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[1]*Research Office, Bulacan Agricultural State College*
[2]*College of Agriculture, Bulacan Agricultural State College*

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Abstract

Cultivation of mushroom is an agriculture-based enterprise that can be practiced by landless folks, because it can be grown using affordable materials such as rice straw, sawdust, used paper, and corn straw. Mushroom is a powerful source of antioxidants that are useful in reducing risk of many diseases. This study was conducted to determine the performance of oyster mushroom (*Pleurotus ostreatus*) using different substrates. Completely randomized design (CRD) was used in the study involving three treatments: banana leaves (T1), rice straw (T2) and sawdust (T3) with three replications. The data gathered were statistically analyzed using analysis of variance (ANOVA), and Tukey's Pairwise Comparison. Results of this experiment showed that there was statistical significance between T1 and T3 in terms of number of fruiting bodies wherein T3 produced a total number of 53 fruiting bodies compared to T1 which is 30 only. In terms of primordial growth, T1 was statistically significant when paired with T2 and T3. On the cap diameter significant difference was observed as T3 got the highest diameter of 50.92 cm. In terms of fresh weight, statistical significance was found between T1 and T3, where T3 got the heaviest fresh weight of 337.13 g while T1 got only 256.60 g. However, when total yield (g) was measured results showed that all substrates were statistically the same. Pairwise comparison generally favored T2 and T3 as the preferred substrate for *P. ostreatus* culture. Meanwhile, considering the return of investment, T2 obtained the highest, followed by T3, and the lowest was T1. Through these findings, the researchers recommend the use of T2 - rice straw because it is locally available that can help mushroom growers to maximize their income.

Keywords: *Mushroom fruiting bodies, Mushroom growers*, *Mushroom substrates, Oyster Mushroom, Pleurotus ostreatus*

Introduction

Oyster mushroom *(Pleurotus ostreatus)* belongs to the Kingdom Fungi under *Basidiomycota* due to unique fungal characteristics. It is an edible fungus shaped like umbrella that is first recognized on year 1651 in the vicinage of Paris by sprinkling the waste from the melon crops with leachate from ripe mushroom. First controlled cultivation of this edible fungus occurs in 1707. Mushroom has a cap mostly brown, white, or cream, bracket-like with either an eccentric stem or a radial stem, convex phased centrally depressed with a wavy margin 5-18 cm across, often an overlapping group but with each stem separately attached to the substrates. It also has a stem, like its cap mostly colored white or cream, woolly at base but sometimes stem less but usually with a short stem 1-3 cm long and 1-2 cm in diameter (Pathmashini *et al*., 2008). Oyster mushroom classified as saprophytes and extracts its nutrients from the substrate through mycelium that acquire the material necessary for its development.

[1]Research Office, Bulacan Agricultural State College
[2]College of Agriculture, Bulacan Agricultural State College

The *Pleurotus ostreatus* can attain its optimal mycelial growth by utilizing various carbohydrates, such as glucose, fructose, maltose, ethanol, starch, sucrose and lactose, with glucose the most utilized and lactose as the least. Peptone supported the greatest mycelia growth as a nitrogen source followed by yeast extract, while inorganic sources had no appreciable effect (Bhattacharjya *et al*., 2014). Mushroom like other crops contain nutrients that helps body to decrease risk of diseases such as antioxidant which can damage one's body cell potentially leading to cancer. Vitamin C, fibre and potassium content of mushroom all chipped in cardiovascular health. It also has selenium that helps to improved immunity, beta-glucans and chitin are dietary fibers found on its cell wall plays a significant role in weight management and satiety. Mushroom often referred as "functional food" because except of its nutrition content it is also naturally low in sodium, fat, cholesterol and calories, it is also rich in Vitamin D and B Vitamins such as B2, B9, B1, B5 and B3.

Cultivation of mushroom introduce to those landless poor because it can be grown using affordable materials such as rice straw, sawdust, used paper, corn straw, crop residue and many more. It doesn't need a lot of space, and also fast-growing crop with high yield. Since mushroom is a fungus, it doesn't have seed like other crop instead it uses spawn to develop and grown in a well-maintained air temperature. It also demanded high moisture content. Now, it is available in the market dried, frozen, canned even pickled mushroom, powder mushroom and mushroom sauces (Yanga and Zheng, 2013).

In the Philippines, cultivation of this fungi was exacerbated since 1995 and according to the record, the lowest production volume was last 2009 wherein only 355 metric tons was produced. Growing mushroom is economically feasible due to abundance of cheap substrates from agro-waste that make it more profitable. Most mushroom consumed here were imported to our Asian neighbor country. Supporting the mushroom industry is vital in developing the rural economy, enhancing employment and income opportunity in the rural communities as well as providing income to the small farmers.

In this study, different substrates were used in cultivating oyster mushroom such as banana leaves, rice straw and sawdust. The main objective of the study was to determine the performance of oyster mushroom using different substrates. Specifically, it aimed to evaluate the response of oyster mushroom grown in sawdust, dried banana leaves and rice straw in terms of number of fruiting bodies, number of primordia, cap diameter, fresh weight and yield per treatment; and find out which substrates will provide highest cost and return on investment (ROI).

Materials and Methods

Experimental Design and Layout

Forty-five (45) fruiting bags purchased at Flourish Farm in Brgy Basuit, San Ildefonso Bulacan were purchased and utilized in the study. Three substrates: banana leaves (T1), rice straw (T2) and sawdust (T3) with three replications were established in San Juan, San Miguel, Bucalan, the study area through completely randomized Design (CRD).

Preparation of Substrates

Banana Leaves

Dried banana leaves were chopped into tiny pieces then contained in clean garbage bin half-filled with water. The chopped dried banana leaves were submerged in the water then covered for 24 hours before getting drained. After draining, the banana leaves substrate was poured in the fruiting bags then sealed with paper and rubber bond following pasteurization for 8 hrs.

Rice Straw

Completely sun-dried rice straw was chopped into 4 cm long strips soaked for 8-12hrs. in tap water. Excess water was drained after and the soaked rice straw were place in a clean dry spot then covered with plastic and stored overnight. After air drying, the rice straw substrate was poured in the fruiting bags then sealed with paper and rubber bond and underwent pasteurization for 8 hrs.

Sawdust

Hardwood sawdust together with rice bran, brown sugar and garden lime was prepared by mixing with enough water in 1:1 ratio. The substrate was also covered for 24 hrs. before getting drained and air drying. Once air dried, the sawdust was poured in the fruiting bags, sealed with paper and rubber bond then pasteurized for 8 hours.

Pasteurization

All the prepared substrates were placed in a drum and was pasteurized through steaming for 8 hours with moderate fire level.

Spawn Selection, Inoculation and Incubation

P. ostreatus spawn were purchased at the Flourish Farm in Brgy. Basuit, San Ildefonso, Bulacan after substrate preparation. Sterilization was done to ensure aseptic condition of the rooms (incubation and growing room) by using 1:20 ratio of chlorinated water and 70% alcohol in cleaning. Temperature was monitored using mercury room thermometer and maintained between 26-28°C One of the researchers removed the paper plugs while the other one was using a stainless rod to mix the spawn thoroughly so it may separate to each other. After sterilization next day, the bags were inoculated with the *P. ostreatus* spawn by heating the opening of a sterile bottle, transferring the spawns to the bags and plugging the paper back on the mouth bottle, and then locked by a rubber bond. Spawning was done at the rate of 5-7% based on the dry weight of the substrates on the bags. The bags were then transferred to the incubation room running under total darkness for about 3 weeks with a temperature maintained around 22°C to 31°C (Odonye, 2019) to allow for fructification.

Fruiting and Harvesting

After twenty-three (23) days of inoculation, the bags were transferred from the inoculation room to growing house. The top end of the bags was cut off and hanged according to the replicates. Watering was done every morning through hand spraying to moisten the substrates, the floor and the wall. The caps were harvested when they turned concave from convex (turning down to turning up) every other day for fifteen times.

Cost and Return Analysis

Economic analysis was done to determine the cost of production of *P. ostreatus* using different substrates and how it may affect return on investment. It was computed using the formula:

Net Income (P) = Gross Profit – Total Cost of Production

$$\text{ROI (\%)} = \frac{\text{Net Income}}{\text{Cost of Production}} \times 100\%$$

Statistical Analysis of Data

All the gathered data were analyzed statistically using Analysis of Variance (ANOVA) and Tukey Pairwise Comparison Test in Past and MS excel software.

Results and Discussion

Number of Fruiting Bodies

Spawn running took three weeks before fruiting bodies started appearing. This mycelial behavior corresponded to the observation of Singh et al. (2017). Table 1 presented the number of fruiting bodies that grew and extended on the mushroom body. Sawdust recorded the highest number of fruiting bodies (mean=14.33) followed by rice straw (13.33) while banana leaves had the least value (mean=10).

Table 1.

Number of fruiting bodies in each substrate after 15 harvests

Name of substrate	Total Number	Means with SD
Banana leaves	30	10.00± 0.57
Rice straw	40	13.33± 2.52
Sawdust	43	14.33± 1.15

Table 2 on the other hand showed the pairwise comparison of the statistical difference among the substrates in terms of mycelia extension. Mycelial growth is a preliminary step that creates suitable internal conditions for fruiting. Thus, outstanding growth of mycelium is a vital factor in mushroom cultivation (Pokhrel et al. 2009).

Table 2.

Pairwise comparison of the three substrates on fruiting bodies

Substrate	Banana leaves	Rice Straw	Sawdust
Banana leaves		0.074	0.030**
Rice straw	3.889		0.745
Sawdust	4.950	1.061	

*** Treatments that had significant difference*

Number of Primordia

Table 3 displayed the average number of primordia of representative sample bags of different substrates. Based on the mean obtained from the three substrates, *P. ostreatus* grown in banana leaves had the greatest number of primordia with a mean of 38.67. It was followed by rice straw with 23.33 mean of primordia and sawdust with 23.33.

Table 3.

Number of primordia in each substrate after 15 harvests

Name of substrate	Total Number	Means with SD
Banana leaves	116	38.67± 4.04
Rice straw	70	23.33±12.06
Sawdust	70	23.33± 4.62

The present study further revealed that banana leaves had significant effect on the primordia growth of *P. ostreatus*. Pairwise comparison (Table 4) showed that statistical significance was observed between banana leaves and rice straw, and banana leaves and saw dust. This finding was similar to the result of the study of Shah et al. (2004) when saw dust and wheat straw were mixed with leaves and lignocellulosic wastes, pinhead formation and total yield of *Agrocybe aegerita*, *Volvariella volvacea*, *Pleurotus spp*., *Lentinula edodes* and *Ganoderma lucidum* had significantly increased.

Table 4.

Pairwise comparison of the three substrates on number of primordia

Substrate	Banana leaves	Rice Straw	Sawdust
Banana leaves		0.115	0.115
Rice straw	0.0341**		1.000
Sawdust	0.0341**	0.100	

*** Treatments that had significant difference*

Average Diameter of the Cap

Table 5.

Measurement of cap diameter (cm) in three substrates after 15 harvests

Name of substrate	Diameter in cm	Means with SD
Banana leaves	34.44	11.48± 1.60
Rice straw	54.84	18.28± 4.93
Sawdust	50.92	16.97± 1.73

Mushroom cap or is the second stage of mycelial growth during cultivation of mushroom. In the present study, these caps were initially observed to sprout and form on day 18-21 in all substrates. Rice straw had the highest number (Table 5) mean=18.28 followed by sawdust, mean=16.97 and banana leaves substrate with the least mean of 11.48.

Table 6.

Pairwise comparison of the three substrates on mushroom cap formation

Substrate	Banana leaves	Rice Straw	Sawdust
Banana leaves		0.025**	0.037**
Rice straw	0.025**		0.654
Sawdust	0.037**	0.654	

*** Treatments that had significant difference*

Table 6 displayed the comparison of significance of the three substrates with rice straw and sawdust showing significance against banana leaves. Based on the studies of Shah et al. (2004) and Iqbal et al. (2005), wood sawdust, wheat straw and cotton wastes may be attributed to the wide formation of mushroom pinheads due to their nutrient content. This finding is in accordance with the results of the current study.

Average Fresh Weight

Table 7.

Mushroom fresh weight (grams) in three substrates after 15 harvests

Name of substrate	Fresh weight (g)	Means with SD
Banana leaves	256.60	85.53± 11.55
Rice straw	320.60	106.87± 22.85
Sawdust	337.13	112.38± 17.67

Table 7 shows the average fresh weight of representative sample bags of different substrates. Data revealed that Treatment 3 has obtained the highest average weight with 112.38 grams. It was followed with Treatment 2 with 106.87 grams and Treatment 1 with 85.20 grams. While there was significant difference in all treatments ($p<0.05$), the statistical significance was only found between sawdust and banana leaves. The data is presented in Table 8.

Table 8.

Pairwise comparison of the three substrates on fresh weight in grams

Substrate	Banana leaves	Rice Straw	Sawdust
Banana leaves		0.375	0.023
Rice straw	2.058		0.926
Sawdust	2.589	0.531	

Mushroom Oyster Yield

Table 9 shows the total yield of different substrates. Result of the study revealed that the highest yield was obtained in Treatment 3 with a mean of 562 g. It was followed by Treatment 2 a mean of 538 g and Treatment 1 obtained the lowest yield with the mean of 429.33 g. Analysis of variance showed that there was no significant difference on the total yield of oyster mushroom produce using different substrates.

Table 9.

Total yield in grams of P. ostreatus using different substrates

Name of substrate	Fresh weight (g)	Means with SD
Banana leaves	1288	429.33± 54.86
Rice straw	1614	538.00±113.48
Sawdust	1686	562.00± 88.10

Pairwise comparison also revealed that all substrates were statistically the same in terms of total yield and that all substrates if use for *P. ostreatus* culture and production will result in the same total yield.

Table 10.

Pairwise comparison of the three substrates on total yield in grams

Substrate	Banana leaves	Rice Straw	Sawdust
Banana leaves		0.356	0.239
Rice straw	2.120		0.942
Sawdust	2.589	0.468	

Cost and Return on Investment

Table 11.

Cost and return on investment of produced oyster mushroom per treatment as grown in different substrates

I. INPUT	T1	T2	T3
A. Labor cost			
Preparation of substrates	26.00	23.92	11.44
Pasteurization	41.60	41.60	41.60
Inoculation and Planting	10.40	10.40	10.40
Watering	52.00	52.00	52.00
Harvesting	13.00	13.00	13.00
B. Materials			
Spawn (₱70/bottle)	52.50	52.50	52.50
PP Bag (₱2/pc)	30.00	30.00	30.00
Bottle neck (₱3/pc)	45.00	45.00	45.00
Paper and Rubber bond	5.00	5.00	5.00
Lime (₱48/kg)	6.00	-	14.40
Brown sugar (₱48/kg)	-	-	14.40
Rice bran (₱13/kg)	-	-	39.00
Banana leaves	18.00	-	-
Rice straw	-	18.00	-
Sawdust	-	-	18.00
Total Expenses	299.50	291.42	346.74
II. OUTPUT			
Yield in grams	1288	1614	1686
Gross sale (₱250/kg)	322.00	403.50	421.50
III. NET INCOME	22.50	112.08	74.76
IV. RETURN ON INVESTMENT (%)	7.51	38.46	21.56

Table 11 shows the cost and return on investment of producing oyster mushroom using different substrates. It was observed that the highest return on investment was obtained in Treatment 2 with 38.46%. It was followed by Treatment 3 with 21.56% and Treatment 1 obtained the lowest return on investment with 7.51%.

Conclusion

Three substrates: banana leaves, rice straw and sawdust were tested in cultivation of *P. ostreatus* in CRD study with three replications. Results of the study revealed that using rice straw and sawdust are the more viable substrate option for growing *P. ostreatus* as it provided more fresh weight but in terms of total yield all three substrates were considered significantly the same. Moreover, cost and ROI analysis showed that rice straw had the highest ROI followed by sawdust and lastly, banana leaves.

Recommendations

This study demonstrated the efficacy of the different substrates in the growth and yield of *P. ostreatus* along with economic analysis to determine which substrate may require the least capitalize but will yield mushroom the highest as well as obtain the highest ROI. As such, both rice straw and sawdust were recommended as the more suitable substrate for growing oyster mushroom since they deliver the highest yield and received higher profits.

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