Comparative investigations on the yield of oyster mushrooms (*Pleurotus ostreatus* var. *florida*) making use of substrate supplements

Abstract

In this study, oyster mushroom (*Pleurotus ostreatus* var. *florida* (Jacq: Fr) Kummer) were grown with various substrate additions to determine their effects on yield. We ran tests to out how different supplements affected the yield and growth of mushrooms. The substrate, composed primarily of sawdust and straw, served as the growth medium. The research encompassed controlled environmental conditions, including temperature, humidity, and light, over a defined study period. Our findings revealed significant variations in mushroom yield and growth parameters across the different supplement treatments. The best supplements to the substrate treatment combination were observed T_{14}- Wheat Straw (60%), + Rice Straw (34 %) + Gram Flour (2% of the substrate) (451.69g) and (452.33g) followed by T_{11} – Rice Straw (60%), + Wheat Straw (34 %) + Maize Flour (2% of the substrate) which increased the yield of oyster mushroom, while others exhibited nuanced effects on mushroom quality. Statistical analyses supported these observations. The implications of this research extend to both commercial and amateur mushroom cultivators. Understanding the influence of substrate supplements on Oyster mushroom growth can lead to more efficient and cost-effective cultivation practices. By optimizing substrate composition, growers can enhance yields, potentially increasing profitability and sustainability in the mushroom industry. This study also highlights the need for further exploration in the field, including investigations into the specific mechanisms underlying supplement-substrate interactions.

Keywords: Agricultural byproducts, Biological efficiency, Growth and yield of *Pleurotus ostreatus*, Oyster mushroom production, substrate supplements.

Introduction

It is an edible, saprophytic, and lignocellulolytic oyster mushroom, According to Randive (2012), the family Pleurotaceae includes the oyster mushroom, order Agaricales, and phylum Basidiomycota. After *Agaricus bisporus*, it is the fungus that is furthermost extensively cultivated comprehensive (Sánchez, 2010). There are still more oyster mushroom species to discover—over 70 have already been identified (Kong, 2004). According to Cohen *et al.* (2002), the Latin words "Pleurotus" and "ostreatus" both indicate "oyster-shaped beside the ear." In *Pleurotus* species, there are large amounts of proteins, minerals and vitamin C and B complex (Çağlarırmak, 2007; FAOSTAT, 2019). They can be used to treat nutrient deficiencies in underdeveloped countries when the diet is deficient in high fineness proteins and minerals (Kumar *et al.,* 2020). Mushrooms area good source of vitamins, minerals, and protein, according to Khan *et al.,* 1981. Mushrooms are primarily composed of water, with the remainder being made up of protein, carbs, lipids, and 1% vitamins and minerals (Tewari, 1986).

Pleurotus species, which can also efficiency break down agricultural outputs, can grow in a wide range of agricultural wastes. A substrate is defined as any substance that serves as a medium for the growth of a living thing and that enzymes can break down to give nutrients for the developing organism by Cantreras *et al.* (2004). The creation of oyster mushrooms can use a range of wastes, but it relies on how affordable and available the substrate is. For mushrooms to grow more successfully and produce more, a high-quality substrate must be available (Jiskani, 1999). For a mushroom to grow quickly, the optimal substrate should have enough nitrogen and carbohydrates (Khare *et al.,* 2010). Mycelium colonization and fruiting body development in oyster mushrooms are significantly influenced by total carbon (C), total nitrogen (N) and carbon/nitrogen ratio (C: N). Hong *et al.* (1981) found that regardless of the C/N ratio, both *A. bitorquis* and *P. ostreatus* generate less mycelium. According to Fazaeli *et al.* (2006), *Pleurotus* fungi mobilize the rice straw's carbohydrate content mostly through the breakdown of cellulose and hemicellulose. Because of its slow digesting carbohydrates, rich straw is a popular substrate for the production of Pleurotus in Asia. According to research conducted by Sarnklong *et al.* (2010), Rice straw is composed of 0.96% N, 73.01% NDF, 41.59% ADF, 31.42% hemicellulose, 33.35% cellulose, and 4.84% acid detergent lignin, and has a generalized carbon (lignocellulosic) nitrogen ratio of 72%. It is comparable to maize cob, which can be applied as a substrate for the growth of *Pleurotus* and has a C/N ratio of 97:1, as it contains 47% cellulose, 25% lignin, 47% total carbon and 0.48% nitrogen (Wha Choi, 2004; Lakhe *et al.,* 2018). Paddy straw has reportedly been shown to be the finest substrate for growing oyster mushrooms out of all the other types of grain straws (Khanna and Garcha, 1982). High quantities of lignocellulose can be found in banana leaves and pseudo stems (Reddy, 2001). These lignocellulose components serve as effective substrates for the white rot fungi that create lignolytic and cellulolytic enzymes (Pointing, 2001). Legume straws are a good choice for *Pleurotus* substrates because they contain a lot of nitrogen (Poppe, 1995, 2004). Choosing the best substrate to generate a high yield of oyster mushrooms can be challenging, despite the seeming availability of a extensive variety of agricultural crop left overs for cultivation.

Consequently, Aim of this study was to assess how different agricultural wastes affected *Pleurotus ostreatus* biological productivity and yield performance.

Methods and Materials

Details about the research site and treatment

The investigate was carried out at the Department of Plant Pathology Laboratory, Faculty of Agriculture, RNTU, Raisen (M.P.). With seventeen treatments (each using spawn at 4% of the substrate), the experiment was carried out using a CRD Design (Completely Randomized Design), with three replications for each treatment.

Substrates preparation and growth condition

The substrates were divided into pieces that ranged in length from 3 to 5 cm, and they were then allowed to soak all night in a tank of water. Substrates were condensation pasteurized in a metal drum at a continuous 90^{0}C for at least 15 to 20 minutes. Subsequently, a sterilized, clean plastic sheet was placed over the substrates for air cooling to below 25°C. In order to fill the substrate in a clean and sterile environment, transparent polybags were utilized. While filling, the substrates' moisture content was about 60%. A total of 575 g of substrates were packed into each polybag on a dry weight basis. On a dry-weight basis, spawning was carried out at a rate of 10% utilizing single-generation wheat grain spawn. Beginning with the lowest layer, spawning was done in three layers: at the bottom, in the middle, and at the top. The bags were spawned, and a rope was used to tie the open ends of the sacks shut. The spawn layers were made visible from the exterior of the bag. After spawning, the bags were weighed and the results were recorded as starting weights. In order to facilitate ventilation, the bags were then pierced eight to ten times with a sterilized needle. After spawning, the bags were taken to a production area and hanged at random. Using sheets of black polyethylene, the space was kept absolutely dark. The room was between 17 and 20°C, with a relative humidity of about 90%. The spawn run’s first 15 days were conducted without any artificial lighting. The polythene covers were taken off once the white mycelium had developed properly. For pinning at the conclusion of the spawn run, ventilation allowed for sufficient fresh air and dim lighting throughout the space. The CO_2 concentration was decreased, which is another effect of this conditioning. To maintain the temperature and relative humidity, the mushroom ball and shed floor were watered twice daily. To prevent the appearance of insects, the substrate was sprayed with the insecticide Nuvan (Dichlorvos 76% EC). Only after the crop was harvested or a week before the first development of pinheads was a preventive insecticidal application made. When the cap started to fold, the mushrooms were ready to be picked. The mushroom was harvested by delicately twisting it and removing it, leaving any stubs. There were up to three flushes when cropping.

Observations

Climatic condition (Optimum)

Light

The mushroom house's large window was enclosed with gunny sacks that were opened in an east-west path to let light enter during the day and at night. Appropriate lighting (8–12 hours per day at 200 lux) The farm house had good ventilation as well.

Humidity

During cultivation, water was soaked into the gunny bags to maintain the right humidity. (70–80%) Relative Humidity Along with watering the substrate, water was also sprayed from above and used to maintain moisture in the sand that was placed on the floor.

Temperature

For *Pleurotus ostreatus* to develop mycelia and bear fruit, the temperature range requires to be between 20 and 30^{0}C. As a result, all of the trials were carried out in 2020–21 and 2021–22.

Moisture content

Fresh fruit bodies weighing 100 grams each were taken from each substrate replication-wise for each sample. The samples were cleaned and dried in a hot air oven at 60+20C. To get the dry weight in grams, the dried fruit bodies were removed and weighed on an electronic scale. The fruiting bodies of each sample were measured content using the following formula

$$\text{Moisture content (\%)} = \frac{\text{weight of fresh sample} - \text{weight of dry sample}}{\text{weight of fresh sample}} \text{X100}$$

SPAWN

Mycelium Growth

Once the mycelium had completely occupied the substrate and molded a thick mycelia mat, the bags were detached from the incubation room, striped of their contents, and placed on wooden shelves in tiers in the cropping room. Once the mycelium has entirely occupied the substrate, the organism is prepared to fruit. Bags with mold growth should be discarded, however bags with sluggish mycelial development should be given a few more days to finish this process. The bags were sprayed with water twice daily, in the morning and the afternoon, to maintain the substrate's wetness.

No. of fruiting bodies

The first fruit bodies, or primordia, of mushrooms began to form three to four days after the bags were opened. After around three days from the time of their debut, fruiting bodies were gathered. By holding the stalk, the mushroom was gently pulled or twisted from the substrate level. After the first flush was harvested, mushroom fruiting proceeded every 7 to 10 days up to 3 to 4 blushes, cover a crop duration of 45 to 60 days. All species require a high level of moisture (70 to 85%) during fruiting, even if they demand varying temperature regimes. Depending on the humidity in the editing area, repeated water showers are required. While organic product bodies produced at relative humidity levels of 65 to 70% are little with high dry issue, those produced under muggy conditions (85 to 90%) are greater with less dry issue.

Biological efficiency

The following formulation was used to regulate the biological efficiency, or yield of oyster mushrooms per kilogram of substrate on a dry weight basis (Cohen *et al.,* 2002).

$$\text{Biological efficiency \%} = \frac{\text{weight of fresh mushroom fruiting bodies}}{\text{weight of dry substrate}} \text{ X } 100$$

Statistical analysis

Utilizing a complete randomized design (CRD), the yield on various substrates and supplements was assessed. The overall significance of the data will be evaluated using analysis of variance (ANOVA) procedures.

Result and Discussion

The table and the following discussion present the growth results and yield data from the investigations on the use of different substrates for *P. ostreatus* cultivation.

The sixteen supplement treatment combinations used for the yield of oyster mushrooms in two years 2021 and 2022 were summarized in (table-1). The oyster mushroom's highest yield was recorded in T_{14}- Wheat Straw (60%), + Rice Straw (34 %) + Gram Flour (2% of the substrate) (452.00g) and (453.00g) followed by T_{11} – Rice Straw (60%), + Wheat Straw (34 %) + Maize Flour (2% of the substrate) (430.33g) and (434.00g) with 88 % & 86.23% moisture content and biological efficiency 43.03% & 45.30% respectively which, when compared to the other treatments, was vastly superior. Oyster mushroom produced in T_9 – Rice Straw (60%) + Wheat straw (34 %) + Wheat bran (2% of the substrate) (417.33g) and (393.66g) was at par T_{15} - Wheat Straw (60%) + Rice Straw (34 %) + Maize Flour (2% of the substrate) (414.34g) & (416.67g) whereas, T_{15} - Wheat Straw (60%) + Rice Straw (34 %) + Maize Flour (2% of the substrate) were at par T_{12} – Rice Straw (60%), + Wheat Straw (34 %) + Soybean Flour (2% of the substrate) (410.00g) and (408.67g) followed by T_{10} – Rice Straw (60%), + Wheat Straw (34 %) + Gram Flour (2% of the substrate) (408.33g) & (406.66g), T_7 - Wheat Straw (94%) + Maize Flour (2% of the substrate) (395.00g) & (384.33), T_{13}- Rice Straw (60%), + Wheat Straw (34 %) + Wheat Flour (2% of the substrate) (389.33g) & (391.66g), T_{16} - Wheat Straw (60%) + Rice Straw (34 %) + Soybean Flour (2% of the substrate) (388.66g) and (387.67g), T_4 - Rice Straw (94%) + Soybean Flour (2% of the substrate) (386.00g) and (384.67g),T_3 - Rice Straw (94%) + Maize Flour (2% of the substrate) (370.33g) and (374.66g), T_8 - Wheat Straw (94%) + Soybean Flour (2% of the substrate) (362.33g) and (362.34g), T_6 - Wheat Straw (94%) + Gram Flour (2% of the substrate) (345.66g) and (346.66g), T_5 - Wheat Straw (94%) + Wheat Flour (2% of the substrate) (337.00g) and (343.67g), T_2 - Rice Straw (94%) + Gram Flour (2% of the substrate) (333.34g) and (335.66g), T_1 - Rice Straw (94%) + Wheat bran (2% of the substrate) (330.33g) and (332.34g) which were significantly higher as compared to control (212.67g) and (224.34g). Our research mostly confirmed Shah *et al*. (2004) finding, which stated that the spawn running occurred 16 to 25 days following immunization. Variations in the carbon-nitrogen ratio (C: N) and chemical composition of the substrates used may be the reason for the change in the number of days needed for a full spawn run on various substrates (Bhatti *et al.,* 2007)

Table-1: Different supplements to the substrate on the yield of Oyster mushroom

Treatments	Moisture content (%)		Day taken for spawn run		Day taken for First harvest		Mushroom yield (g)/Bag		Biological Efficiency (%)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T_1 - Rice Straw (94%) + Wheat bran (2% of the substrate)	87.4	86	21	19	20	24	330.33	332.34	33.03	33.23
T_2 - Rice Straw (94%) + Gram Flour (2% of the substrate)	85.6	84.2	21	19	21	23	333.34	335.66	33.33	33.56
T_3 - Rice Straw (94%) + Maize Flour (2% of the substrate)	86.5	87.6	20	18	19	25	370.33	374.66	37.03	37.46
T_4 - Rice Straw (94%) + Soybean Flour (2% of the substrate)	88	86	21	20	21	22	386	384.67	38.6	38.46
T_5 - Wheat Straw (94%) + Wheat Flour (2% of the substrate)	85.7	86.5	20	18	21	25	337	343.67	33.7	34.36
T_6 - Wheat Straw (94%) + Gram Flour (2% of the substrate)	90.1	92.05	21	20	19	18	345.66	346.66	34.56	34.66
T_7 - Wheat Straw (94%) + Maize Flour (2% of the substrate)	88	87.26	21	20	19	18	395	384.33	39.5	39.36
T_8 - Wheat Straw (94%) + Soybean Flour (2% of the substrate)	88	89.23	22	19	19	21	362.33	362.34	36.23	36.23
T_9 - Rice Straw (60%) +Wheat straw (34 %) + Wheat bran (2% of the substrate)	87.6	86.12	20	23	22	19	417.33	393.66	41.7	38.43
T_{10} – Rice Straw (60%), + Wheat Straw (34 %) + Gram Flour (2% of the substrate)	90.1	91.22	22	24	21	20	408.33	406.66	40.83	40.66
T_{11} – Rice Straw (60%), + Wheat Straw (34 %) + Maize Flour (2% of the substrate)	88	86.23	21	20	19	18	430.34	433	43.03	43.3
T_{12} – Rice Straw (60%), + Wheat Straw (34 %) + Soybean Flour (2% of the substrate)	85.7	56.21	23	20	19	22	410	408.67	41	40.86
T_{13} - Rice Straw (60%), + Wheat Straw (34 %) + Wheat Flour (2% of the substrate)	90.1	89.26	22	24	23	19	389.33	391.34	38.93	39.13

T_{14} - Wheat Straw (60%), + Rice Straw (34 %) + Gram Flour (2% of the substrate)	88	87.11	19	22	24	20	452	453	45.2	45.3
T_{15} - Wheat Straw (60%), + Rice Straw (34 %) + Maize Flour (2% of the substrate)	87.4	88.29	24	22	18	20	414.34	416.67	41.43	41.66
T_{16} - Wheat Straw (60%), + Rice Straw (34 %) + Soybean Flour (2% of the substrate)	85.6	86.14	19	20	22	21	388.66	387.67	38.86	38.76
T_{17} – Control.	90.26	91.25	22	21	20	23	212.67	224.34	21.26	22.43
CD at 5%							**9.45**	**24.64**		
Sem							**326**	**8.51**		

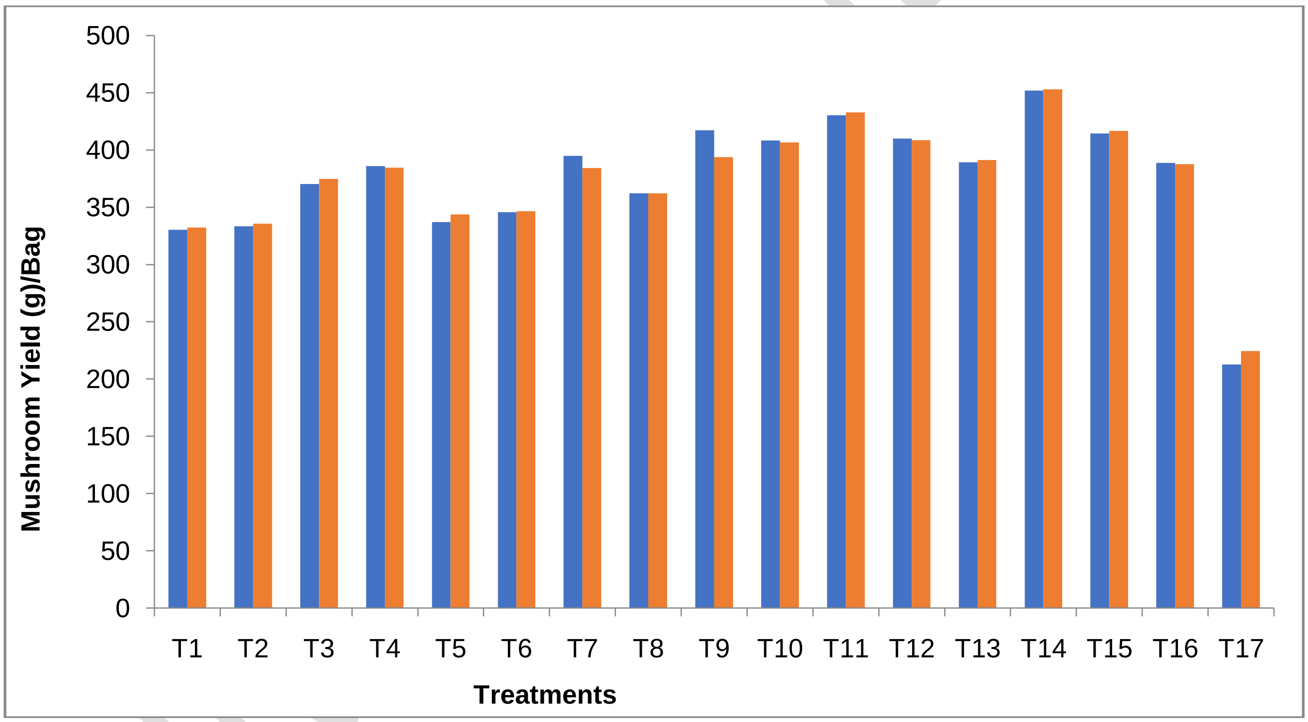

Fig.3 Yield oyster mushroom in different supplements

Conclusion

In the conclusion section, summarize your findings and their significance. Also: It is confirmed by the current investigation that the best supplements to the substrate treatment combination were observed T_{14}- Wheat Straw (60%), + Rice Straw (34 %) + Gram Flour (2% of the substrate) (451.69g) and (452.33g) followed by T_{11} – Rice Straw (60%), + Wheat Straw (34 %) + Maize Flour (2% of the substrate) which increased the yield of oyster mushroom. To control the potential effects of various agricultural wastes on the growth of oyster mushrooms, more research must be done.

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