Cultivation of Pleurotus Ostreatus on Agricultural Waste and their Combination

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Research Article

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Abstract

Background:

Mushrooms are increasingly becoming an important component of diets worldwide and it is of paramount importance to choose appropriate substrates to grow them. The objective of this study was to grow *Pleurotus ostreatus* using different agricultural substrates.

Methods:

Corncobs, Finger millet straw and Bamboo waste were collected from different sites of Awi zone. The substrates were chopped in to small pieces and 500g of their dry mass alone and their combination was measured packed in polythene bag, moistened, and pasteurized. The cooled substrates inoculated with a spoon of *P. ostreatus* spawn brought from Debre Berhan University. The bags were placed in growing room and growth parameters were recorded continuously with monitoring of environmental variables. The experimental setup was completely randomized design, six treatments with three replicates.

Results:

The fastest spawn running phase of *P. ostreatus* was observed in 28.71±0.80 days, pinhead formation of 32.36±0.26 days and fruiting bodies formation of 5.19±0.74 days after pinhead appearance was recorded on Corncob substrate. The highest fresh weight and biological efficiency with significant statistical association was obtained from the *P. ostreatus* grown on Finger millet straw (253.07±1.05 and 50.20±0.47 respectively). The highest average number of pinhead and fruiting bodies (29.60 and 11.44 respectively) was recorded on Finger millet straw. The lowest biological efficiency (20.80±0.41), fresh weight (101.48±0.91), number of pinhead (14.40), number of fruiting bodies (4.25) was recorded from a mixture of Corncob and Bamboo waste (50% each) substrates.

Conclusion:

The use of mixed Corncob and Bamboo waste (1:1) for cultivation of *P. ostreatus* is not encouraged due to poor growth performance.

Background:

One of the world’s biggest challenge is food insecurity. This problem is largely common in low and middle-income countries that mainly have poor food production systems and suffer from serious malnutrition. Mushroom cultivation could be a possible option to alleviate poverty and develop the life style of vulnerable people [1]. Mushroom growing naturally are good for human consumption. Some species are edible and others are poisonous [2]. The genus Pleurotus consist of 40 different species commonly known as “Oyster mushroom.” Among several species of this genus, *Pleurotus ostreatus* is widely consumed globally due to their taste, flavor, high nutritional content and medicinal properties [3].
Oyster mushroom is an important nutrient source of protein carbohydrates, vitamin, calcium, and iron [4]. Edible mushroom has low crude fat content and high proportion of polyunsaturated fatty acids [5]. Production of Oyster mushroom is becoming popular throughout the world due to it’s potential to grow at wide range of temperature and utilization of various lignocelluloses [6]. Mushroom cultivation does not always require access to land and significant capital investment, it’s production can be practiced by rural, peri-urban and urban dwellers [7].

Pleurotus species are widely cultivated throughout the world commonly in Asia, America and Europe because of simple, low-cost production technology and high biological efficiency [8]. The growth of Oyster mushroom requires high humidity (80–90%) and temperature of 25–30 °C for fruiting body formation [9]. The substrates for Mushroom production include rice straw, rice bran, wheat straw, pulp, corncobs, cocoa shell waste, cotton waste, spent grain, saw dust, maize husks, and cassava peelings [2, 10]. Other substrates are soybean straw, paddy straw, sun flower stalks, Sugarcane bagasses, fruit waste, used tea leaves, bamboo leaves and Maize stalk [11, 1, 12].

The spent substrate left after harvest could be used as soil conditioner for growth of plants and animal feed after mushroom cultivation [13]. Therefore, the current study intended to evaluate *Pleurotus ostreatus* cultivation on different substrates alone and their combination.

**Results:**

**Cultivation of** *Pleurotus ostreatus* **on different substrates**

Oyster mushroom (*Pleurotus ostreatus*) was grown on various crop residues as substrates. The growth performance of *Pleurotus ostreatus* on substrates alone and their combination was depicted in (table 1). The number of days taken for full spawn run ranged from 28.71 days to 43.79 days for Corncob and Bamboo waste respectively. The lowest growth period (32.36 days) for primordia initiation was recorded on Corncob alone, statistically significant with the longer duration (48.10 days) for primordia development recorded on Bamboo waste. The maximum number of days taken from pinhead formation to fruiting bodies formation exhibited significant difference between combination of Corncob & Bamboo waste (12.13 days). The lowest growth period for fruiting bodies formation was recorded on a combination of Corncob & Finger millet straw (4.64 days).

In our experiment the pileus diameter was highest (4.58 cm) on Finger millet straw significantly different with lowest (2.95cm) diameter observed on a combination of Corncobs and Bamboo waste. The highest (253.07g) fresh weight of harvested mushroom was recorded on Finger millet straw alone and the lowest (101.48g) was recorded on combination of Corncob and Bamboo waste. Biological efficiency varied significantly among the substrates used. The highest percentage of biological efficiency (50.20%) was reported from Finger millet straw significantly different from the least (20.80%) observed in combination of Corncob & Bamboo waste.
Table (1). Morphological parameters of *Pleurotus ostreatus* mushroom grown on different agricultural waste and their combination

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Spawn running in days</th>
<th>Appearance pinhead in days</th>
<th>Days for fruiting body formation</th>
<th>Pilus diameter in centimeter</th>
<th>Fresh weight of fruiting</th>
<th>Biological efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 = CC</td>
<td>28.71 ± 0.80</td>
<td>32.36 ± 0.26</td>
<td>5.19 ± 0.74</td>
<td>4.00 ± 0.79</td>
<td>144.18 ± 0.98</td>
<td>41.07 ± 0.37</td>
</tr>
<tr>
<td>T2 = FMS</td>
<td>34.88 ± 0.69</td>
<td>38.22 ± 124</td>
<td>5.20 ± 1.46</td>
<td>4.58 ± 0.15</td>
<td>253 ± 1.05</td>
<td>50.20 ± 0.47</td>
</tr>
<tr>
<td>T3 = BW</td>
<td>43.79 ± 1.54</td>
<td>48.10 ± 0.79</td>
<td>5.28 ± 0.59</td>
<td>2.99 ± 1.61</td>
<td>180.79 ± 0.56</td>
<td>35.07 ± 0.77</td>
</tr>
<tr>
<td>T4 = CC + FMS</td>
<td>30.99 ± 1.0</td>
<td>35.75 ± 1.50</td>
<td>4.64 ± 1.23</td>
<td>3.37 ± 0.49</td>
<td>233.74 ± 0.42</td>
<td>49.12 ± 1.11</td>
</tr>
<tr>
<td>T5 = CC + BW</td>
<td>43.45 ± 0.95</td>
<td>47.84 ± 0.73</td>
<td>12.13 ± 1.25</td>
<td>2.95 ± 0.41</td>
<td>101.48 ± 0.91</td>
<td>20.80 ± 0.41</td>
</tr>
<tr>
<td>T6 = FMS + BW</td>
<td>36.55 ± 0.95</td>
<td>39.08 ± 0.72</td>
<td>6.24 ± 0.73</td>
<td>3.40 ± 0.85</td>
<td>211.11 ± 0.98</td>
<td>42.27 ± 0.78</td>
</tr>
<tr>
<td>CV%</td>
<td>2.84</td>
<td>2.55</td>
<td>16.37</td>
<td>24.09</td>
<td>0.45</td>
<td>1.77</td>
</tr>
<tr>
<td>LSD</td>
<td>1.83</td>
<td>1.71</td>
<td>1.87</td>
<td>1.52</td>
<td>1.52</td>
<td>1.25</td>
</tr>
</tbody>
</table>

CC = Corncob, FMS = Finger millet straw, BW = Bamboo waste

Mean values within a column sharing the same superscript letter(s) are not significantly different by using LSD test at (P = 0.05).

**Discussion:**

Oyster mushroom (*Pleurotus ostreatus*) was successfully grown on substrates used for cultivation. [14] reported that agricultural wastes make the most ideal form of materials needed for substrate production and nearly all types of agricultural wastes are useful for mushroom production. In our study the spawn running phase took 28.71 days on Corncob 100% and 43.79 on Bamboo waste 100%. Our finding was disagreeing with [15], who reported that the vegetative growth phase takes 2–3 weeks after inoculation on Corncob and Sawdust 100%. Pinhead formation is the second stage in mycelia growth in mushroom cultivation. The pinhead formation observed between 2.53–4.76 days for all substrates after a period of complete mycelium running phase. Similarly [16], found that pinheads appeared 5.50 days after the spawn running. Buah et al., (2010), also reported that pinheads formed over six days for all substrates used in the experiment. Similarly [2], reported that the lowest time (5.80 days) for primordia initiation was
recorded on Sawdust statistically similar with Corncobs and palm cones in both (1:3) and (3:1) after mycelium running phase.

The maximum number of days taken from pinhead formation to development of fruiting bodies in our experiment was 12.13 days recorded on combination of Corncob & Bamboo waste (1:1). The lowest period (4.64 days) for fruiting bodies formation was recorded on Corncob & Finger millet straw (1:1). On the other hand, the fruiting body formation of all agro-industrial waste used tooks between 2–4 days after pinhead formation [17]. The Pilus diameter of harvested mushroom recorded to be between 2.95 to 4.58 cm on a combination of Corncobs and Bamboo waste (1:1) and Finger millet straw respectively. The finding was disagreement with the recorded cap-diameter of (8cm-14cm) on waste paper [18]. Similarly, our finding was in opposite with the highest cap diameter (12.65 cm) recorded on T12 (25% brewery spent grain + 75% cotton seed) and the lowest cap diameter (8.75) was recorded on T4 (100% saw dust) [16].

The highest (253.07g) weight of harvested mushroom was recorded on Finger millet straw (100%) and the lowest (101.48g) was recorded on combination of Corncob and Bamboo waste (50%). However, the finding was significantly higher than [19], who reported that Cotton waste produced maximum yield of (41.27g) followed by Paddy straw and Wheat straw with total yield of (35.87g) and (32.87g) respectively. Our observation was in opposite with [20], who found that the highest yield of mushroom recorded on a combination of maizcob & paddy straw 401.30g and lowest 276.80g cultivated on paddy straw. As shown in table 1, Biological efficiency varied significantly among various substrates used. The highest biological efficiency (50.20%) was obtained from Finger millet straw was significantly different from the least (20.80%) observed in combination of Corncob & Bamboo waste. The substrates with higher moisture retaining capacity perform better than those with lower moisture retaining capacity it was true in case of Finger millet straw in our experiment. However, the finding of this study was lower than reported literature of [17], who found that the highest biological efficiency of 79.72 % and lowest 48.5% Pleurotus ostreatus grown on different substrates. Also results of this study were far from reports of [18], biological efficiency of 136%-114% from the substrates of cotton seed wastes, maize leaves and maize sheaths

**Conclusion:**

The present study revealed that oyster mushroom (*Pleurotus ostreatus*) can grow on Corncob, Finger millet straw, Bamboo waste and their combination with varying growth performances. The least biological efficiency and fresh weight was recorded from a mixture of Corncob and Bamboo waste substrates. Finger millet straw was the best substrate in terms of yield & Biological efficiency.

**Materials And Methods:**

**Study site**
The study was conducted at Injibara University. The University was governmental institution and the cornerstone for establishment laid down in 2015 and started teaching undergraduate students in 2017. It was located in Injibara town, the capital city of the administrative center of Awi- Zone, Amhara, Ethiopia.

**Preparation of substrates**

Prior to collection of growing agricultural substrates, formal letter of recognition was given by Injibara University, research directorate to do so. Then Corncob (*Zea mays*) and Finger millet straw (*Eleusine coracana*) substrates were collected from districts of Chagni town. Bamboo waste (*Phyllostachys pubescens*) was collected from Injibara town. The substrates were transported to Injibara University and chopped into section 2 to 5 cm long. Finger millet straw, Bamboo waste and Corncob alone and their combination in (1:1) ratio were used as cultivation substrates. The weight of substrates were measured and soaked overnight in separate clean, fresh water plastic can. The excess water manually removed by squeezing with hand. Each substrate filled in polythene bag (500g/bag) with addition of lime at the rate of 5% (on dry weight basis) and their mouths was plugged by inserting water absorbing cotton with the help of plastic rings. The bags were pasteurized in drums at 100°C for 5 hours and are kept to cool for 6 hours.

**Treatment formulation of substrates**

For the cultivation of *P. ostreatus* the following treatments were made from different substrates

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Substrates</th>
<th>Composition</th>
<th>Dry Weight per bag</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-1</td>
<td>CC</td>
<td>CC (100%)</td>
<td>500 grams</td>
</tr>
<tr>
<td>T-2</td>
<td>FMS</td>
<td>FMS (100%)</td>
<td>500 grams</td>
</tr>
<tr>
<td>T-3</td>
<td>BW</td>
<td>BW (100%)</td>
<td>500 grams</td>
</tr>
<tr>
<td>T-4</td>
<td>FMS + CC</td>
<td>FMS (50%) + CC (50%)</td>
<td>250 gram each</td>
</tr>
<tr>
<td>T-5</td>
<td>CC + BW</td>
<td>CC (50%) + BW (50%)</td>
<td>250 gram each</td>
</tr>
<tr>
<td>T-6</td>
<td>FMS + BW</td>
<td>FMS (50%) + BW (50%)</td>
<td>250 gram each</td>
</tr>
</tbody>
</table>

CC=Corncob (*Zea mays*), FMS=Finger millet straw (*Eleusine coracana*), BW=Bamboo waste (*Phyllostachys pubescens*)

**Spawning**

One table spoonful of mother culture grain containing mycelia of *Pleurotus ostreatus* was placed aseptically through the hole of each bag. The bags were placed in a cropping dark room at 25°C for
spawn running phase and 17-20°C for fruiting body formation. Bags were sprinkled with water twice a day to maintain relative humidity.

**Harvesting of mushroom**

Harvesting performed when gills were well-formed and while the edge of the mushroom is still curled under. Harvesting was performed by gently pulling or twisting the mushrooms from the substrate.

**Fungal growth measurement**

**Days for spawn running phase**

Colonization of substrates with fungal mycelia was monitored at five days intervals. The numbers of days with full mycelia coverage of substrates after the day of spawning was recorded.

**Days for Pinhead Formation**

After the bags were partially opened, the formation of primordia was observed every day and the number of days that was taken for first primordia formation was observed and recorded.

**Days for Fruit body Formation**

The number of days taken for the formation of fruiting body of *Pleurotus ostreatus* was inspected daily after the formation of effective primordia. The days were numerically recorded.

**Pileus Diameter**

The pileus diameter of the caps was measured by using the measuring ruler and expressed in centimeter.

**Biological Efficiency**

Total weight of the fruiting bodies harvested from the substrates measures the efficiency of mushroom. Biological efficiency was calculated by the formula; \((\text{BE} \%) = \frac{\text{FWM}}{\text{DWS}} \times 100\). Where: \(\text{BE}=\)Biological Efficiencies, \(\text{FWM}=\)Fresh weight of mushroom and \(\text{DWS}=\)Dry weight of substrates

**Data collection and statistical analysis**

The experiment was completely randomized design (CRD) with three replications and six treatments. Analysis of one-way ANOVA was employed to test the overall significance of data while the least significance difference (LSD) test was used to compare the differences among varieties means. Time taken for completion of mycelium on substrates, appearance of pinheads, fresh weight, biological efficiency and maturation of fruiting bodies of different treatments was compared.

**Declarations:**
Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Availability of data and materials
Not applicable.

Competing interests
The authors declares that they have no competing interest.

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Authors' contributions
BK conceived experiments and drafted manuscript. BA and MM analyzed and interpreted the data. All authors read and approved the final manuscript.

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