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Technical Report

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BY:

D. Baka, D. L. Narh, M. Obodai, M. Dzomeku and R. K. Takli

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CSIR-Food Research Institute, P. O. Box M20, Accra

Abstract

The yield performance and physical characteristics of *Pleurotus ostreatus* strain EM-1 grown on composted sawdust of *Triplochiton scleroxylon* under Ghanaian conditions were studied. These were studied using four cropping techniques on the plastic bag: one surface exposed, two surfaces exposed, ten slits and ten punches on the sides of the bag. The bags with ten punches had the highest mean cap weight (14.86g) with the side slit bags having the least weight (3.82g). The increasing order of the cap to stipe weight ratio recorded was: one surface exposed, two surfaces exposed, ten side slits and ten punches. Based on the biological efficiency obtained within six weeks of cropping, the alternate technique to be used in the cultivation of oyster mushrooms is making ten side slits on the compost bag.

Introduction

There is a very high incidence of malnutrition, especially of protein deficiency in developing countries. The situation is especially severe in sub-Saharan Africa, which is the region with the highest prevalence of under nourishment with one in three people deprived of access to sufficient food (FAO, 2006). Protein malnutrition will become even more acute since the supply of protein for diet has not kept pace with population growth (FAO, 1996). Such a situation has forced planners and nutritionists to think about unconventional alternative sources of protein such as mushrooms (Chang and Mshigeni, 2001).

Mushrooms have been used as food for centuries in stews, soups, etc, being valued particularly for the variety of flavours and textures they can provide (Sadler, 2003). In Ghana, they have been well-known for centuries as a delicious and nutritious food. Mushrooms contain high amounts of protein, carbohydrates, vitamins and mineral salts (Chang and Mshigeni, 2001). Protein tends to be present in an easily digested form and on a dry weight basis, mushrooms normally range between 20 and 40% protein, which is better than many legume sources like soybeans, peanuts, and other protein-yielding vegetable foods (Chang and Buswell, 1996; Chang and Mshigeni, 2001). Moreover, mushroom proteins contain all the essential amino acids needed in the human diet and are especially rich in lysine and leucine, which are lacking in most staple cereal foods (Chang and Buswell, 1996; Sadler, 2003).

Mushrooms are low in total fat content and have a high proportion of polyunsaturated fatty acids (72 to 85%) relative to total fat content, mainly due to linoleic acid. The high content of linoleic acids is one of the reasons why mushrooms are considered a health food (Chang and Mshigeni, 2001; Sadler, 2003). Furthermore, they contain significant amounts of carbohydrates and fibres as well as vitamins, especially B complex vitamins and some vitamin C, and they appear to be rich in inorganic mineral nutrients (Crisan and Sands, 1978; Chang and Buswell, 1996).

In Ghana, wild mushrooms come into season at the beginning of the wet season from March to September. During this period, they form an important part of diet and income for many rural and urban dwellers. Mushroom in recent times has become a contemporary business enterprise because of its high nutritional and medicinal values, and consequently high societal demand. There is therefore the need to maintain a constant supply of mushroom by cultivating rather than depend on seasonal forest supplies (Onuoha *et al.*, 2009).

With the introduction of the plastic bag method in Ghana, edible mushrooms such as *Pleurotus* species can be produced all year round on composted sawdust prepared from *Triplochiton scleroxylon* popularly known as "wawa" and other lignocellulosic by-products (Obodai and Johnson, 2002). These mushrooms serve as a source of income for mushroom farmers. It is also important to note that not only must mushrooms be cultivated all year round but that the yields that arise should be high enough to cater for the demands of the market and for farmers to enjoy the benefits of their input.

This paper presents the yield performance with physical characteristics of *Pleurotus ostreatus* strain EM-1 grown on composted sawdust of *T. scleroxylon* under Ghanaian conditions using the plastic bag method and four cropping techniques.

Materials and Methods

2.1. *Culture preparation and maintenance:*

The mushroom species used for the study is *Pleurotus ostreatus* strain EM-1 originally obtained from Mauritius and maintained alternately on Potato Dextrose Agar and Malt Extract Agar (OXOID, England) slants. Spawn of this mushroom was prepared on sorghum grains as described by Oei (1996). Both the cultures and the spawn were incubated at 26-28°C and 60-65% RH.

2.2. *Substrate preparation*

The compost was prepared by the outdoor single phase solid waste fermentation. Fresh sawdust of *Triplochiton scleroxylon* K. Schum obtained from Timber Market, Accra was mixed and composted as described by Obodai and Johnson (2002).

2.3. *Cropping*:

After the spawn run the bags were transferred onto horizontal racks inside a cropping house (a wooden framed tent structure with cemented floor, covered with woven straw mats on the outside). Four cropping techniques with five replicates were used in this experiment:

a) One side open and placed horizontally on the racks (TA) control (Figure 1)

b) Two sides open and placed horizontally on the racks (TB) (Figure 2)

c) Ten diagonal side slits with length 2.7cm and 7.4cm apart were made along the length of the bags using a scapel. These bags were placed vertically on the racks (TC) (Figure 3)

d) Ten punches made with a cork borer of diameter 5mm were made on the bags at 5.9cm apart along the length of bags. These were placed vertically on the racks (TD) (Figure 4).


Figure 1

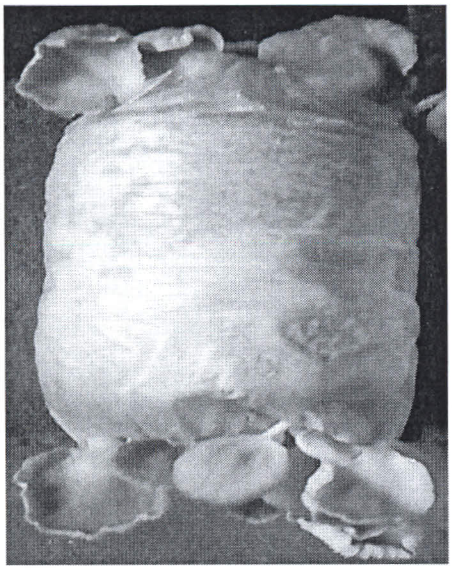
Figure 2


Figure 3


Figure 4

NB: Figures 1, 2, 3 and 4 are showing the various cropping techniques with the first flush of mushrooms.

Watering of the bags was done twice daily to increase the humidity and induce fruit body formation at 26±2°C and 90±5% RH. The number of days taken from opening the bags to the formation of primordia was recorded. Also, the physical characteristics (cap and stipe weight, the cap diameter, the stipe circumference and its length) of the first flush of mushrooms were recorded. The ratio of cap weight to stipe weight was also determined. The total yield per flush, as well as the total number of fruit bodies was also recorded. The biological efficiency was determined as a percentage of the ratio of the fresh weight of mushrooms to the dry weight of substrate at spawning as described by Mueller *et al*. (1985)

2.4 *Statistical Analysis*

Experimental results were analyzed statistically, where necessary, using the two-way ANOVA statistics of Microsoft Office Excel 2007 and the results quoted at 5% level of significance.

Results and Discussion

Mycelial growth during incubation

Diameters of mycelia growth ranging between 4.1 and 5.2cm and 4.2 and 5.5cm on day 7 and day 14 of incubation have been reported by Obodai *et al* (2003) for this same strain EM-1 cultivated on various substrates: fresh and composted sawdust, rice husk, corn husk, banana leaves and rice straw. The values obtained in this study are within those of other authors (Obodai *et al*., 2003). However, when a comparison was carried out on composted sawdust alone slightly higher values were obtained in this study (Table 1) than that of Obodai *et al*., (2003) (3.0cm and 4.2cm for day 7 and 14 respectively). This variation could be attributed to varying environmental conditions prevailing during the time of experimentation. Spawn run period for the mushroom during incubation (Table 1) falls within the range of 20-47 days recorded by Frimpong-Manso *et al* (2010) for *P. ostreatus* cultivated on composted sawdust supplemented with rice husk in varying concentrations. Dense mycelia growth were observed on the bags.

Table 1: **Mycelial growth on substrate.**

Parameter	**Value**
Diameter of mycelia growth on day 7 (cm)	4.5±0.4
Diameter of mycelia growth on day 14 (cm)	5.8±0.7
Spawn run period (days)	32.0±1.5
Mycelial density	+++

+++ Dense mycelia growth

Physical characteristics of first flush

The physical characteristics of the first flush of mushroom fruit bodies are presented in Table 2. Varying differences were observed in the cap and stipe weights, the cap diameter, the stipe circumference and its length for the different cropping techniques (Table 2). The bags with 10 punches (TD) had the highest mean cap weight (14.86g) with the side slit bags (TC) having the least (3.82g) (Table 2). Bags with cropping technique TC (side slits) had the lowest stipe weight of 0.9g compared to that of the one side open (TA), which had 2.68g.

The increasing order of the cap to stipe weight ratio recorded was as follows: one side opened (TA) – 2:1, both sides opened (TB) – 3:1, ten side slits (TC) – 4:1 and ten punches (TD) – 7:1.

Table 2: Physical characteristics of fruit bodies for first flush of mushrooms

Cropping techniques	Cap weight (g)	Stipe weight (g)	Cap diameter (cm)	Stipe circumference (cm)	Stipe length (cm)
TA	1.5-19.5	0.5-5.0	3.3-9.6	1.4-4.9	5.6-10.9
Means	6.32	2.68	6.12	2.8	8.06
TB	2.0-30.0	0.5-8.0	3.2-12.9	1.5-5.2	4.6-9.3
Means	6.08	2.02	5.8	2.52	6.6
TC	0.5-11.5	0.5-2.5	3.4-8.5	0.9-3.8	2.2-5.6
Means	3.82	0.9	5.44	2.1	4.22
TD	3.5-33.5	0.5-4.5	4-13.5	0.5-5.8	1.5-7.2
Means	14.86	2.06	8.7	3.3	4.9

Mushroom Production

The bags with the two surfaces exposed and placed horizontally on the racks (TB) had a relatively shorter time for the formation of primordia as compared to the other cropping techniques (Table 3). Across all cropping techniques, flush 1 gave the highest mean yield (64.1g) and flush 5 the lowest mean yield of 31.2g. Flush 2 produced the second highest mean yield (46.8g). Significant differences ($P<0.05$) were found between flushes 1, 2, 4 and 5. Although by flush 3 more than 70% of the total yield of the fruit body had been obtained, the proportional weight of mushrooms obtained per flush shows the importance of continuously harvesting till flush 5 (Table 3). The biological efficiency obtained for the different cropping techniques shows that cropping with ten slits is significantly higher ($P<0.05$) than the other techniques used. The biological efficiency (BE) obtained with one end exposed (TA) in this study (63.49%) was comparable with previous work done by Obodai *et al.*, (2003) who obtained a BE of 61.04% using the same substrate and the same cropping technique.

Table 3: Biological efficiency and yield of mushrooms per flush.

Cropping techniques	Days from bag opening to primordia formation	Yield/ Flush(g) 1st flush	2nd flush	3rd flush	4th flush	5th flush	Biological Efficiency (%)
TA	3	53.1	54.8	42.1	35.0	25.0	63.49a
TB	2	90.0	36.0	41.4	22.6	23.0	61.78a
TC	3	74.1	45.3	47.6	40.6	44.1	77.11b
TD	5	39.1	50.9	53.7	56.6	32.5	62.06a

Values in the same column followed by a common letter **do not** differ significantly ($P \geq 0.05$)

In general, the number of fruit bodies per flush recorded decreased from flush to flush (Table 4) indicating that the nature and amount of nitrogen available in a substrate after each flush influence the degree of cellulose degradation which in turn affects the yield (Zadrazil and Brunnert, 1980). The number of fruit bodies ranged from 22 in the first flush to 8 by the 5th flush. In terms of the cropping techniques the flushes obtained for the two ends exposed (TB) from the second flush through to the end of the study period showed lower yields. This may be due to the fact that when both ends are exposed there is a wide surface area available for water loss from the bags through evaporation. This large surface area also accounts for the high yield obtained for the first flush. The possibility of the wide surface area being available for water loss cannot be overlooked as a reason for the observed low yields per flush from the second through to the last flush. A larger surface area exposed to open air would lead to production of small mushrooms (Oei, 1996). The number of fruit bodies also account for the high biological efficiency recorded.

Table 4: Number of fruitbodies per flush.

Cropping Technique	Mean number of fruitbodies/flush					Total number of fruit bodies
	1st flush	2nd flush	3rd flush	4th flush	5th flush	
TA	9.0±1.60	7.0±1.40	7±0.89	6.0±1.36	4.0±0.26	159
TB	16.0±1.40	9.0±1.02	8±0.48	4.0±1.02	6.0	214
TC	22.0±1.59	6.0±1.29	7.0±1.96	7.0±1.28	8.0±0.58	235
TD	4.0±1.24	4.0±0.24	8.0±2.50	7.0	3.0	122

The bags with 10 punches made along the length of the bag and placed vertically on the racks (TD) showed rise in the number of fruit bodies from the third and fourth flushes as compared to the other setups including the control with one surface exposed (TA). The reduced yield for the last flush can be attributed to changes in conditions necessary for flushing.

Conclusion

Efforts to improve the biological efficiency of *Pleurotus ostreatus* (Jacq. ex. Fr.) Kummer has been an area of continuous research in Ghana. Different cropping techniques in addition to different additives and substrates have been identified as possible ways of increasing the biological efficiency of mushrooms using the plastic bag method. Cropping techniques which requires making slits on the bags has proved to increase the biological efficiency by 18% over the control.

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