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Effects of Different Substrate Media and Supplements on Growth and Yield of Mushroom (*Pleurotus ostreatus*)

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ABSTRACT

This study investigates the opportunities and challenges of oyster mushroom production in Nangarhar province because no research had been done before to find out best substrate media for mushroom cultivation that is most effective and locally available. The study was conducted at (PHDC) research center. The experiment consisted of wheat straw, corn stover, rice straw, saw dust and mixture of them (WS+CS+RS+SD) as substrates and supplemented with 15% wheat bran, 5% soybean powder and 2% lime. The study was laid out in a completely randomized design (CRD) containing 15 treatments, four replications and total 60 bags. The result revealed that there was a significant difference ($P< 0.05$) among the treatments. The highest stalk length (12.2 cm), cap diameter (5.8 cm), total yield (659.5 g), biological efficiency (131.9 %) and B:C ratio (6.3) were obtained from rice straw + 2% lime (RS+LI) compared to other treatment. The lowest stalk length (5.3 cm), cap diameter (3.4 cm), total yield (101.3 g), biological efficiency (20.8 %) and B:C ratio (0.9) were obtained from corn stover + 15% wheat bran. The study recommends and suggests that rice straw + 2% lime can be considered as best compared to other treatments and can be considered for commercial cultivation. Further studies on oyster mushroom cultivation are needed in Nangarhar to further promote the industry.

Keywords: Growth, mushroom, substrates, supplements, yield

INTRODUCTION

The mushroom (*Pleurotus Ostreatus*) is classified under the division basidiomycota and is a member of the kingdom fungi which belongs to the genus Pleurotus and the family Pleurotaceae (Mahari et al., 2020). They exude enzymes that break down the decomposing organic matter into smaller piece that are then taken up as nutrients (Temple, 2017). These comprise a range of substrates made from waste materials, including sawdust and cotton waste paddy straw (Das et al., 2014).

The nutritional value of the substrate is another crucial factor to take into account when selecting a substrate, even if all lignocellulosic materials may have a high potential as a mushroom culture substrate. This is because the substrate will also have an impact on the oyster mushrooms' growth and yield. The soluble inorganic and organic components from the

substrate will be taken by the mushrooms as nutrients for growth and the development of fruiting bodies, substrate type is one of the most important factors in oyster mushroom cultivation (Chang and Miles, 2004).

The midribs of banana leave plus 10% cow manure and 1% lime use for mushroom production as supplements to effects on growth and yield. However, rice straw + 10% horse dung + 1% lime and rice straw + 10% poultry litter + 1% lime also had a good result (Hasan et al., 2010). In general, there are two types of factors that influence the growth and yield of mushrooms: intrinsic (C: N ratio, substrate type, PH, nitrogen content, carbon content, moisture content) and extrinsic factors (temperature, humidity, and light or environmental factors).

MATERIALS AND METHODS

Study Area

Study was carried out at Nangarhar Agriculture directorate related farm, Perennial Horticulture development center (PHDC) during September 2024 to December 2024.

Experimental design and Experimental materials:

The experiment was laid out in a completely randomized design (CRD) with 15 treatments and four replications. Four agricultural wastes—wheat straw, corn stover, rice straw, sawdust—and their mixture were used as substrates. Supplements included 15% wheat bran, 5% soybean powder, and 2% lime. A total of 60 substrate bags were prepared, each containing 500 g of a balanced substrate mixture (on a dry weight basis). The appropriate amounts of supplements and 40 g of mushroom spawn were added to each bag.

Preparation of substrates:

One kilogram of sawdust, maize stover, rice straw, and wheat straw were initially weighed on dry weight basis before being divided into containers and ready for boiling. After that, they were all boiled in water for 30 minutes. The substrate was then removed from the water and allowed to sit on a cement floor for fifteen hours in order to remove any remaining water. The supplements were then added in accordance with the needs of the treatment. Additionally, 2% $CaCO_3$ was added to the spawn preparation substrate, 15% wheat bran, and 5% dry weight soybean powder. The measured ingredients were transferred to a plastic bowl and well mixed by hand.

Experiment Room layout

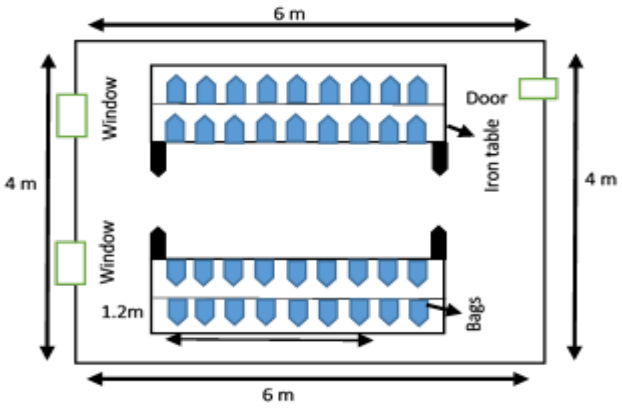

Figure 1: layout of research room

Climate Condition

The climate conditions of Nangarhar play a crucial role in mushroom production. Different climatic characteristics during experiment in different months of the year are presented in figure 2.

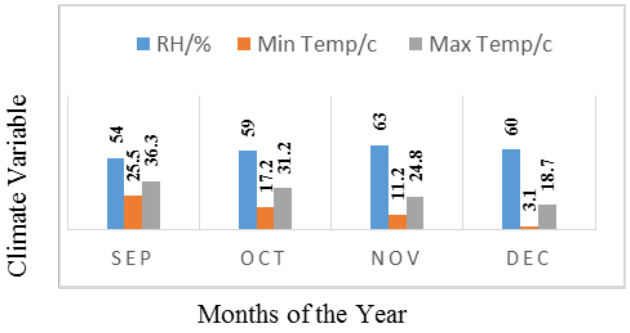

Figure 2. Showing the weather data (e.g., temperature, humidity, rainfall) during the experiment.

Statistical analysis:

Statistical analysis was conducted using analysis of variance (ANOVA) and descriptive statistics to evaluate the data. Least Significant Difference (LSD) test was applied at the 5% significance level, the method described by (Gomez and Gomez, 1984).

RESULTS

Number of Bunches per Bag

The different substrate combinations had a significant effect on the number of mushroom bunches per bag (Table 1). The highest number was recorded in wheat straw + 2% lime (4.9), which was statistically similar to wheat straw + 15% wheat bran (4.3). Other effective treatments included the mixture of all four substrates + 15% wheat bran (4.2), rice straw + 5% soybean powder (4.1), corn stover + 2% lime (3.8), sawdust + 15% wheat bran (3.4), and rice straw + 15% wheat bran (3.4). The lowest number was observed in corn stover + 15% wheat bran (2.1), statistically similar to corn stover + 5% soybean powder (2.6), wheat straw + 5% soybean powder (2.9), sawdust + 5% soybean powder (3.0), rice straw + 2% lime (3.1), and the mixture of all substrates + 2% lime (3.3).

Stalk length (cm)

Substrate effects on stalk length (cm) were statistically different. The highest stalk length was recorded in wheat straw + 15% wheat bran (12.4 cm), which was statistically similar to rice straw + 2% lime (12.2 cm). Other effective treatments included the mixture of all four substrates + 2% lime (11.6 cm), corn stover + 2% lime (11.0 cm), sawdust + 15% wheat bran (10.8 cm), rice straw + 5% soybean powder (10.7 cm), rice straw + 15% wheat bran (10.6 cm), and the mixture of all four substrates + 15% wheat bran (10.5 cm). The lowest stalk length was observed in the mixture of all four substrates + 5% soybean powder (8.5 cm), which was statistically similar to wheat straw + 2% lime (9.4 cm), wheat straw + 5% soybean powder (9.5 cm), and sawdust + 2% lime (9.8 cm).

Cap Diameter (cm)

According to statistical analysis at the 0.05 significance level, the largest cap diameter was recorded in rice straw + 2% lime (5.8 cm), which was statistically similar to the mixture of all four substrates + 2% lime (5.6 cm), the mixture of all four substrates + 5% soybean powder (5.6 cm), sawdust + 2% lime (5.5 cm), rice straw + 5% soybean powder (5.4 cm), wheat straw + 15% wheat bran (5.3 cm), corn stover + 5% soybean powder (5.3 cm), rice straw + 15% wheat bran (5.2 cm), the mixture of all four substrates + 15% wheat bran (5.2 cm), sawdust + 5% soybean powder (5.1 cm), sawdust + 15%

wheat bran (5.0 cm), and wheat straw + 2% lime (5.0 cm). The lowest cap diameter was observed in corn stover + 15% wheat bran (3.4 cm), which was statistically different from all other treatments.

Table 1: Effect of Substrates on Number of Bunches, Cap diameter and Stalk length of Mushroom.

Treatment Details		**No. of Bunches/bag**	**Stalk Length (cm)**	**Cap Diameter (cm)**
wheat straw	15% wheat bran	4.3 ^{ab}	12.4^{a}	5.3^{ab}
	5% Soybean powder	2.9^{bcd}	9.5^{def}	4.4^{c}
	2% lime	4.9^{a}	9.4^{ef}	5^{abc}
Corn Stover	15% wheat bran	2.1^{d}	5.3^{d}	3.4^{d}
	5% Soybean powder	2.6^{cd}	11.7^{abc}	5.3^{ab}
	2% lime	3.8^{abcd}	11^{abcde}	4.7^{bc}
Rice straw	15% wheat bran	3.4^{abcd}	10.6^{abcde}	5.2^{abc}
	5% Soybean powder	4.1^{abc}	10.7^{abcde}	5.4^{ab}
	2% lime	3.1^{bcd}	12.2^{ab}	5.8^{a}
Saw dust	15% wheat bran	4.3^{ab}	10.8^{abcde}	5^{abc}
	5% Soybean powder	3^{bcd}	10.3^{bcdef}	5.1^{abc}
	2% lime	3.7^{abcd}	9.8^{cdef}	5.5^{ab}
Wheat straw + Corn Stover + Rice straw + saw dust	15% wheat bran	4.2^{abc}	10.5^{abcdef}	5.2^{abc}
	5% Soybean powder	2.8^{bcd}	8.5^{f}	5.6^{ab}
	2% lime	3.3^{bcd}	11.6^{abcd}	5.6^{a}
LSD (0.05)		**1.4**	**1.79**	**0.74**
C.V %		**27.4**	**12**	**9.9**

In a values within the same column having similar letters are not significantly different at the (0.05).

Figure 3: Show Bunch, Stalk Length and Cap Diameter of Mushroom

Yield of Flush One (g)

The maximum yield was obtained from the mixture of all four substrates + 15% wheat bran (319.5 g), which was statistically similar to rice straw + 2% lime (316.25 g), wheat straw + 2% lime (316.25 g), wheat straw + 15% wheat bran (304.3 g), and the mixture of all four substrates + 5% soybean powder (301.3 g). The lowest yield was recorded in corn stover + 15% wheat bran (42.2 g), which was statistically different from all other treatments.

Yield of Flush Two (g)

The highest yield in the second flush was obtained from rice straw + 2% lime (236.5 g). The lowest yield was recorded in rice straw +

15% wheat bran (61.0 g), which was statistically similar to rice straw + 5% soybean powder (65.8 g), corn stover + 15% wheat bran (80.7 g), corn stover + 5% soybean powder (80.8 g), sawdust + 5% soybean powder (81.8 g), and wheat straw + 5% soybean powder (88.0 g).

Yield of Flush Three (g)

The substrates had various effects on yield of flush three/g. The highest yield in third flush was obtained from rice straw + 2% lime (106.8 g) supplements While the lowest yield was recorded in saw dust + 5% soybean powder (27 g) which was statistically similar with corn stover + 15% wheat bran (44.8 g), wheat straw + soybean powder (33.8 g), saw dust + 2% lime (34.5g), saw dust + 15% wheat bran (37.3 g), corn stover + 5% soybean powder (44.8 g), wheat straw + 15% wheat bran (48.3 g), corn stover + 2% lime (52.3 g).

Total yield (g)

The different substrate combinations had a significant effect on the total yield per bag (Table 2). The highest yield was recorded in rice straw + 2% lime (659.5 g), which was statistically different from all other treatments. The lowest yield was observed in corn stover + 15% wheat bran (101.3 g), which was also statistically different from all 15 treatments.

Benefit cost ratio

The different substrate combinations had a significant effect on the benefit-cost ratio of oyster mushroom (Figure 3). The highest ratio was recorded in rice straw + 2% lime (6.3). The lowest ratio was observed in corn stover + 15% wheat bran (0.9), which was statistically different from all other treatments.

Table 2: Effect of Substrates on Yield of First, Second, Third Flushes and Total Yield of Mushroom.

Treatment details		Yield/g			
		1st flush	2nd flush	3rd flush	Total yield
wheat straw	15% wheat bran	304.3^{a}	153^{b}	48.3^{cd}	505.5^{b}
	5% Soybean powder	222.7^{b}	88de	33.8^{cd}	344.5^{d}
	2% lime	312.5^{a}	90.5^{de}	69^{bc}	472b^{c}
Corn Stover	15% wheat bran	42.2^{d}	80.7^{e}	33.5^{cd}	101.3^{f}
	5% Soybean powder	182.7^{b}	80.8^{e}	44.8^{cd}	308.3^{de}
	2% lime	179.7^{b}	94.5^{de}	52.3^{cd}	326.5^{de}
Rice straw	15% wheat bran	203^{b}	61^{ef}	92.3^{ab}	356.3^{d}
	5% Soybean powder	196.5^{b}	65.8^{ef}	69.8^{bc}	332d^{e}
	2% lime	316.2^{a}	236.5^{a}	106.8^{a}	659.5^{a}
Saw dust	15% wheat bran	169.7^{b}	90.8^{de}	37.3^{cd}	297.8^{de}
	5% Soybean powder	161.5^{c}	81.8^{e}	27^{d}	270.3^{de}
	2% lime	104.2^{c}	112.3^{cde}	34.5^{cd}	251^{e}
Wheat straw + Corn Stover + Rice straw + saw dust	15% wheat bran	319.5^{a}	160.5^{b}	60.3^{bcd}	540.3^{b}
	5% Soybean powder	301.3^{a}	132.8^{cd}	62.3^{bcd}	496.3^{bc}
	2% lime	214^{b}	164.3^{b}	68.8^{bc}	447^{c}
LSD (0.05)		**59.54**	**44.23**	**32.6**	**76.54**
C.V (%)		**12.5**	**14.3**	**8.9**	**13.3**

In a values within the same column having similar letters are not significantly different at the (0.05).

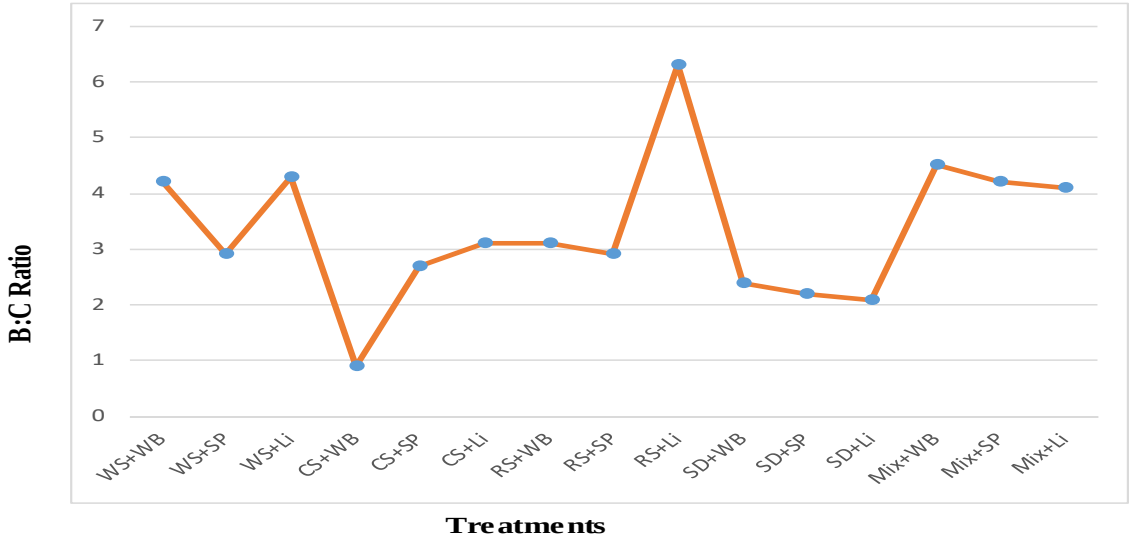

Figure 4: Shows Effects of Different Substrates on BC Ratio of Mushroom

DISCUSSION

Oyster mushroom (*Pleurotus spp.*) is known for its ability to degrade lignocellulosic material and convert them into protein rich biomass (Rowel et al,. 2000). These results are in agreement with earlier findings that reported wheat straw supplemented with lime or wheat bran improves mushroom yield and the number of fruiting bodies. For instance, Song et al., (2018) observed that the addition of 2% calcium carbonate (lime) to sawdust and wheat bran substrates significantly enhanced the number of fruiting bodies per. Similarly, Moonmoon et al., (2011) reported that supplementation of sawdust with wheat bran at 25% increased fruiting body formation in. These findings suggest that both lime and bran supplementation enhance substrate quality, either by balancing pH or providing additional nutrients. Furthermore, stalk length (cm) were also affected by substrates. The result observed from the present study was a little bit similar with the outcomes of Dubey et al., (2019) who recorded maximum stipe length with rice straw substrates.

Cap diameter (cm) showed different outcomes in the present study. Dubey et al., (2019) stated that the cap diameter improved the yield and quality of the mushrooms when grown on rice straw. This may be attributed to the higher cellulose and hemicellulose content in rice straw, which provides a steady energy source for mycelial growth and promotes the development of larger fruiting bodies. A quite different result was obtained with the present study by Ananbeh and Almomany (2005) and they reported that the maximum cap diameter was produced by gypsum, wheat bran, and wheat straw. The gypsum and wheat bran not only enhance the nutritional composition of the substrate but also improve its physical structure and water-holding capacity. Gypsum supplies calcium and sulfur, which are essential for maintaining the firmness and morphology of the fruiting bodies (Girmay et al., 2016).

The yield of flushes one, two and three showed different effects. The current study's findings were consistent with those of earlier research, as reported by (Iqbal and Rauf 2005). The outcome demonstrated that rice straw produced the highest yield, followed by wheat straw. The first flush contributed the major portion of the total yield, with subsequent flushes showing progressive reduction. Additionally, Masevhe et al., (2016) found that oyster mushrooms grew best in wheat straw which contains balanced cellulose, hemicellulose, and lignin that support strong mycelial growth. Rice straw is a good substrate for oyster mushroom cultivation, according to (Adams et al., 2022). Providing a favorable composition of carbohydrates that enhance yield and cap development. The effectiveness of both wheat straw and rice straw may be attributed to their relatively loose structure, which improves aeration and water-holding capacity while allowing efficient enzyme penetration for lignocellulose degradation. Hassan et al., (2010) conducted the same type of study and stated that the rice straw substrate produced the highest yield out of all the substrates evaluated. This could be due to the high cellulose and hemicellulose content of rice straw, which serve as major carbon sources for fungal growth, as well as its relatively soft and porous structure that allows easy mycelial penetration and colonization.

Cultivation of mushroom on paddy straw as a substrate showed the best result on fruiting body weight because the available nutrients were optimum for fruiting body formation (Zikriyani et al., 2018). This effect was attributed to the optimum nutrient profile of paddy straw, particularly its balanced carbon-to-nitrogen ratio, which supports efficient enzymatic activity and promotes the development of larger fruiting structures.

The yield in the 3rd harvest who also found to be highest in wheat straw followed by rice straw (Archana, 2022). This trend suggests that wheat straw has a higher nutrient reserve and better structural stability, allowing it to sustain mushroom production over longer cropping cycles compared with other substrates. The combination of nutrient availability and favorable physical properties in cereal straws, therefore, plays a critical role in supporting both fruiting body weight and cumulative yields across flushes.

CONCLUSION

These findings indicated that the highest stalk length (12.2 cm), cap diameter (5.8 cm), yield of first (316.2 g), second (236.5 g), third (106.8 g) flushes, total yield (659.5 g) and B:C ratio (6.3) were obtained from rice straw + 2% lime (RS+LI) compared to other treatments. Rice straw+2% lime is recommended for farmers and producers of oyster mushroom cultivation. Moreover, utilizing rice straw a common agricultural waste as a primary substrate contributes positively to environmental sustainability by reducing crop residue burning, which is a major source of air pollution. The addition of lime not only improves mushroom yield but also accelerates the decomposition of straw, facilitating effective waste management and nutrient recycling. Adoption of this substrate treatment can thus support eco-friendly mushroom production systems while promoting sustainable utilization of agricultural by-products.

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AUTHORS CONTRIBUTIONS:

Conceptualization, methodology, software, analysis, investigation, resources, original draft preparation, review and editing, visualization, supervision, project administration and funding acquisition. All authors have read and agreed to the published version of the manuscript.

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