Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 6 (7): 1098-1102, 2007
ISSN 1682-3974

Yield Evaluation of *Lentinus squarosulus* (Mont) Sing. On Selecte Sawdust of Economic Tree Species Supplemented with 20% Oil Palm Fruit Fibers

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Abstract: The yield of *Lentinus squarrosulus* (Mont) singer was evaluated following its cultivation on sawdust from seven economic trees (*Mansonia altissima*, *Piptadeniastrum africanum*, *Nesogordonia papaverifera*, *Combretodendron macrocarpum*, *Terminalia* sp., *Khaya ivorensis* and *Brachystegia nigerica*). The sawdust in each case was supplemented with 20% oil palm fruit fibers. Good growth was observed in all the sawdust except *Combretodendron macrocarpum*. Between the control and each sample, differences in mean mycelial density were significant (p = 0.05) but differences among the different supplemented sawdust media were not. Supplementation with 20% oil palm fruit fibers advanced the time of primordial emergence and enhanced the fresh weight and number of flushes of the mushroom. The sawdust giving the highest yield was *Brachystegia nigerica* while the one with the lowest was *Combretodendron macrocarpum*.

Key words: Yield evaluation, *Lentinus squarosulus*, sawdust, oil palm fruit fibers, supplementation

INTRODUCTION

The history of mushroom cultivation is traced to the Romans. In early times, cultivation failed because the biology of fungi was not understood and this led to the initial problems of mushroom cultivation (Oei, 1996; Stamets, 2000). Today, there is a better understanding of the biology, nature and development of many species of edible mushroom (Isikhuemhen *et al*., 2000; Okhuoya, 2000; Okhuoya *et al*., 2000; Kurtzman, 2000; Martinez-Carrera, 2000; Wuyep *et al*., 2002).

In many countries, particularly developed countries, mushroom cultivation and its products yield a lot of income and enhanced dietary meals and improved health of the people (USDA, 2000; Mattila *et al*., 2001; Mau *et al*., 2001, 2002; Wasser, 2002; Chu and Chao, 2002; Akpaja *et al*., 2003). Agricultural wastes, wild grasses and industrial wastes that include sawdust and leaves of many plants, rice bran and wheat bran which are generally abundant in many countries and cause pollution problems are utilised as raw materials in preparing substrates for the growth of mushroom mycelia and fruit bodies (Isikhuemhen *et al*., 2000; Okhuoya, 2000; Osemwegie *et al*., 2002; Joshua and Agina, 2002; Kuforiji *et al*., 2003; Agina and Joshua, 2004; Chiroro, 2004; Okhuoya *et al*., 2005). In order to enhance mycelial and fruit body growth, these substrate materials commonly are supplemented with nutrients that are rich sources of nitrogen, vitamins and carbohydrate (Royse *et al*., 1990, 1991; Royse, 1996; Isikhuemhen *et al*., 1999; Stamets, 2000; Chiroro, 2004). The supplementation enhances yield in several mushrooms as it provides extra nitrogen or easily degradable carbohydrates or both. In turn these extra nutrients improve flavour production, quality and shelf life of cultivated mushrooms (Mau *et al*., 1991; Chang, 1996; Isikhuemhen *et al*., 1999; Chiroro, 2004; Okhuoya *et al*., 2005). In addition, supplementation improves the biological efficiency of mushrooms.

The present study was undertaken in order to evaluate the mycelial growth and yield of *Lentinus squarrosulus* on different sawdust of economic trees supplemented with 20% Oil Palm Fruit Fibers (OPFF). The overall significance of this is that sawdust is a necessary (waste) product from economically important trees that are exploited to yield timber. Although sawdust is used predominantly as domestic fuel nowadays, its economic advantage would be much higher if channelled to mushroom cultivation. That would also reduce environmental pollution which would otherwise result from burning the sawdust.

MATERIALS AND METHODS

Sawdust from *Mansonia altissima*, *Piptadeniastrum africanum*, *Nesogordonia papaverifera*, *Combretodendron macrocarpum*, *Terminalia* sp., *Khaya ivorensis*, *Brachystegia nigerica* was obtained during timber processing from Uwasota sawmill at Uwasota street

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in Benin City, Nigeria. Calcium carbonate ($CaCO_3$) was bought from a chemical dealer in Benin City, Nigeria while sugar was bought at Uselu market in Benin City, Nigeria. Oil Palm Fruit Fibers (OPFF) were collected from an oil mill factory in Benin City, Nigeria. Cellophane bags (15×30 cm) were purchased in the market for the study. The study was carried out at the Department of Botany, University of Benin, Benin City, Nigeria in May, 2005.

Each sawdust type was mixed 1% $CaCO_3$, 1% sugar and 20% OPFF on oven dry weight basis. They were composted separately by adding enough water and heaping up to ferment for 7 days with turning every 2 days (Quimio *et al*., 1990). The moisture content of the fermented sawdust was adjusted to 75% with sterile distilled water.

Five hundred grams oven dry weight equivalent of the fermented and moistened substrates were loaded into cellophane bags measuring 15×30 cm each. Five replicate bags were prepared for each treatment A polyvinyl chloride (PVC) pipe measuring 5 cm wide and 3 cm long was passed through the top of each bag. Thereafter, the mouth of the bag was plugged with cotton wool and covered with foil paper.

The bags were then loaded into a steamer and steamed for 4 h at the temperature of about 70°C. They were allowed to cool down to ambient temperature before they were inoculated at 5% level of spawning. After complete colonization of the substrates, the bags were opened for fruiting. This was followed by periodic watering of bags with sterile distilled water. The environment was ventilated for adequate aeration.

The following parameters were determined:

- Time for complete colonization.
- Time of primordial emergence.
- Fresh weight and dry weight of mushroom.
- Flush pattern.
- Percentage organic matter loss (calculated by subtracting the weight of spent substrate from dry weight of substrate divided by dry weight of substrate and multiplied by hundred).
- Percentage biological efficiency (calculated by fresh weight of mushroom divided by the dry weight of substrate and multiplied by hundred).

The experiment was arranged as a complete randomised design and the results were analysed using simple descriptive statistics such as mean and standard error. Mean was separated using analysis of variance (ANOVA).

RESULTS

Supplementation of sawdust from seven economic trees with 20% oil palm fruit fibers enhanced the mycelial growth and sporophore yield of *Lentinus squarosulus.* Mean mycelial density was higher in supplemented sawdust than control (sawdust only) (Table 1). There was a significant difference in mean mycelial density ($p = 0.05$) between control and each sample but none among the different sawdusts.

The time of primordial emergence also varied between the control and the supplemented sawdust. The first appearance was on control of *Piptadeniastrum africanum* (40.66±0.88 days) and followed by *Combretodendron macrocarpum* (49.67±5.93 days). The first emergence in supplemented substrates was also in *Piptadeniastrum africanum* (55.00±1.00 days) followed by *Brachystegia nigerica* (56.33±1.20 days). The latest emergence of sporophore in the control was in *Terminalia* sp. (63.60±1.16 days) while the latest emergence on supplemented substrates was observed on *Combretodendron macrocarpum* (61.33±5.46 days) (Table 2). There was significant difference among the controls ($p = 0.05$) while there was no significant difference among the treated substrates at $p = 0.05$.

Mean fresh weight was higher in all the treated sawdust than in the controls except in *Combretodendron macrocarpum.* The highest yield on treated sawdust was on *Brachystegia nigerica* (46.10±1.5 g) while the least was *Combretodendron macrocarpum* (21.63±5.90 g). In the control, the highest yield was on *Brachystegia nigerica* (32.10±1.56 g) while the least was on *Terminalia* sp., (5.20±0.31 g) (Table 3).

Percentage biological efficiency was higher in treated sawdust than in the control. The highest biological efficiency was observed on treated sawdust of *Brachystegia nigerica* (8.13%) while the least was on *Piptadeniastrum africanum* (3.94%). In the control, *Mansonia altissima* has the highest biological efficiency

Table 1: Mean fresh weight (g) of mycelia of *Lentinus squarosulus* on sawdust of selected economic trees supplemented with 20% Oil Palm Fruit Fibers (OPFF)

	Mean fresh weight (g)	
Economic trees	Control (Sawdust only)	SD+20%OPFF
Mansonia altissima	4.67±0.33	5.00±0.00
Piptadeniastrum africanum	1.33±0.33	5.00±0.00
Nesogordonia papaverifera	2.33±0.33	4.33±0.33
Combretodendron macrocarpum	3.00±0.58	5.00±0.00
Terminalia sp.	4.00±0.58	4.33±0.67
Khaya ivorensis	1.67±0.33	5.00±0.00
Brachystegia nigerica	3.00±0.55	5.00±0.00

SD = Sawdust

Table 2: Time of sporophore emergence of *Lentinus squarosulus* on sawdust of selected economic trees supplemented with 20% Oil Palm Fruit Fibers (OPFF)

	Time of sporophore emergence (Days)	
Economic trees	Control (Sawdust only)	SD+20%OPFF
Mansonia altissima	61.00±2.31	56.67±0.88
Piptadeniastrum africanum	40.66±0.88	55.00±1.00
Nesogordonia papaverifera	65.33±2.60	57.67±2.03
Combretodendron macrocarpum	49.67±5.93	61.33±5.46
Terminalia sp.	63.60±1.16	57.67±0.67
Khaya ivorensis	53.00±3.21	56.67±1.33
Brachystegia nigerica	43.33±1.86	56.33±1.20

SD = Sawdust

Table 3: Mean fresh weight of *Lentinus squarosulus* on selected economic trees supplemented with 20% Oil Palm Fruit Fibers (OPFF)

	Mean fresh weight (g)	
Economic trees	Control (Sawdust only)	SD+20%OPFF
Mansonia altissima	25.61±5.11	34.07±5.140
Piptadeniastrum africanum	7.47±0.58	22.13±9.910
Nesogordonia papaverifera	19.73±1.53	36.93±13.15
Combretodendron macrocarpum	26.03±9.49	21.63±5.900
Terminalia sp.	5.20±0.31	30.00±2.710
Khaya ivorensis	22.63±1.25	42.63±10.91
Brachystegia nigerica	32.10±1.56	46.10±1.500

SD = Sawdust

Table 4: Percentage biological efficiency of *Lentinus squarosulus* on selected economic trees supplemented with 20% Oil Palm Fruit Fibers (OPFF)

	Biological efficiency (%)	
Economic trees	Control (Sawdust only)	SD+20%OPFF
Mansonia altissima	4.27	6.32
Piptadeniastrum africanum	1.25	3.94
Nesogordonia papaverifera	3.10	5.83
Combretodendron macrocarpum	3.87	4.00
Terminalia sp.	0.87	4.17
Khaya ivorensis	3.21	5.74
Brachystegia nigerica	3.37	8.13

SD = Sawdust

Table 5: Mean number of flushes of *Lentinus squarosulus* on sawdust of selected economic trees supplemented with 20% Oil Palm Fruit Fibers (OPFF)

	Mean No. of flushes	
Economic trees	Control (Sawdust only)	SD+20%OPFF
Mansonia altissima	1.00±0.00	1.33±0.33
Piptadeniastrum africanum	1.00±0.00	1.00±0.00
Nesogordonia papaverifera	2.00±0.00	1.00±0.00
Combretodendron macrocarpum	1.33±0.33	1.00±0.00
Terminalia sp.	1.00±0.00	1.33±0.33
Khaya ivorensis	2.33±0.33	1.33±0.33
Brachystegia nigerica	1.67±0.33	1.00±0.00

SD = Sawdust

(4.27%) while the least was observed on *Terminalia* sp. (0.87) (Table 4). The mean number of flushes was almost the same except in the control of *Nesogordonia papaverifera*, *Khaya ivorensis* and *Brachystegia nigerica* which had higher mean numbers of flushes than the treated sawdust (Table 5).

Table 6: Percentage organic matter loss in substrates of *Lentinus squarosulus* on sawdust supplemented with 20% Oil Palm Fruit Fibers (OPFF)

	Percentage organic matter loss	
Economic trees	Control (Sawdust only)	SD+20%OPFF
Mansonia altissima	17.33	15.95
Piptadeniastrum africanum	17.74	24.18
Nesogordonia papaverifera	24.63	9.29
Combretodendron macrocarpum	8.20	9.84
Terminalia sp.	29.80	3.63
Khaya ivorensis	42.57	9.88
Brachystegia nigerica	16.41	13.43

SD = Sawdust

The total percentage organic matter loss was higher in control than in the treated substrates except in *Piptadeniastum africanum* and *Combretodendron macrocarpum* which have the highest percentage organic matter loss (Table 6).

DISCUSSION

Supplementation of substrates has become one of the major aspects of mushroom cultivation. This is in order to boost the yield of mushrooms. *Lentinus squarrosulus* grew better on the different sawdust when 20% oil palm fruit fibers were added. The supplement obviously modified the substrates, hence, there was a better conversion and utilisation of the substrates for mycelial growth and sporophore yield. This is in line with the report of Zadrazil (1993) who reported that supplements usually change the decomposition rate and the sequence of decomposition of substrate components during mushroom growth. Supplementation of substrates with different levels of carbon and nitrogen-based additives has been shown to enhance mushroom production (Royse *et al*., 1990, 1991; Zadrazil, 1993; Fasidi and Kadiri, 1993; Royse, 1996; Isikhuemhen *et al*., 1999; Stamets, 2000). Royse *et al*. (1990) have reported formulas incorporating supplements, particularly grains in mushroom substrates. In this study, all the sawdust types, supplemented with 20% OPFF showed variable results in supporting mycelial density and sporophore yield of *Lentinus squarrosulus.*

There was a higher mycelial density in all the sawdust types when supplemented with 20% OPFF except in *Terminalia* sp. It does appear that OPFF at 20% failed to promote mycelial formation in *Terminalia* sawdust. This may be due to the carbon to nitrogen imbalance in the *Terminalia* sawdust (Stamets, 2000; Okhuoya *et al*., 2005). It could also be due to the fact that the concentration used fell below or above the required concentration that can promote mycelial growth (Stamets, 2000; Okhuoya, 2005).

The supplement reduces the time of sporophore emergence in *Mansonia altissima*, *Nesogordonia papaverifera* and *Terminalia* sp. and there was a delay in sporophore emergence in *Piptadeniastrum africanum*, *Combretodendron macrocarpum*, *Khaya ivorensis* and *Brachystegia nigerica*. This observation is contrary to the report of Fasidi and Kadiri (1993), Royse (1996), Isikhuemhen *et al.* (1999) and Kuforiji *et al.* (2003) who reported that supplementation stimulates both mycelial extension and sporophore emergence and yield in *Lentinus subnudus* and *Pleurotus tuberregium* on agricultural wastes.

There was higher fresh weight of *Lentinus squarrosulus* on all sawdust supplemented with 20% OPFF except on *Combretodendron macrocarpium*. This is in line with the report of Royse and Schisler (1986), Han *et al.* (1981) who reported higher yield of Shiitake mushrooms when supplements were added to their substrates at different concentrations. The stimulatory effect observed with 20% OPFF may be due to the nutrients in OPFF which stimulate the utilization of the sawdust effectively. The lower fresh weight observed in *Combretodendron macrocarpium* may be due to the inability of the 20% OPFF to stimulate the growth of *Lentinus squarrosulus* on the sawdust (Stamets, 2000). According to Han *et al.* (1981), there is an optimum concentration of different supplements and on different substrates which can enhance or stimulate mycelial growth and sporophore yield of mushrooms. This may be the case in *Combretodendron macrocarpium*. The 20% OPFF may be below or above the concentration needed to stimulate sporophore yield in *Lentinus squarrosulus*.

A higher Biological Efficiency (BE) was observed in supplemented substrates with 20% OPFF. This supported the works of Fasidi and Kadiri (1993), Royse (1996) on *Pleurotus tuberregium* and *Lentinus subnudu*, respectively. The observed variation in organic matter loss was in line with the report of Fasidi and Kadiri (1993), Isikhuemhen *et al.* (1999) who observed that the stimulatory concentration of supplements varies according to the substrates and ability of the supplement to modify the substrate for the mushroom to utilize effectively.

This study showed that OPFF at 20% concentration significantly enhanced the yield of *Lentinus squarrosulus* on different sawdusts tested. It therefore means that OPFF can be employed as supplement in the cultivation of *Lentinus squarrosulus*. This could lower the cost of production. However, the limiting concentration of OPFF for yield enhancement needs further investigation.

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