh weight and dry weight of fruiting bodies, 100% corn cob was superior. Fruiting bodies on the 100% corn cob had a mean fresh weight of 30 g and a dry weight of 10 g compared to the 24 and 9 g fresh weight and dry weight respectively obtained on the sawdust (Table 2).

Oyster mushroom consumes significant amount of cellulose, hemicelluloses and nitrogen as their main nourishment source for fruiting body formation and mycelia growth while lignin is rarely used in the formation of fruiting bodies (Viziteu, 2000). Viziteu (2000) reported higher assimilable nitrogen, cellulose and hemicelluloses for corn cob as against sawdust. The superiority of corn cob over sawdust in the weight of fruiting bodies and length of mycelia could be explained by the observations of Viziteu (2000).

Maria *et al*. (2008) have reported that corn cob has a nitrogen content of 0.5% which is higher than that of sawdust derived from trees and Fujihara *et al*. (2000) have also reported that the growth of mushroom is dependent on the nitrogen content on the substrate.

Contrary to present findings however, is the report of Islam *et al*. (2009) who reported from their study that sawdust was consistently the best substrate supporting mycelia growth and fruiting body formation. His highest yield was however obtained on Mango sawdust and not a mixture of wood shavings as used in this study. Ayodele and Okhuoya (2007) had also obtained higher fresh weight of fruiting bodies (61.63 g) on sawdust compared to the 30 g obtained from our corncob substrate. It is not clear however if the sawdust used in the study of Ayodele and Okhuoya (2007) was a mixture of wood shavings as is usually used or were wood shavings from a particular tree species.

The sawdust used in our study was a mixture of wood particles from different plants, there may therefore be some particles from some of the wood that may tend to inhibit the growth of the fungus. This inhibition effect of sawdust mixture has been reported by Davis and Aegeter (2000). This is further collaborated by Candy (1990) who grew mushrooms on different pure sawdust types and obtained the best results from Eucalyptus sawdust followed by pine sawdust confirming the fact that sawdust from different trees produces different effects on the growth of mushroom. Zervakis *et al*. (2001) had also reported that supplemented oak sawdust was a poor substrate for the growth of *Pleurotus sajorcaju*. Islam *et al*. (2009) on the other hand, had also reported that sawdust is consistently the best medium for mycelia growth and fruitification.

The mycelia length was least on sawdust and corncob combinations of 40+60% (5.0 cm) and 60+40% (5.37 cm) as shown in Table 2.

The mycelia length obtained from the corn cob and sawdust substrates were comparable to that obtained by Atikpo ***et al.*** (2008) who cultivated mushroom on fresh fish waste. The mycelia should have colonized the entire compost within four weeks as reported by Quimio *et al*. (1990). However, during the study, the spawn run lasted for more than 5 weeks. This could also be due to the compactness of the substrate as also reported by Stamets (2005). The 100% corn cob substrates gave the highest figures for mycelia girth (2.08 cm), diameter of fruiting bodies (8.0 cm), fresh weight (30.0) and dry weight (10.0) of fruiting bodies. These parameters were least on the two substrate combinations of 40% sawdust + 60% corn cob and 60% sawdust + 40% corn cob as shown in Table 2. This could be due to a change in the pH of the medium since the mycelium of mushroom prefers a pH range of 5.5 -7.8 for optimum growth (Viziteu, 2000). When a sample of the substrates which consisted of 40% sawdust and 60% corn cob as well as that of 60% sawdust and 40% corn cob were mixed with water and the pH of the solutions taken, the pH of the two substrates were 4.0 and 5.2 respectively, which were lower than any of the optimum pH ranges for mushroom growth.

The biological efficiency was worked out against the dry weight of each substrate. It is clear from Table 3 that as a substrate, 100% corn cob showed the highest biological efficiency of 91.21% and this was followed by sawdust 85.69%. The higher biological efficiency of sawdust has been confirmed by Shah *et al*. (2004) who reported that Pleurotus ostreatus gave maximum bioefficiency on sawdust and the biological efficiency of Substrates have been linked to the yield of oyster mushrooms (Shah *et al*., 2004).

CONCLUSION

It is concluded that corn cob used as a substrate for oyster mushroom cultivation performs better than saw dust in terms of the growth and yield of the mushroom.

Corn cob can therefore substitute for saw dust since it is cheaply available all year round unlike sawdust where the demand is between mushroom growers and poultry farmers.

ACKNOWLEDGMENT

We acknowledge the support of the Technology Village of the School of Agriculture, University of Cape Coast, Ghana for their support in supplying the mushroom spawns and also making their mushroom cultivation room completely available to us for the success of this study.

REFERENCES

Anderson, E.E. and C.R. Feller, 1942. The food value of mushroom, *Agariucus compestri*. Pool Am. Soc. Hort., 41: 301-303.

Atikpo, M., O. Oghenekome, M. Abazinge, C. Louime, M. Dzomeku, L. Boateng and A. Bawa, 2008. Sustainable mushroom production in Africa: A case study in Ghana. Afr. J. Biotechnol., 7: 249-253.

Ayodele, S.M. and J.A. Okhuoya, 2007. Cultivation studies on *Psathyrella atroumbonata* Pegler. A nigerian edible mushroom on different agro industrial wastes. Int. J. Bot., 3: 394-397.

Candy, C.L., 1990. The cultivation of Pleurotus in Mauritania. Proceedings 1st Conference on African Mycology, (CAM'90), Mauritius, pp: 1-5.

Davis, R.A. and B.J. Aegerter, 2000. Edible Mushroom Cultivation. Scientific Publishers, Jodhupur, India, pp: 2-5.

Fujihara, S., A. Kasuga, T. Sugahara, K. Hashimoto, Y. Shimizu, T. Nakazawa and Y. Aoyagi, 2000. Nitrogen content of shirtake mushroom [*Lentinus edodes (berk.)* Sing] cultivated on *Sawdust medium* and dependence on that in the medium. J. Japan. Soc. Food Sci. Technol., 47: 191-196.

Hilbe, J.M., 2007. GenStat 9. Am. Stat., 61: 269-273.

Islam, M.Z., M.H. Rahman and F. Hafiz, 2009. Cultivation of Oyster Mushroom(*Pleurotus flabellatus*) on different substrates. Int. J. Sustainable Crop Product., 4: 45-48.

Khan, S.M., A.G. Kausar and M.A. Ali, 1981. Yield performance of different strains of oyster mushroom (*Pleurotus* spp.) on paddy straw in Pakistan. Mush Sci., 11: 675-679.

Kurtzman, R.H. Jr., 1976. Nutrition of *Pleurots sapidus*: Effects of lipids. Mycologia, 68: 286-295.

Maria, P., E. Gonzalez, J. Mattusch and R. Wennrich, 2008. Chemically modified maize cobs waste with enhanced adsorption properties upon methyl orange and arsen. Bioresour. technol., 99: 5134-5139.

Onuha, C.T., 2007. Cultivation of the mushroom (*Pleurotus tuber regium*) using some local Substrates. Sci. J., 4: 58-61.

Osei, P., 1996. Mushroom Cultivation with Special Emphasis on an Appropriate Techniques for Developing Countries. Backhuys Publishers, The Netherlands, ISBN-10: 9070857367, pp: 2-21.

Quimio, T.H., 1976. Cultivation ganoderma the Pleurotus-way mushroom. Newslett. Trop., 6: 12-130.

Quimio, T.H., S.T. Chang and D.J. Roysee, 1990. Technical Guidelines for Mushroom Growing in the Tropics (FAO Plant Production and Protection Papers). Food and Agriculture Organization of the United Nations, Rome, Italy, pp: 106.

Shah, Z.A., M. Ashraf and M. Ishtiaq, 1981. Comparative study on cultivation and yield performance of oyster mushroom (*Pleurotus ostreatus*) on different substrates (Wheat straw, Leaves and Sawdust). Pak. J. Nutr., 3: 158-160.

Shah, Z.A., M. Ashraf and M. Ishtiaq, 2004. Comparative study on cultivation and yield performance of oyster mushroom (*Pleurotus ostreatus*) on different substrates. Pak. J. Nutr., 3: 158-160.

Stamets, P., 2005. Mycelium Running, How Mushroom can Save the World? Ten Speed Press, Berkeley, CA., ISBN: 1580085792, pp: 339.

Tan, K.K., 1981. Cotton waste is a fungus (*Pleurotus*) good susbtrate for cultivation of *Pleurotus ostreatus* the oyster mushroom. Mush. Sci., 11: 705-710.

Tewari, R.P., 1986. Mushroom Cultivation. Indian Institute of Horticulture Research, Banglore, India, pp: 36.

Vetayasuporn, S., 2007. The feasibility of using coconut residue as a substrate for oyster mushroom cultivation. Biotechnology, 6: 578-582.

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.

Zervakis, G.A., S. Philippoussis, S. Ioannidou and P. Diamantopoulou, 2001. Mycelium growth *Kinetics* and optimal temperature conditions for the cultivation of edible mushroom Species on lignocellulosic substrates. Folia Microbiol. (Praha), 46: 231-234.