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# GROWTH IMPROVEMENT AND YIELD PERFORMANCE OF Pleurotus SPECIES USING DIFFERENT SUBSTRATE COMBINATIONS

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## ABSTRACT

Mushrooms are edible fungi that obtain food from decaying organic matter and are considered healthy food that contain nutrients such as high quality proteins, essential amino acids, fats, vitamins, carbohydrates and fiber. This study was conducted to improve the growth and yield performance of *Pleurotus* species, specifically, *Pleurotus ostreatus*, *Pleurotus sajor-caju*, and *Pleurotus djamor* by improving the composition of fruiting bags using different substrate combinations. Based on the findings of the study, Treatment 3 (70% rice straw: 25% banana leaves: 2% rice bran: 2% molasses: 1% lime) performed the best in terms of length of incubation of fruiting bags of *P. ostreatus*, while Treatment 3 and Treatment 4 (70% rice straw: 25% tobacco midribs: 2% rice bran: 2% molasses: 1% lime) for *P. sajor-caju* and *P. djamor*. Comparing the three (3) *Pleurotus* species in terms of length of incubation, results show that *Pleurotus ostreatus* had the shortest length of incubation using Treatment 1 (70% rice straw: 30% sawdust) and Treatment 3. In terms of biological efficiency, Treatment 2 (70% rice straw: 25% sawdust: 2% rice bran: 2% molasses: 1% lime) had the highest biological efficiency among all the *Pleurotus* species used; *Pleurotus ostreatus* at 21.53%, *Pleurotus sajor-caju* at 21.93% and *Pleurotus djamor* at 21.53%.

**Keywords:** *Pleurotus* species, mushroom, substrate, substrate combinations, biological efficiency

## INTRODUCTION

### Rationale

Mushrooms have long been valued as delicious and nutritional food in many countries. These have been initially consumed for their flavor and are now consumed because of their rich nutritional value in terms of protein, mineral and vitamin content and medicinal properties.

Mushroom cultivation involves providing a medium and the right environment for the fungi (mushroom) to expand their mycelia until the mycelial mass transforms into fruiting bodies (the mushroom). The medium, often called as substrate, can be prepared from clean agricultural waste materials such as rice straw, rice bran, sawdust, banana leaves, etc.

Small-scale production of mushrooms does not require any huge capital investment. Since it does not require a large access to land area, mushroom cultivation is a viable and attractive activity for rural farmers and peri-urban dwellers. Mushrooms can be cultivated on a part time basis, and require minimal maintenance. It is an enterprise both for men and women and is especially an excellent enterprise for women since it does not demand much labor for production.

Mushroom cultivation is gaining popularity due to low cost technology and easy availability of various substrates for its cultivation. Central Luzon, as the rice granary of the Philippines devotes most of its agricultural

land into farming which generates tons of agricultural residues that can be used for mushroom production. Majority of mushroom growers in Central Luzon grow *Pleurotus* species in large scale, but their production still need adequate attention on the aspect of fruiting bag production.

Thus, this study aims to address the needs to improve the composition of mushroom fruiting bags in order to improve the growth and yield performance of *Pleurotus* species. It aims to evaluate various kinds of plant waste materials for cultivation of *Pleurotus* spp., so that alternative sources are available for use as substrates or as supplements to rice straw.

**Objectives**

Generally, the study aimed to improve the growth and yield performance of different *Pleurotus* species using different substrate combinations.

Specifically:

- to evaluate the performance of different *Pleurotus* species in different substrate combinations in terms of length of incubation;
- to determine the biological efficiency of *Pleurotus* species in different substrate combinations; and
- to determine the cost efficiency of each substrate combination used.

## METHODOLOGY

**Conceptual Framework**

| | |
|---|---|
| **GOAL** | Improve the composition of mushroom fruiting bags by using different substrate combinations. |
| **EXPECTED OUTPUT** | Determine the best substrate combination for *Pleurotus* species. |
| **S&T INTERVENTION** | Evaluate growth and yield performance of *Pleurotus* species in different substrate combinations in terms of length of incubation and biological efficiency. |
| **S&T GAP** | Need for other raw materials as substrates or supplements to rice straw for optimum growth and yield performance of *Pleurotus* species. |
| **PROBLEM** | Need for improvement of growth and yield performance of *Pleurotus* species. |

**Experimental Design**

Two-factor experiment using Completely Randomized Design was used in this study. The following were the treatments:

**Factor A (*Pleurotus* species)**
*Pleurotus ostreatus*
*Pleurotus sajor-caju*
*Pleurotus djamor*

**Factor B (Substrate combination)**
Treatment 1 - 70% rice straw: 30% sawdust (control)
Treatment 2 - 70% rice straw: 25% sawdust: 2% rice bran: 2% molasses: 1% lime
Treatment 3 - 70% rice straw: 25% banana leaves: 2% rice bran: 2% molasses: 1% lime
Treatment 4 - 70% rice straw: 25% tobacco midribs: 2% rice bran: 2% molasses: 1% lime

For each substrates combination (Factor B), three (3) replicates with eight (8) samples each were prepared for each *Pleurotus* species (Factor A).

**Preparation and Combination of Substrates**

The dried substrates (rice straw, tobacco midribs and banana leaves) were shredded, placed in clean sacks and soaked overnight. After soaking, the substrates were washed and drained. The different substrates were mixed according to each treatment (see Table 1) and each treatment was composted for three (3) days. After partial composition of the treatments, the moisture content and pH of the substrates were measured using a moisture and pH analyzer. The different substrate combinations were packed in 6x12 inches polypropylene bags (PP bags) with 750 g in weight, and PVC pipe was placed to serve as neck for the bags and were secured with a rubber band and cotton. The bags were sterilized using steam pasteurization method in a steel drum for eight (8) hours. After sterilization, bags were transferred to the inoculation room. The bags were cooled down for one (1) hour and were then inoculated with spawn grains of the three (3) *Pleurotus* species. Bags were incubated at room temperature until full ramification of mycelia. Daily monitoring of mycelial growth was done. The temperature and relative humidity of the incubation room was also recorded.

**Cropping**

Upon full ramification, the fruiting bags were then transferred to the fruiting house. The bags were opened on both sides and were watered three (3) times a day. Mushroom fruits were harvested every day for two (2) months of fruit flushing. Weight of fruits per harvest was recorded.

**Determination of Biological Efficiency**

Total weight of the harvested fruiting bodies in all pickings was considered as the total yield of each treatment. The biological efficiency (B.E.) of mushroom per kg substrate on dry weight basis was calculated using the formula by Chang, *et al*., (1981).

$$\text{B.E. (\%)} = \frac{\text{Fresh weight of mushroom}}{\text{Dry weight of substrate}} \text{ X } 100$$

**Statistical Analysis**

The data gathered were analyzed using Completely Randomized Design (CRD) and were subjected to test of significance using two-factor Analysis of Variance (ANOVA) and Least Significant Different Test (LSD) for means comparison.

## RESULTS AND DISCUSSION

Moisture content and pH of each treatment was measured using a pH and moisture analyzer and were recorded (Table 1).

**Table 1.** Moisture content and pH of each treatment.

| Treatments | Moisture | pH |
|---|---|---|
| T1 | 40% | 7.4 |
| T2 | 40% | 7.5 |
| T3 | 40% | 7.6 |
| T4 | 40% | 7.2 |

Moisture content of all treatments was regulated at 40% since it is the common practice of mushroom growers. According to Yaday (2001), *Pleurotus* species grow at substrates with pH ranging from 5 to 8. Therefore, all pH observed from each treatment were considered favorable for the growth of *Pleurotus* species.

Mycelial ramification, survival rate, and contamination rate of fruiting bags in each treatment was observed. The length of incubation of fruiting bags was also recorded.

**Table 2.** Length of incubation of *Pleurotus* species in different substrate combinations.

| ***Pleurotus* Species** | **Trmts** | **Ramification (+, -)** | **Length of incubation period (days)** | | | **Average length of incubation** |
|---|---|---|---|---|---|---|
| | | | **R1** | **R2** | **R3** | |
| Oyster (*P. ostreatus*) | T1 | + | 30.5 | 32 | 32 | 31.5[a] |
| | T2 | + | 34.5 | 33 | 32.5 | 33.3[a] |
| | T3 | + | 25.5 | 28.5 | 27 | 27.0[b] |
| | T4 | + | 31.5 | 32.5 | 30 | 31.3[a] |
| Gray Oyster (*P. sajor-caju*) | T1 | + | 35.5 | 35 | 33.5 | 34.6[a] |
| | T2 | + | 32.5 | 32.5 | 35 | 33.3[ab] |
| | T3 | + | 31 | 32.5 | 31.5 | 31.6[bc] |
| | T4 | + | 30.5 | 30 | 30.5 | 30.3[c] |
| Pink Oyster (*P. djamor*) | T1 | + | 33.5 | 34 | 34.5 | 34.0[a] |
| | T2 | + | 34.5 | 34.5 | 33.5 | 34.2[a] |
| | T3 | + | 29 | 31 | 30 | 30.0[b] |
| | T4 | + | 30 | 32 | 30.5 | 30.8[b] |

Based on the table, all treatments used for the three (3) *Pleurotus* species exhibited mycelial ramification at a temperature range of 25.9˚C - 36.6˚C and 52.7 - 76.2% humidity. Using ANOVA, it was revealed that T3 has the shortest length of incubation in *P. ostreatus* and has a significant difference among the treatments with p-value = 0.0011. In *P. sajor-caju* and *P. djamor*, T3 and T4 provided the shortest period of full mycelial ramification and have significant difference from T1 and T2 at 0.0031 for *P. sajor-caju* and 0.0004 for *P. djamor*.

**Table 3.** Comparison of *Pleurotus* species using different substrate combinations in terms of length of incubation.

| ***Pleurotus* species** | **Treatment 1** | **Treatment 2** | **Treatment 3** | **Treatment 4** |
|---|---|---|---|---|
| *Pleurotus sajor-caju* | 34.00[a] | 34.17[a] | 30.00[a] | 30.83[a] |
| *Pleurotus otreatus* | 31.50[b] | 33.30[a] | 27.00[b] | 31.33[a] |
| *Pleurotus djamor* | 34.67[a] | 33.33[a] | 31.67[a] | 30.33[a] |

Using ANOVA, a significant difference was observed among the different *Pleurotus* species in terms of length of incubation. The values for *Pleurotus sajor-caju* and *Pleurotus djamor* were significantly different from *Pleurotus ostreatus* using Treatment 1 and Treatment 3 with a p-value = 0.0013. No significant difference was observed on *Pleurotus sajor-caju* and *Pleurotus djamor* using all treatments.

**Table 4.** Contamination and survival rate of of *Pleurotus* species in different substrate combinations.

| ***Pleurotus* Species** | **Treatments** | **Total no. of contaminated fruiting bags** | **Contamination rate (%)** | **Survival rate (%)** |
|---|---|---|---|---|
| Oyster (*P. ostreatus*) | 1 | 1 | 4.17 | 95.83 |
| | 2 | 4 | 16.67 | 83.33 |
| | 3 | 1 | 4.17 | 95.83 |
| | 4 | 1 | 4.17 | 95.83 |
| Gray Oyster (*P. sajor-caju*) | 1 | 2 | 8.33 | 91.67 |
| | 2 | 2 | 8.33 | 91.67 |
| | 3 | 1 | 8.33 | 91.67 |
| | 4 | 2 | 8.33 | 91.67 |
| Pink Oyster (*P. djamor*) | 1 | 1 | 4.17 | 95.83 |
| | 2 | 4 | 16.67 | 83.33 |
| | 3 | 1 | 4.17 | 95.83 |
| | 4 | 3 | 12.5 | 87.50 |

The number of contaminated fruiting bags among the 24 (3 replicates with 8 samples each) fruiting bags was observed and contamination rate for each treatment was computed using the formula:

$$\text{Contamination rate} = \frac{\text{No. of contaminated fruiting bags}}{\text{Total no. of fruiting bags}} \times 100$$

The survival rate of the three (3) *Pleurotus* species has no significant difference among species (p-value = 0.3664), among treatments (p-value = 0.4231), and among species:treatments at p-value = 0.7328.

**Table 5.** Biological efficiency of different *Pleurotus* species using different substrate combinations.

| Mushroom species | Treatments | Average weight of substrates (g) | Average weight of harvested fruits (g) | Biological Efficiency (%) |
|---|---|---|---|---|
| Oyster (*P. ostreatus*) | T1 | 15,000 | 2,515 | 16.77 |
| | T2 | | 3,230 | 21.53 |
| | T3 | | 2,020 | 13.47 |
| | T4 | | 2,370 | 15.80 |
| Gray Oyster (*P. sajor-caju*) | T1 | | 2,680 | 17.87 |
| | T2 | | 3,290 | 21.93 |
| | T3 | | 2,715 | 18.10 |
| | T4 | | 2,405 | 16.03 |
| Pink Oyster (*P. djamor*) | T1 | | 3,225 | 21.50 |
| | T2 | | 3,230 | 21.53 |
| | T3 | | 2,150 | 14.33 |
| | T4 | | 1,610 | 10.73 |

Based on the table, all treatments applied to the three (3) *Pleurotus* species exhibited fruit flushing with a temperature of 26.6°C - 32.4°C and 72.5 – 88.9% humidity. Treatment 2 provided the highest biological efficiency in all the *Pleurotus* species; *P. ostreatus* at 21.53%, *P. sajor-caju* at 21.93%, and *P. djamor* at 21.53%.

The costs of the different substrate and the cost of substrate in one (1) fruiting bag for each treatment were also observed and recorded (Table 4). Rice straw and banana leaves were obtained for free at the DA-CLIARC station.

**Table 6.1.** Cost of different substrates.

| Substrates | Price (Php) |
|---|---|
| Rice straw | 0 |
| Sawdust | 30/sack |
| Rice bran | 12/kilogram |
| Molasses | 25/liter |
| Lime | 15/kilogram |
| Banana leaves | 0 |
| Tobacco midribs | 50/bundle |

**Table 6.2.** Cost to produce fruiting bags using each treatment.

| Trmts | Substrates | Weight of substrates (20 kg) | Cost of substrates (Php) | Total cost (Php) | No. of produced bags in 20 kg. of substrate | Cost of substrate in one (1) fruiting bag |
|---|---|---|---|---|---|---|
| T1 | Rice straw (70%) | 14kg | 0 | **15** | **26** | **0.58** |
| | Sawdust (30%) | 6kg | 15 | | | |
| T2 | Rice straw (70%) | 14kg | 0 | **29.80** | | **1.15** |
| | Sawdust (25%) | 5kg | 12 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Rice bran (2%) | 400g | 4.8 | | | |
| | Molasses (2%) | 400g | 10 | | | |
| | Lime (1%) | 200g | 3 | | | |
| T3 | Rice straw (70%) | 14kg | 0 | **17.80** | | **0.68** |
| | Banana leaves (25%) | 5kg | 0 | | | |
| | Rice bran (2%) | 400g | 4.80 | | | |
| | Molasses (2%) | 400g | 10 | | | |
| | Lime (1%) | 200g | 3 | | | |
| T4 | Rice straw (70%) | 14kg | 0 | **30.30** | | **1.17** |
| | Tobacco midribs (25%) | 5kg | 12.50 | | | |
| | Rice bran (2%) | 400g | 4.80 | | | |
| | Molasses (2%) | 400g | 10 | | | |
| | Lime (1%) | 200g | 3 | | | |

Based on cost efficiency, T1 has the lowest cost to produce one (1) fruiting bag at Php 0.58, followed by T3 at Php 0.68.

## CONCLUSION

This study was conducted to improve the growth and yield performance of *Pleurotus* species, specifically, *Pleurotus ostreatus*, *Pleurotus sajor-caju*, and *Pleurotus djamor* using different substrate combinations. Based on the results obtained, Treatment 3 (70% rice straw: 25% banana leaves: 2% rice bran: 2% molasses: 1% lime) performed the best in terms of length of incubation of fruiting bags of *P. ostreatus*, while Treatment 3 (70% rice straw: 25% banana leaves: 2% rice bran: 2% molasses: 1% lime) and Treatment 4 (70% rice straw: 25% tobacco midribs: 2% rice bran: 2% molasses: 1% lime) for *P. sajor-caju* and *P. djamor*. Comparing the three (3) *Pleurotus* species in terms of length of incubation, results show that *Pleurotus ostreatus* had the shortest recorded length of incubation using Treatment 1 (70% rice straw: 30% sawdust) and Treatment 3 (70% rice straw: 25% banana leaves: 2% rice bran: 2% molasses: 1% lime).

In terms of biological efficiency, Treatment 2 (70% rice straw: 25% sawdust: 2% rice bran: 2% molasses: 1% lime) had the highest biological efficiency among all the *Pleurotus* species used; *Pleurotus ostreatus* at 21.53%, *Pleurotus sajor-caju* at 21.93% and *Pleurotus djamor* at 21.53%. While in terms of cost efficiency, no significant difference was found among treatments, but the lowest cost to produce substrates for one (1) fruiting bag was observed in Treatment 1 (70% rice straw: 30% sawdust), followed by Treatment 3 (70% rice straw: 25% banana leaves: 2% rice bran: 2% molasses: 1% lime).

## RECOMMENDATIONS

- Conduct nutrient analysis on the substrate combinations used;
- Combine substrates used in treatments that exhibited good performance in terms of length of incubation, biological efficiency, and cost efficiency;
- Conduct studies on substrate combinations for other mushroom varieties.

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**DOCUMENTATION**

**Figure 1. Shredding of substrates.**


**Figure 2. Measurement of pH and moisture content**

**Figure 3. Bagging of substrates.**

**Figure 4. Fruiting bags in incubation room.**


**Figure 5. *Pleurotus* species in the cropping room.**