YIELD OF EDIBLE *PLEUROTUS* MUSHROOMS GROWN ON RICE STRAW WITH AND WITHOUT CHICKEN MANURE SUPPLEMENTATION IN MOROGORO, TANZANIA

[1]Andrew S.M. [1]Maliondo, S.M.S [1]Munishi, P.K.T. & [2]Msita H.

[1]Department of Forest Biology, Faculty of Forestry & Nature Conservation, Sokoine University of Agriculture, P.O. Box 3010, Chuo Kikuu, Morogoro, Tanzania

[2]Department of Soil Science, Faculty of Agriculture, Sokoine University of Agriculture, P.O. Box 3000, Chuo Kikuu, Morogoro, Tanzania

Corresponding Author: smacrice@yahoo.com, smacrice@suanet.ac.tz

ABSTRACT

An experiment was conducted to determine the performance of different species of edible *Pleurotus* mushrooms grown on rice straw substrate with and without chicken manure supplementation. The *Pleurotus* species /varieties tested were *P. flabellatus* of Tanzania, India and Thailand origin, and *P. sajor caju* from Tanzania. Rice straw with and without chicken manure were used as substrates. The results showed that the duration of time from spawning to pin formation and from pin formation to first harvest was not significantly different for both treatments (p=0.05). The yields of the Indian and Thai *P. flabellatus* varieties were significantly higher than yields of *P. flabellatus* and *P. sajor caju* from Tanzania (p=0.05). The yields of the substrate amended with manure and un-amended were not significantly different. These results suggest that yields of the studied varieties of *Pleurotus* mushrooms are not influenced by substrate amendments rather other factors like spawn quality. This implies that use of high quality spawn can be a good determinant of high yields. On the other hand local varieties had lower yields than exotic varieties under the same treatments showing that research and breeding to screen and select for good quality local edible varieties can adequately improve yields and utilization of local breeds/varieties.

Key words: Pleurotus flabellatus - Pleurotus sajor caju – yield – amendmended, un-amended substrates

INTRODUCTION

Pleurotus or oyster mushroom is a wood destroying, saprophytic fungus though sometimes it appears as parasitic. It is a primary decomposer, and commonly known as "flesh fungi" (Chang & Hayes 1978). In the mid 1980's it was the fourth edible mushroom to be produced world wide in tonnage (Chang 1987). They grow on wide range of forest and agricultural wastes than other mushrooms (Poppe 2000). Even without any artificial inoculation, mushrooms have always been observed on different kinds of humid agricultural and forestry waste materials. This fungus also grows on dead tree trunks and branches, but rarely on living trees (Hashimoto & Takahashi 1974).

More than 1500 macro fungi are already widely used as human food although only a few are grown on large scale. Because all these macromycetes are active in biotransformation of lignocellulose waste, we should stimulate the domestication of at least hundred desired wild edible species (Somasundaram *et al.* 1992). *Pleurotus* is one of the preferred edible mushrooms which can be cultivated in the tropics. Although it has gained importance only in the last two decades, it is now being cultivated in many countries in the subtropical and temperate zones (Chang & Quimio 1982). It can be used as a source of protein and other food nutrients especially in the developing countries where meat may be rare and expensive. They are good source of non-starchy carbohydrates, dietary fibre, essential amino acids, minerals and vitamins of the B group and folic acid (Rajarathnam

1986). They also contain vitamin C and D (FAO 1990). *Pleurotus* as a source of medicine has been reported by Cochran (1978), and contain also retene-a substance that has an antagonistic effect on some forms of tumours (Ikekawa 1969). *Pleurotus* has the advantage that being a primary decomposer (Stametes 1993), its substrates need not be processed into compost. This raises the possibility for the small growers who would not have facilities for composting. On the other hand such farmers may have substantial quantities of crop residues like rice straw, maize cobs etc. which could be used for mushroom production.

Mushrooms vary in their ability to convert substrate materials into the edible product as measured by a simple formula known as the Biological Efficiency (B.E), originally developed by the white buttons mushroom industry. The formula states that: One lb of fresh mushrooms grown from 1 lb of dry substrate is 100% biological efficiency considering the host substrate is moistened to approximately 75% water content and that most mushrooms have a 90% water content at harvest, 100% B.E is also equivalent to growing 1 lb of fresh mushrooms for every 4 lbs of moist substrate, a 25% conversion of wet substrate mass to fresh mushrooms or achieving a 10% conversion of dry substrates mass into dry mushrooms (Stametes, 1993). Many of the cultivation techniques will give yield substantially higher than 100% B.E up to half conversion of wet substrate mass into harvestable mushrooms.

FAO (1990) reported that yields range from 100-200% of the dry weight of the substrate and depend on the substrate combination as well as the way in which the substrate has been managed during the fruiting season. From the observations the richer the combination and the whiter and denser the mycelium the greater will be the mushroom yield. It is hypothesised that Nitrogen supplementation will result into higher yields. Magingo *et al*. (2004) in his experiment on cultivation of *Oudemansiella tanzanica* nom. prov. on three agricultural solid wastes, he supplemented with dried chicken manure (Nitrogen supplement). The best results in fresh weight were obtained in paddy straw that was supplemented with 5% chicken manure. To date, few researches have been done to increase the yields of oyster mushrooms by substrates combinations in Tanzania. We therefore hope that, this study will contribute significantly to mushroom cultivation knowledge.

Generally, cultivated mushrooms can grow on agricultural and industrial wastes, which constitute a source for obtaining good protein. Agricultural wastes are used in mushroom cultivation. These wastes are useless by products which can be recycled to produce additional food in the form of mushrooms for human consumption. In the process, environmental pollution may be reduced. Further more it can be a source of employment potential. Such wastes can therefore be marshalled to aid in solving many problems of global importance including protein shortages, resources recovery and environmental management. This necessitated the study on the suitability of different locally available substrate and combination levels to increase yields of the different species of *Pleurotus* mushrooms. The experience gained can be conveyed to small farmers hence improve production under minimum cost. Also the knowledge can be used to motivate other farmers who are not aware of such possibilities so that they can enter into production and thus improve their income by selling the produce which is highly demanded even in the local market.

Therefore, the study reported here was carried out to evaluate the effect of manure supplement to the rice straw substrates on the yield of four different varieties of oyster mushrooms. *Pleurotus flabellatus* was chosen because it is the most brilliantly

coloured while *Pleurotus sajor caju* is capable of fixing nitrogen (Thayumanavan 1980). Specific objectives were;

a) To determine the effects of treatments on the duration it takes for the spawn run to colonise substrates sufficiently to start producing the fruiting bodies.
b) To compare the effects of manure supplementation in the rice straw substrate on the overall yield performance of varieties.
c) To determine the duration of harvesting before the substrate becomes exhausted for each combination of substrate and supplement.

MATERIALS AND METHODS

Procurement of mushroom spawn

Spawn of *Pleurotus flabellatus* varieties from Tanzania, India and Thailand and *Pleurotus sajor caju* from Tanzania were obtained from the University of Dar es salaam, Microbiology Unit.

Preparation of the substrate and their spawning

The substrates were rice straw from Sokoine University Farm and its surrounding environment for provision of carbohydrates, the basic food for mushroom, and chicken manure to provide nitrogen, potassium and phosphorus. All fresh substrates had been dried before any degradation had occurred. To increase the surface area for the colonization of the fungi, rice straw was chopped into 2 to 6 cm pieces (FAO 1990). It was then soaked in water overnight for moisture absorption. The straw was then pasteurized by boiling in water in a pan for 1.5 to 2 hours. After boiling, the straw was placed on wire sieves to drain off excess water. The manure was also boiled separately. Then, the rice straw was mixed with chicken manure in the manure supplement treatments. The treatments were control with 500 g of rice straw (unamended), and 500 g of rice straw with 50 g of rotten chicken manure (amended) (Magingo *et al*. 2004). For each treatment, the substrate was placed in a 10 x 16 cm polyethylene bag while wet. The substrate in a polyethylene bag was emptied and spread on a clean, dry polyethylene sheet for mixing with the spawn. Spawn of 100 g per 5 kg substrate (wet weight basis) was added and thoroughly mixed with each treated substrate. The polyethylene bags of 10 x 16 cm were re-filled with foregoing mix, tied at one end and eight holes of about 2 cm were made on the polyethylene bags to aid air circulation.

Spawn running and fructification

We created an environment similar to mushroom cultivation conditions in other places (Oei 1996). The bags contained spawned substrates were placed on disinfected shelves in floor concrete dark room. Windows and the door frames were covered with wire gauze to bar insects and rodents. The dark room was kept humid by pouring 5 litres of water daily and the temperature ranged from 21 to 35^0C of which after 11 to 14 days the mycelium had sufficiently colonized them.

Substrates were subjected to fructification conditions. The beds were placed in a well ventilated room with temperature which ranged from 25 to 32^0C and lowered relative humidity of 35-75% by placing pans perpetually filled with water. The beds were subsequently watered 2 to 3 times a day during the cropping period.

Harvesting of fruit bodies

The fruit bodies were harvested when the caps were open. All fruit bodies were collected from different treatments, kept separate and fresh weight measured. Data were recorded systematically for analysis.

Experimental design

The experiment was arranged in a completely randomised block design (CRBD). Varieties of mushroom used were *P. flabellatus* (Indian, Thai and Tanzanian) and *P. sajor caju*. Substrates were rice straw with no manure as control

(unamended) and straw supplemented with manure (amended). These treatments were replicated four times.

Data analysis

The following observation were made; days from inoculation to pin formation, days from pin formation to first harvest, yields of each harvest and total yields, were analysed to get means and summations. Analysis of variance (ANOVA) was employed to determine the variations between treatment means. Tukey's test was used to separate means where ANOVA showed that significant differences existed.

RESULTS AND DISCUSSION

Yield performance of the different *Pleurotus* species/varieties in manured substrate

The yields of the mushrooms on manured rice straw are presented in Table 1. From the table the first harvest of the Indian and Thai *P. flabellatus* varieties produced significantly (P=0.05) higher yields than the Tanzanian varieties of *P. sajor caju* or *P. flabellatus*. In the second and third harvests, all the varieties did not differ significantly in yields. These harvests were being significantly (P=0.05) lower than the first one. The total yields followed the same trend as the first harvest.

Table 1 Yield performance of different species/varieties grown on substrate supplemented with chicken manures

Species/varieties	Yields (g)			
	1st harvest	2nd harvest	3rd harvest	Total yields
P. sajor caju Tanzanian variety	20.87b	13.84a	8.41a	43.12b
P. flabellatus Tanzanian variety	19.70b	5.25a	2.38a	27.26b
P. flabellatus Indian variety	38.21a	15.35a	8.43a	61.99a
P. flabellatus Thai variety	42.59a	18.20a	8.09a	68.87a

Means within a column followed by the same letter were not significantly (P=0.05) different according to Tukey's test. The duration of time from spawning to pin formation was significantly (P=0.05) longer in the Indian and Thai varieties than in the Tanzanian varieties (Table 2). But there was no difference in all the varieties in the duration from pin formation to the first harvest (Table 2).

Table 2 Duration taken by the species/varieties from spawning to pin formation and from pin formation to first harvest in the manured substrate

Species/varieties	Duration (days)	
	Pin formation	1st harvest
P. sajor caju, Tanzanian variety	25ab	2.3a
P. flabellatus, Tanzanian variety	23b	3.0a
P. flabellatus, India variety	26a	2.5a
P. sajor caju, Thai variety	26a	2.8a

Means within a column followed by the same letter are not significantly (P=0.05) different according to Tukey's test

The significantly (P=0.05) higher yields, in both the first harvest and subsequently the total yields, in the Indian and Thai varieties compared to the Tanzania ones, may be due to long term and thorough screening and

selection of the former for high yields. For example, Stametes (1993) stated that elsewhere much work has been done to select the good strains which can give high yields of good quality mushrooms. This is unlike in the Tanzanian varieties, which like in many tropical countries have not undergone any rigorous screening for higher yields for commercial purposes. Rather, the only screening done has been largely for suitability in resolving other specific genetic problems and ease in handling in the laboratory (Chang & Quimio 1982). Therefore, such varieties need more screening to be undertaken to maximize yields.

The lack of significant difference in the yields of all the varieties in the second and third harvests, and the lower levels of yields in these harvests compared to the first one, may be due to depletion of nutrients in the substrate. Thus, competition for nutrients resulted in yields reduction since the mycelia were well established throughout the whole substrate. This depletion caused low yield in those subsequent harvests. Similar observation were made by Nita (1998), that though the mushrooms appeared in the beds, there were no heavy flushes later on in the depleted substrate.

Generally, the performance per 500g of substrate in the present study was low compared to the yields obtained from other experiments. For example FAO (1990), obtained 210-270g per 500g of substrate for some *Pleurotus* spp. The lower yields might have been partly due to failure of maintaining the optimum aeration conditions for fruitfication.

The duration from spawning to pin formation of *Pleurotus* in the present study was within the range of 20-30 days. The same trend was observed by Zadrazil (1974) with the straw substrate taking 20-30 days for mycelia to establish. Also, Nallathambi and Marimuthu (1994) reported that a sample of paddy straw was colonized by *P. sajor caju* for 20 ± 2 days at optimal condition before pins were formed. Further more, depending on the substrate combination the mycelia took 20-30 days to develop (FAO 1990). The longer duration exhibited by the Indian and Thai varieties are consistent with the higher yields by those varieties and the vice versa for the Tanzanian varieties. The longer duration may have resulted in better and more extensive development of the mycelia, thus contributing to the higher yields. For example Rajarathnam *et al*. (1986) observed that prolonging the spawn run period by serially disturbing and rebuilding mushroom beds led to a further increase in yield.

The duration from pin formation to first harvest in the present study also agrees well with report by other workers. For example, Nallathambi and Marimuthu (1994) reported that it took 2 days to harvest under experimental conditions. Also, it was mentioned that the mature mushrooms should be ready for harvesting in 2 to 3 days after pin formation (FAO 1990).

Yield performance of the different *Pleurotus* species/varieties in un-amended substrate

The yields of the mushrooms on manured rice straws are presented in Table 3. The yields of the first harvest for all varieties of the Tanzanian, Indian and Thai *P. flabellatus* were not significantly different (P=0.05).

Table 3 Yield performance of different species/varieties grown on un-amended substrate

Species/varieties	Yield (g)		
	1st harvest	2nd harvest	Total yield
P. sajor caju, Tanzanian variety	26.98a	*	26.98a
P. flabellatus, Tanzanian variety	26.83a	2.92b	29.75b
P. flabellatus, India variety	38.41a	19.65a	58.06a
P. sajor caju, Thai variety	34.55a	16.82a	51.37a

Means within a column followed by the same letter are not significantly (P=0.05) different according to Tukey's test. (*) No harvest obtained

Table 4. Duration taken by the species/varieties from spawning to pin formation and from pin formation to first harvest in the un-amended substrate

Species/varieties	Duration (days)	
	Pin formation	1st harvest
P. sajor caju, Tanzanian variety	27a	2.0a
P. flabellatus, Tanzanian variety	21c	3.0a
P. flabellatus, India variety	25bc	3.3a
P. sajor caju, Thai variety	28b	4.0a

Means within a column followed by the same letter are not significantly (P=0.05) different according to Tukey's test.

In the second harvest the Indian and Thai varieties of *P. flabellatus* produced significantly (P=0.05) higher yields than the Tanzanian varieties of *P. flabellatus.* The total yields followed the trend of the second harvest.

The duration of time from spawning to pin formation was significantly (P=0.05) longer in the Thai variety and the Tanzanian *P. sajor caju* followed by the Indian *P. flabellatus* variety and lastly the Tanzanian variety (Table 4). But there was no difference between varieties in duration from pin formation to first harvest (Table 4).

It is hard to explain the similar yields observed in all mushroom varieties in the first harvest. But significantly ((P=0.05) higher yields of the Indian and Thai varieties in the second harvest and in total yields as compared to the Tanzanian variety may imply that the foreign varieties were better able to colonise and extract nutrients from the unamended substrate than was the Tanzanian variety.

The duration from spawning to pin formation of three varieties were within the range of 20-30 days as it was observed in manured substrate. Also the duration from pin formation to the first harvest was as in manured substrate.

The longer duration from spawning to pin formation in the Tanzanian *P. sajor caju* variety in the un-amended substrate (Table 4) compared to the amended one (Table 2) may be due to shortage of nutrients in the un-amended substrate. Manuring of the substrate introduced an ample supply of nutrients, unlike in the un-amended substrate. Therefore, it took much longer for the mycelium to mineralize nutrients and to fully colonize the un-amended substrate before forming pins.

Effects of manure on yield performance

The yields of the mushrooms on both un-amended and amended rice straw are presented in Table 5. From the table, the total yields or harvests of both un-amended and amended substrate were not significantly (P=0.05) different. The duration of time from spawning to pin formation was not significantly (P=0.05) different between those which were

amended and those un-amended substrates (Table 6). Also, the duration from pin formation to first harvest was not significantly different in both treatments (Table 6).

Table 5 Effect of manures on overall yield performance of the mushroom varieties

Treatments	Yields (g)
Un-amended substrates	33.27a
Manured substrates	33.50a

Means within a column followed by the same letter are not significantly (P=0.05) different according to Tukey's test.

Table 6 Comparison of duration from spawning to pin formation and pin formation to first harvest in control versus manure substrate

Treatments	Duration (days)	
	Pin formation	1st harvest
Un-amended substrates	18.38a	3.42a
Manured substrates	18.44a	2.75a

Means within a column followed by the same letter are not significantly (P=0.05) different according to Tukey's test.

The lack of significant difference in yields between manured and control treatments may be due to the fact that in the amended substrate the nitrogen added during spawning was used only for spawn run growth (Smith 1974). The manure was not used for increasing yields after spawn run. Rajarathman *et al.* (1986) stated that materials added during spawning were not fully utilized by the mushrooms due to the mushroom's small biomass. Thus, yields were not increased. However, it has been reported by Rajarathman et al. (1986) that organic nitrogen supplementation of the substrate increased yields and protein contents of the fruits bodies significantly only if applied after spawn run. In this way, the yields obtained were higher compared to those from unamended substrate, as was similar observed by Smith (1974).

CONCLUSION AND RECOMMENDATIONS

The varieties of P. flabellatus of India and Thai origin gave higher yields than the Tanzanian varieties of P. flabellatus and P. sajor caju. Manure supplements during spawning had no significant effects on yields. From the study it shows that there is a need to undertake breeding work to screen and select our edible local varieties in order to improve yields to equal or surpass the exotic varieties. Further studies could investigate optimization of nutritive potential of various substrate formulations in our environments which could lead to high yields, even under small producer conditions. P. sajor caju in control plots were late in fruiting, further research is needed. The growers engaged in Pleurotus mushroom production should use spawn of high quality and yields high.

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