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Performance of Oyster Mushroom (*Pleurotus ostreatus)* on Cotton Waste Amended with Maize and Banana Leaves

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Abstract: The experiment was conducted to evaluate the growth and performance of oyster Mushroom (*Pleurotus ostreatus*) on the different substrates. The substrates used in the study were T_1 (100% C.W), T_2 (50% C.W + 50% Banana leaves), T_3 (75% C.W + 25% Banana leaves), T_4 (50% C.W + 50% Maize leaves) and T_5 (75% C.W + 25% Maize leaves). The numbers of days to complete the mycelium growth and days to reach harvesting stage were decreased in treatments T_1 and T_5 when compared to others treatments followed by T_2. The numbers of matured mushrooms were greater in T_1, T_2 and T_5. Total yield was significantly higher in T_1 (125 g), T_2 (121 g) and T_5 (119.8 g) respectively. The maximum dry weight was produced by T_1 (27.2 g) and T_2 (25.0 g) respectively over others treatments. The nitrogen contents after harvesting of mushrooms were also affected. These results investigated that 100% cotton waste and 50% cotton waste + 50% Banana leaves are suitable for the cultivation of mushrooms as compared to other growing media.

Key words: Cotton waste, mushroom, *Pleurotus ostreatus*, yield, substrate

INTRODUCTION

Mushroom is one of the most suitable fungal organisms for producing protein rich food from various agro-wastes without composting. Oyster mushrooms (*Pleurotus* sp.) belong to class Basidiomycetes and family pleutaceae, grow naturally in the temperate and tropical forests on dead and decaying wooden logs. Mushrooms convert agro-wastes into protein rich palatable food through enzymatic action. It contains 85-90% moisture, 3% protein, 4% carbohydrates, 0.2% fat and 0.1% mineral and vitamins (Tewari, 1986). Mushrooms are not only used as food but are also known for anticholestrol, anti tumor and anti cancerous properties. Quimio (1976) mentioned the effect of *Gunoderma lucidium* on the diabetes, ulcers, liver and lungs maladies. Mushrooms have been used as a food and medicine since long time. There appears to be a reference to Muslims in a saying of Holy Prophet Muhammad (SAW) that mushrooms was a part of mun-o-salwa (food given to the followers of Prophet Moses (Khan *et al*., 1980).

Its cultivation was first described at the beginning of the 20th century on tree logs.

Cultivation of oyster mushroom is becoming more popular throughout the world because of their abilities to grow at a wide range of temperatures utilizing various lignocelluloses (Khanna and Garcha, 1981). The normal fruiting period is during the autumn and winter months when the temperature is approximately 15-25°C. Oyster mushrooms in particular are valuable with good marketability and are relatively easy to grow. Climate is a successful factor for mushroom cultivation. Indoor cultivation methods, which allow precise climate control, are generally very expensive to establish and operate. Many agricultural by-products and waste materials have been used to produce the Oyster mushroom. It represents one of most efficient biological ways by which these residues can be recycled (Madan *et al*., 2003). The growth and fruiting of an individual mushroom species on a particular waste material will hence depend largely upon the ability of that mushroom to produce the enzymes essential to degrade the major components of the waste particular (or its growth substrate) and thereafter absorb it as food.

A large amount of waste materials are available in Pakistan (Anonymous, 2000). *P. ostreatus* has been cultivated on substrates such as cereal straw, com cobs, sawdust, bagasse, wood pulp, cotton and oil palm waste, banana leaves, coconut husks, poultry wastes, tree bark and leaves. For spawn running and fruit body development lignin and cellulose materials such as com cobs, all cereal straws, paper, wood shavings, sawdust, nutshells and vegetable wastes as well as food industry wastes are sufficient (Yildiz *et al*., 2002). *Pleurotus* species have extensive enzyme systems capable of utilizing complex organic compounds which occur as agricultural wastes and industrial by-products.

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For this reason, it is not necessary to process substrates for cultivation of *Pleurotus* sp. Production of *Pleurotus* sp. accounted for 14.2% of the total world output (616,100 t) of edible mushrooms in 1988 (Chang and Miles, 1989). The higher price received for fresh Oyster mushrooms reflects, in part, the less developed and less reliable technology available to growers for cultivating these species (Das and Mukherjee, 2007).

Cultivation of Oyster mushroom in Pakistan is in its teething stage and its pace of development is very slow because of the insufficient public and private sector support. Farmers in Pakistan usually use cotton waste and other water materials for Oyster mushroom production due to its high biological efficiency. Mushroom can be grown on different additives (agricultural waste material) to increase its production. Therefore, keeping in view the availability of agricultural industrial waste materials in Pakistan, study was conducted to evaluate the performance of oyster mushrooms on agricultural residues such as cotton waste, maize waste and banana leaves.

MATERIALS AND METHODS

The present investigation was conducted in the Mushroom laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. The oyster Mushroom (*Pleurotus ostreatus*) was cultured on cotton waste, banana leaves and maize leaves. The species of oyster mushroom *Pleurotus ostreatus* were obtained from the culture bank of mushroom laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Five different substrates i.e., T_1 (100% Cotton waste), T_2 (50% Cotton waste + 50% Banana leaves), T_3 (75% Cotton waste + 25% Banana leaves), T_4 (50% Cotton waste + 50% Maize leaves), T_5 (75% Cotton waste + 25% Maize leaves) were used. Experiment was laid out in completely randomized design with five replications.

Cotton waste, banana leaves and maize leaves were used as substrates in the study. These substrates were soaked in water and 2-4% lime was mixed. Mixture was then piled up, covered with plastic sheet and allowed to ferment for 3-5 days. The substrates was spread on the ground to remove the excessive water, finally humidity of substrate was maintained up to 70%. Then the material was filled into heat resistant polypropylene bags.

Substrate filled bags were pasteurized in an ordinary drum at 1000°C for one hour. Next day bags were inoculated with grain spawn at the rate of 10 gram per bag. When the bags became white due to impregnation by fungal mycelium, the mouths were opened in the racks in a growing room for cropping. During spawn running the temperature in growth room was controlled be from 20-25°C. Humidity was maintained between 70-80% by sprinkling water on the floor several times a day. Spawn was placed on the top of the substrates and the openings of the bags were tied up loosely with the thread and small holes were made in the plastic bags. The spawned bags were kept perfectly in the dark room until mycelium was fully penetrated the substrate downward. After the completion of previous step, later in case of cropping, moisture content of the substrate were visually checked daily. However, during the cropping period the bags were sprinkled with water twice a day.

Chemical analysis of substrates for nitrogen determination was performed, according to the method approved by AOAC (1960). Data collected on different parameters of mushroom were analyzed statistically by using MSTAT-C programme and means were compared using Fisher's protected Least Significant Differences (LSD) test at 5% probability level (Steel and Torrie, 1998).

RESULTS AND DISCUSSION

Number of days taken to complete mycelial growth: The analyses of variance indicated that the treatments significantly affected the number of days taken to complete mycelial growth of mushroom (Table 1). It was observed that treatment T_4 (50% C.W + 50% Maize leaves) required maximum days (45 days) to complete mycelial growth followed by T_3 (75% C.W + 25% Banana leaves; 33.60 days) which took (33.60 days). In Cotton waste least number of days were required to complete mycelial growth and were on par with T_2 (50% C.W + 50% Banana leaves), T_5 (75% C.W + 25% Maize leaves). It might be due to the use of different growing media that delayed mycelial growth. The results of study were confirmed by findings of Saghir (1998) who obtained maximum mycelial growth on cotton waste.

Time taken to appear pinheads: Significant differences among the different treatments on pinhead development were observed (Table 1). Cotton waste substrate took minimum number of days (9.20 days) to produce pinheads in mushroom which was statistically not different to T_2 (50% C.W + 50% Banana leaves), T_3 (75% C.W + 25% Banana leaves) and T_5 (75% C.W + 25% Maize leaves). While highest numbers of days were taken in T_4 (50% C.W + 50% Maize leaves). The results of study are supported by outcome of Khan and Khan (2001) who conducted the oyster mushroom cultivation on different substrates and observed that pin head formation took 7-8 days and sporocarps formed in 10-12 days after spawn running on different media. Similarly the same conclusion was made by the study of Shah *et al*. (2004) who reported that pin head formation took 6-7 days.

Number of pinheads: Different growing media had a significant effect on the number of pinhead (Table 1). Maximum pinheads were recorded in T_1 (100% Cotton waste) followed by in T_2 (50% C.W + 50% Banana

Table 1: Effect of different substrates on mycelial growth, appearance of pinheads, number of pinheads and harvesting of mushrooms

Substrates	Days to complete the mycelial growth	Days taken to appear pinheads	Number of pinheads	Days to reach harvesting stage
100% Cotton waste	28.60c	9.2b	37.60a	33.20d
50% C.W + 50% Banana leaves	30.80c	10.0ab	33.40b	35.40c
75% C.W + 25% Banana leaves	33.60b	10.4ab	30.40bc	39.80b
50% C.W + 50% Maize leaves	45.00a	11.8a	28.00c	52.20a
75% C.W + 25% Maize leaves	29.00c	10.8ab	32.00b	34.40cd
LSD (p>0.05)	2.78	1.85	3.38	2.10

Mean followed by the same letters in column are statistically similar to each others at p>0.05

Table 2: Effect of different substrates on the yield components of mushrooms

Substrates	Number of mature mushrooms	Yield of mushrooms on 1st flush (g)	Yield of mushroom on 2nd flush (g)	Total yield of mushrooms (g)
100 % Cotton waste	15.40a	73.20a	53.80a	125.00a
50% C.W + 50% Banana leaves	14.00ab	69.80ab	52.20a	121.40ab
75% C.W + 25% Banana leaves	11.20c	67.40b	48.20a	115.60b
50% C.W + 50% Maize leaves	12.20bc	66.80b	41.00b	107.80c
75% C.W + 25% Maize leaves	13.40abc	68.20b	50.20a	119.80ab
LSD (p>0.05)	2.57	4.25	5.80	7.70

Mean followed by the same letters in column are statistically similar to each others at p>0.05

leaves) that was statistically similar to T_5 (75% C.W + 25% Maize leaves) and T_3 (75% C.W + 25% Banana leaves). While minimum pinheads were observed in T_3 (75% C.W + 25% Banana leaves) and was at par with T_4 (50% C.W + 50% Maize leaves). The greater number of pinheads is due to moisture contents present in the growing media. Our findings are similar with the results of Khan and Ali (1981).

Number of days to reach harvesting stage: Days taken to harvesting stage were significantly affected by different growing media (Table 1). The substrate T_1 (100% Cotton waste) took less time to achieve harvesting stage and was on par with T_5 (75% C.W + 25% Maize leaves) and T_2 (50% C.W + 50% Banana leaves). The maximum number of days to reach harvesting stage were observed in T_4 (50% C.W + 50% Maize leaves) and T_3 (75% C.W + 25% Banana leaves) respectively. Our results are in accordance with the investigation of Heltay (1987) who observed that cultivation of *P. florida* on different substrates such as barley, rye and wheat bran took 49 days.

Number of mature mushrooms: The number of mature mushrooms was significantly differed in different substrates (Table 2). The maximum number of mushrooms was obtained in T_1 (100% Cotton waste) and was statistically similar to T_2 (50% C.W + 50% Banana leaves) and T_5 (75% C.W + 25% Maize leaves). The minimum matured mushrooms were recorded in T_3 (75% C.W + 25% Banana leaves) and T_4 (50% C.W + 50% Maize leaves). Silva *et al*. (2002) also observed maximum yield of *P. pulmonarius* on cotton waste.

Yield of mushroom on 1st and 2nd flush: The maxim yield of mushrooms on first flush was observed in T_1 (100% Cotton waste) and on par with T_2 (50% C.W + 50% Banana leaves) followed by T_5 (75% C.W + 25% Maize leaves), T_3 (75% C.W + 25% Banana leaves) and T_4 (50% C.W + 50% Maize leaves). Our results are consistence with the findings of Upadhyay and Vijay (1991) who observed cottonseed substrate as a superior supplement for yield of *P. fossulatus*. The data regarding to yield of mushroom on 2nd flush was influenced significantly by the use of different media (Table 2). The highest yield was obtained in T_1 (100% Cotton waste) that was similar to T_2 (50% C.W + 50% Banana leaves), T_5 (75% C.W + 25% Maize leaves) and T_3 (75% C.W + 25% Banana leaves). The lowest mushrooms yield was observed in T_4 (50% C.W + 50% Maize leaves). Our results are in conformity with Belewu *et al*. (2006).

Total yield of mushrooms: The total fresh weight of mushrooms was significantly affected on different substrates (Table 2). Maximum total yield was observed in T_1 (100% Cotton waste) and was similar to T_2 (50% C.W + 50% Banana leaves) and T_5 (75% C.W + 25% Maize leaves) followed by T_3 (75% C.W + 25% Banana leaves). The minimum total yield was weighed in treatment T_4 (50% C.W + 50% Maize leaves). This result is similar to that of Khan and Khan (2001) who reported that cotton waste produced highest yield as compared to other growing media.

Dry weight of mushroom: The different substrates showed different response on dry weight of mushrooms (Table 3). Maximum dry weight of mushroom was noticed in T_1 (100% C.W) followed by treatment T_2 (50% C.W + 50% Banana leaves). Minimum dry weight of mushroom was recorded in T_4 (50% C.W + 50% Maize leaves) and was similar to T_5 (75%C.W + 25% Maize

Table 3: Effect of different substrates on dry weight and nitrogen contents before and after harvesting of mushrooms

Substrates	Dry weight of mushroom (g)	Nitrogen of substrate before harvest (%)	Nitrogen of substrate after harvest (%)
100% Cotton Waste	27.20a	0.76a	0.45a
50% C.W + 50% Banana leaves	25.00a	0.49c	0.29bc
75% C.W + 25% Banana leaves	24.40b	0.55c	0.39ab
50% C.W + 50% Maize leaves	23.00bc	0.65b	0.43a
75% C.W + 25% Maize leaves	23.40bc	0.37d	0.18c
LSD (p>0.05)	1.3	0.12	0.14

Mean followed by the same letters in column are statistically similar to each others at p>0.05

leaves). The present results coincide with those observed by Dhanda *et al*. (1996) who found that maximum dry weight of mushrooms on cotton waste.

Chemical analysis of substrates for nitrogen before and after harvesting of mushrooms: Five substrates were chemically analyzed to evaluate the nitrogen %age before the growing of the mushrooms (Table 3). According to chemical analysis, in T_1 (100% C.W) maximum nitrogen was present followed by treatment T_4 (50% C.W + 50% Maize leaves). While minimum nitrogen percentage was observed in T_5 (75% C.W + 25% Maize leaves).

Rajarathnam *et al*. (2001) also found more nitrogen percentage in cotton waste as compared to other substrates. Nitrogen %age of the different substrates was significantly reduced after the harvesting of the crop. Maximum nitrogen was determined in T_1 (100% C.W), T_4 (50% C.W + 50% Maize leaves) and T_3 (75% C.W + 25% Banana leaves) respectively. While minimum nitrogen contents were recorded in T_5 (75% C.W + 25% Maize leaves) and T_2 (50% C.W + 50% Banana leaves) respectively. These results are supported by study of Ranged and Jandaik (1997) who reported that nitrogen content of the substrate was depleted due to the consuming of nutrients by formation of fruit bodies.

Conclusion: Cotton waste substrate was found to be the best one for the growth and yield of *Pleurotus ostreatus* and was almost similar to mixing of cotton waste with Banana leaves and maize leaves respectively. Cotton waste is cost bearing and poor farmers are unable to use the cotton waste for the production of mushroom. While banana and maize leaves are easily available locally and can be used for the preparation of mushroom substrate. In this way, leaves of both banana and maize along with cotton waste are fruitful to reduce the cost of production of mushroom for ordinary mushroom growers.

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