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# Evaluating the Growth Behaviour, Fruiting Body characteristics and Yield Potential of Oyster Mushroom (*Pleurotus ostreatus)* on Different Straw Substrates

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**ABSTRACT: Oyster mushroom (*Pleurotus* spp.) is a popular edible mushroom known for its delicate flavor and nutritional value. Rice and wheat straw are the major substrates used for the production of mushroom. The use of different basal substrate has been a common practice for optimization of the C:N ratio, enhance the yield, nutritional and medicinal values. In the present investigation, eleven substrates were evaluated in two years respectively for 2020-21 and 2021-22 for the growth behaviour, fruiting body and its characteristics and biological efficiency of Oyster mushroom. After pooling the data of two years, significant effect of different substrates was recorded. The results of the present investigation revealed that wheat straw substrate recorded significantly less time for spawn run (14.65 days), pinhead initiation (19.725 days), 1st harvesting days (25.06 days), 3rd harvesting days (45.47 days) and 4th harvesting days (57.225 days). Supplementation with rice straw resulted into the best result for 2nd harvesting where it took 34.38 days. For fruiting body characteristics, Wheat straw exhibited the best result on the parameters of total no. of fruiting bodies (97.99), Maximum weight of fruiting body (25.84 gm), average length of stalk (7.85 cm), average width of stalk (2.79 cm), average diameter of mushroom cap (8.13 cm) and total diameter of mushroom (12.81 cm). For minimum weight of fruiting body with 7.84 gm, rice straw exhibited the finest response. Use of wheat straw enhanced the yield significantly in all four flushes with pooled total yield (965.53 g) and biological efficiency (96.20%). In a few of the observations Maize substrate and Sugarcane bagasse exhibited wonderful positive results. Overall, wheat straw and rice straw substrate were the best and maize straw, sugarcane bagasse were above par.**

**Keywords:** Oyster mushroom, *Pleurotus ostreatus*, straw substrates, spawn, flush.

## INTRODUCTION

The oyster mushroom (*Pleurotus* species) plays a significant role in the global market for mushrooms, and various species are raised for profit in many nations on both a large and small scale (Adebayo *et al*., 2012a). Food insecurity is one of the largest problems facing the planet. This issue is primarily prevalent in low- and middle-income nations, many of which have subpar food production systems and experience severe malnutrition. India has a significant oyster mushroom cultivation industry, particularly in states like West Bengal, Kerala, Tamil Nadu, and Maharashtra. Oyster mushrooms are popular due to their ease of cultivation and adaptability to diverse climatic conditions. Growing mushrooms might be a viable solution to reduce poverty and improve the quality of life for disadvantaged people (Diriba *et al.*, 2013). Natural mushroom growth is beneficial for human consumption; certain species are harmful while others are edible (Samuel *et al*., 2012). There are 40 different species in the genus Pleurotus, all of which are referred as "oyster mushrooms." Due to its taste, flavour, high nutritional content, and therapeutic benefits, *Pleurotus ostreatus*, one of numerous species in this genus, is consumed widely worldwide (Deepalakshmi and Mrunalini 2014). Mushrooms have antineoplastic, antibacterial, antiviral, hypoglycaemic, hypocholesterolemic, anti-inflammatory and anti-oxidative properties (Guillamon *et al*., (2010); (Wasser, 2014). Among all the cultivated mushrooms, oyster mushroom species are one of the most cultivated mushrooms worldwide following *Agaricus bisporus* (Kües and Liu 2000). This is due to the fact

that *Pleurotus* spp. are easily cultivated at low production cost with high yield and biological efficiency (Mane *et al*., 2007). Furthermore, the *Pleurotus* spp. could be easily cultivated on a number of readily available substrates (Kumari and Achal 2008). Oyster mushrooms are a significant source of protein, carbs, vitamins, calcium, and iron (Yang *et al.*, 2015). Edible mushrooms have a high proportion of polyunsaturated fatty acids and a low amount of crude fat (Jonathan *et al.*, 2013). Due to its ability to grow at a variety of temperatures and use different lignocelluloses, oyster mushroom production is growing in popularity on a global scale (Khan *et al.*, 2012). Mushroom production can be carried out by people who live in rural, peri-urban, and urban areas and does not always require access to land or major financial inputs (Chang *et al.*, 2007). *Pleurotus ostreatus* demands few environmental controls, and their fruiting bodies are not often attacked by diseases and pests, and they can be cultivated in a simple and economic way (Kues & Liu 2000). Due to their simplicity, low-cost production method, and great biological efficiency, Pleurotus species are widely cultivated around the world, most frequently in Asia, America, and Europe (Hoa and Wang 2013). The oyster mushroom needs high humidity (80–90%) and a temperature of 25–30°C to create fruiting bodies (Onyango *et al.*, 2011). Oyster mushrooms (*Pleurotus florida*) with its ability to grow within a short time span, less water and less space requirement has left behind other types of mushrooms in terms of production and demand (Muswati *et al.*, 2021). After mushroom cultivation, the spent substrate that was left behind after harvest might be used as a soil conditioner for plants and animal feed (Soto-cruz *et al.*, 1999). Another interesting thing is that oyster mushroom requires less amount of nitrogen and more carbon for growth. Thus, it can be grown on materials that have abundant quantity of lignin, cellulose and hemi cellulose such as different agricultural waste products including saw dust, rice straw, sugarcane baggase, wheat straw, corncob, banana leaves etc. (Dubey *et al*., 2019; Neupane *et al*., 2018). In another study it was recommended that apart from our traditionally used rice straw other agro-wastes like sal leaves, Lantana camara etc. can also be used for small- and large-scale production of oyster mushroom maintaining all its nutritional parameters as high as rice straw (Kundu *et al*., 2022). Almost all producers use rice straw for the production of *P. osteratus*, which is also one of the best substrate in this study. Therefore, use of a variety of the substrates is essential. Although the amount of yield is lower than in rice straw, other substrates such as rice straw plus wheat straw, rice straw plus paper and sugarcane bagasse can also be used as alternative substrates with supplement in the cultivation of *P. osteratus* (Sonia *et al*., 2013). The current study intended to evaluate *Pleurotus ostreatus* cultivation on different substrates alone and in combination.

## MATERIAL AND METHOD

**Mushroom Culture.** The Pure culture of Oyster mushroom (*P. ostreatus*) was isolated, cultured and purified from the forest of Vindhya region. Culture was maintained on PDA medium using BOD incubator at 25+2°C temperature.

**Preparation of Mushroom spawn.** First cleaned and healthy wheat grains were washed with clean water and boiled for 40 minutes to soften the coat of wheat grains. Excess water after boiling was drained off and the grains were cooled in wooden/ plastic tray up to 60% moisture. These cooled grains were supplemented with 2% calcium carbonate and 2% calcium sulphate on dry weight basis of grains to avoid clumping of grains. These supplemented boiled wheat grains were filled in the glass bottle or polythene bags and plugged tightly then sterilized for two time**s** in consecutive days at 15 psi, 121 °C for 90 min. These-grain filled bottles/bags were aseptically inoculated with fully grown culture of *Pleurotus ostreatus* with two or three mycelium bits. These inoculated bottles/bags were incubated at 25+2°C in BOD incubator for mycelial growth in the absence of light for 15 to 20 days until the mycelium fully covered the grains. These bottles were shakenat interval to allow proper spread of the mycelium between the grains.

**Preparation of substrates for the cultivation of mushroom.** Wheat straw substrates were first cut into small pieces and soaked in water for overnight and excess water was drained out to maintain 70% moisture content. Moistened wheat straw was autoclaved at 15 psi, 121°C for 90 minutes, then, 2.5kg of Sterilized wheat straw substrates were filled in each sterilized plastic bags. Sterilized bags were inoculated with spawned grain at a rate of 6% (w/w) in two to three layers in each bag, for growth of spawn the pinholes were made in the bags for proper ventilation. The bags were incubated at 20ºC under dark condition. The humidity was maintained by spraying water twice a day. Prior to incubation, weights of substrate-filled bags were recorded for uniformity.

**Collection of Agricultural wastes.** Agricultural wastes used in the experiments were collected from farmer's field present in the vicinity of university. From the farmer's field several agricultural wastes were collected i.e. wheat straw, Ricestraw, Maize straw, Groundnut straw, Peastraw, Sugarcane bagasse, gram straw and lentil straw. These agricultural wastes were used as substrates for production of *Pleurotus ostreatus alone and in combinations.*

**Preparation of substrate.** For preparation of substrate, all agricultural wastes were soaked in water for 18-20 hours and then excess water was drained off. The moist substrate was then sterilized by steaming under pressure inside an autoclave for 40 minutes at 15 lb pressure (121°C). After sterilization substrates were taken out of the auto clave and allowed to cooldown at room temperature.

**Spawning.** For spawning, completely colonized fresh spawns were spread in 2-3 layers in the substrate at a rate of 3-4% (w/w) on weight basis. Two kg substrate with spawns were filled in each polythene bag and mouth was tied with thread /rubber band and 8-10 small holes(1mm dia.) were made for aeration.

**Cropping.** The spawn bags were placed in dark growing chamber where temperature and relative humidity ranged between 20-25°C and 80-85% respectively. Bags were kept vertically on a raised platform in cropping chamber for mycelial colonization of the substrate. After complete colonization of the mushroom bed, the polythene bags were removed and these blocks of compact substrate were arranged on the shelves. Humidity was maintained by sprinkling water on the floor and walls frequently. After completion of spawn running, pin heads were started appearing within one week and they became ready to harvest within next 2 week.

**Harvesting.** Fruiting bodies were harvested in about 4-5 days after their appearance. Picking was done by gently twisting the mushroom so that it was pulled out without leaving any stub behind and not disturbing the surrounding fruiting bodies. After harvesting, lower parts of the stalks/stipes with adhering debris should be cut using a knife. Fresh mushrooms were harvested four times at appropriate intervals.

## RESULT

**Growth behavior of Oyster mushroom (*P. ostreatus*)**

**Spawn run period:** As per the data given in Table 1 the spawn run period was ranged between 14.64 to 21.04 days, 14.67 to 22.33 days and 14.65 to 21.68 days respectively for 2020-21, 2021-22 and for pooled analysis. During 2020-21, lowest spawn run period was observed with wheat straw (14.64 days) followed by rice straw (16.19 days) and maize straw (16.24 days) and the highest spawn run period was observed when Mustard straw (21.04 days) was used as a substrate followed by Lentil straw (19.99 days) and Wheat straw + Groundnut shell (18.4 days). Similarly in 2021-22, lowest spawn run period was observed in wheat straw (14.67 days) followed by rice straw (15.33 days) and maize straw (16 days) and the highest spawn run period was observed when Mustard straw (22.33 days) was used as a substrate followed by Groundnut straw (19.67 days) straw and Lentil straw (19.33 days). In the pooled data wheat straw (14.65 days) exhibited the lowest spawn run time and highest spawn run time was exhibited by Mustard straw (21.67).

**Pinhead initiation:** As per the data given in Table 1 for pinhead initiation days was ranged between 18.12 to 24.4 days, 21.33 to 27 days and 19.72 to 23.28 days respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-21, wheat straw (18.12 days) taken the lowest days for pinhead initiation followed by Maize straw (19.19 days) and rice straw (19.85 days), poorest among all the substate for pinhead initiation was Mustard straw (24.4 days) followed by Lentil straw (23.23 days) and Sugarcane bagasse (22.5 days) whereas in 2021-22, wheat straw (21.33 days) followed by rice straw (22 days) and Wheat straw + Maize cob shell (22 days) performed well among the substrates and the poorest substrates were Mustard straw (27 days) followed by Wheat straw + Groundnut shell (24.33 days) and Sugarcane bagasse (24 days). The pooled data showed the similar results where wheat straw (19.72 days) was the best substrates and mustard straw (25.7 days) exhibited the poorest result.

**1st harvesting days:** As per the data given in Table 1 for first harvesting days was ranged between 23.37 to 29.43 days, 23 to 31 days and 24.58 to 29.84 days respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by sugarcane bagasse where the first harvesting was done after 23.37 days followed by wheat straw (23.45 days) and maize straw (24.03 days). However, when we used gram straw, mustard straw, and lentil straw the time taken by the mushroom for first harvesting was relatively high and among them gram straw exhibited the poorest result where the first harvesting was done after 29.43 day followed by mustard straw (28.68 days) and lentil straw (28.12 days). In the next year where we used the same substrates for harvesting data, wheat straw + maize cob shell exhibited the best results where it took 23 days for first harvesting followed by rice straw (26.33 days) and wheat straw (26.67 days) where the poorest result was exhibited by mustard straw (31 days) followed by lentil straw (30.33 days) and wheat straw + groundnut shell (29.67 days). Pooled data exhibited that wheat straw + maize cob shell had the best result for first harvesting (24.5 days) followed by wheat straw (25.06 days) and maize straw (25.35 days). The poorest result was exhibited by mustard straw (29.84 days) followed by lentil straw (29.22 days) and wheat + groundnut shell (28.74 days).

**2ND harvesting days:** As per the data given in table no.1 for second harvesting days was ranged between 33.77 to 41.91 days, 35 to 42.33 days and 34.38 to 42.03 days respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by rice straw (33.77 days) followed by wheat straw (33.84 days) and pea straw (33.86 days). However, when we used gram straw, mustard straw, and lentil straw the time taken by the mushroom for second harvesting was relatively high and among them gram straw exhibited the poorest result where the second harvesting was done after 41.91 days followed by lentil straw (41.73 days) and mustard straw (40.4 days). In the next year with the same substrates for harvesting data, rice straw exhibited the best results where it took 35 days for second harvesting followed by wheat straw (36.33 days) and pea straw (37.33 days) and the poorest result was exhibited by lentil straw (42.33 days) followed by mustard straw (41 days) and wheat straw + groundnut shell (40.33 days). Pooled data exhibited that rice straw (34.38 days) showed the best result for second harvesting followed by wheat straw (35.08 days) and pea straw (35.59 days). The poorest result was exhibited by Lentil straw (42.03) followed by Mustard straw (40.7 days) and gram straw (40.29 days).

**3rd Harvesting days:** As per the data given in table no.1 for third harvesting days was ranged between 43.27 to 52.49 days, 47.67 to 54.33 days and 45.47 to 52.38 days respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by wheat straw where the third harvesting was done after 43.27 days followed by wheat straw + maize cob shell (45.98 days) and maize straw (45.99 days). However, when gram straw, mustard straw, and lentil straw was used as substrate the time taken by the mushroom for third harvesting was relatively high and among them. Wheat straw+ groundnut shell exhibited the poorest result where the third harvesting was done after 52.49 days followed by mustard straw (50.43 days) and gram straw (49.21 days). In the next year with the same substrates for harvesting data, wheat straw exhibited the best results where it took 47.67 days for third harvesting followed by sugarcane bagasse (48.33 days) and rice straw (49.33 days). Among them the poorest result was exhibited by mustard straw (54.33 days) followed by groundnut straw (52.33 days) and lentil straw (51.67 days) and wheat + groundnut shell (51.67 days). Pooled data exhibited that wheat straw (45.47 days) showed the best result for third harvesting followed by maize straw (47.66 days) and sugarcane bagasse (48.11 days). The poorest result was exhibited by mustard straw (52.38 days) followed by wheat straw + groundnut shell (52.08 days) and groundnut straw (50.115).

**4th harvesting days:** As per the data given in table no.1 for fourth harvesting days was ranged between 57.78 to 64.97 days, 56.67 to 66 days and 57.22 to 64.98 days respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by wheat straw where the fourth harvesting was done after 57.78 days followed by gram straw (59.06 days) and maize straw (59.94 days). However, when mustard straw, wheat straw + groundnut shell, and sugarcane bagasse was used as substrate the time taken by the mushroom for fourth harvesting was relatively high. Among them, mustard straw exhibited the poorest result where the fourth harvesting was done after 64.97 days followed by wheat straw + groundnut shell (63.03 days) and sugarcane bagasse (62.24 days). In the next year with the same substrates for harvesting data, wheat straw exhibited the best results where it took 56.67 days for fourth harvesting followed by sugarcane bagasse (60.67 days) and rice straw (61 days). Among them the poorest result was exhibited by lentil straw (66 days) followed by mustard straw (65 days) and groundnut straw (63.33 days). Pooled data exhibited that wheat straw showed the best result for fourth harvesting (57.22 days) followed by rice straw (60.56 days) and gram straw (60.69 days). The poorest result was exhibited by mustard straw (64.98) followed by lentil straw (63.85 days) and wheat straw + groundnut shell (63.01 days).

**Table 1: Evaluation of different substrates for growth behavior of Oyster mushroom (*P. ostreatus*) in 2020-21 and 2021-22.**

| Substrates | Mushroom growth period recorded in days after spawning | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spawn run period (Days) | | | Pinhead initiation (Days) | | | 1st harvesting (Days) | | | 2nd harvesting (Days) | | | 3rd harvesting (Days) | | | 4th harvesting (Days) | | |
| | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled |
| Wheat straw | 14.64 | 14.67 | 14.655 | 18.12 | 21.33 | 19.725 | 23.45 | 26.67 | 25.06 | 33.84 | 36.33 | 35.085 | 43.27 | 47.67 | 45.47 | 57.78 | 56.67 | 57.225 |
| Rice straw | 16.19 | 15.33 | 15.76 | 19.85 | 22 | 20.925 | 25.88 | 26.33 | 26.105 | 33.77 | 35 | 34.385 | 49.55 | 49.33 | 49.44 | 60.13 | 61 | 60.565 |
| Maize straw | 16.24 | 16 | 16.12 | 19.19 | 22.33 | 20.76 | 24.03 | 26.67 | 25.35 | 37.65 | 38 | 37.825 | 45.99 | 49.33 | 47.66 | 59.94 | 62.33 | 61.135 |
| Pea straw | 16.89 | 15.67 | 16.28 | 20.63 | 22.67 | 21.65 | 26.37 | 28.33 | 27.35 | 33.86 | 37.33 | 35.595 | 48.05 | 49.67 | 48.86 | 60.41 | 62.67 | 61.54 |
| Sugarcane bagasse | 16.98 | 18.8 | 17.89 | 22.5 | 24 | 23.25 | 23.37 | 28 | 25.685 | 37.87 | 37.33 | 37.6 | 47.9 | 48.33 | 48.115 | 62.24 | 60.67 | 61.455 |
| Ground-nut straw | 18.04 | 19.67 | 18.855 | 21.46 | 24 | 22.73 | 28.07 | 29 | 28.535 | 37.46 | 38.67 | 38.065 | 47.9 | 52.33 | 50.115 | 60.6 | 63.33 | 61.965 |
| Mustard straw | 21.04 | 22.33 | 21.685 | 24.4 | 27 | 25.7 | 28.68 | 31 | 29.84 | 40.4 | 41 | 40.7 | 50.43 | 54.33 | 52.38 | 64.97 | 65 | 64.985 |
| Gramstraw | 17.51 | 17.67 | 17.59 | 20.2 | 23.33 | 21.765 | 29.43 | 27.67 | 28.55 | 41.91 | 38.67 | 40.29 | 49.21 | 50.67 | 49.94 | 59.06 | 62.33 | 60.695 |
| Lentil straw | 19.99 | 19.33 | 19.66 | 23.23 | 23.33 | 23.28 | 28.12 | 30.33 | 29.225 | 41.73 | 42.33 | 42.03 | 47.31 | 51.67 | 49.49 | 61.7 | 66 | 63.85 |
| Wheat straw + Groundnut shell | 18.4 | 18.44 | 18.42 | 22.19 | 24.33 | 23.26 | 27.82 | 29.67 | 28.745 | 39.44 | 40.33 | 39.885 | 52.49 | 51.67 | 52.08 | 63.03 | 63 | 63.015 |
| Wheat straw + Maize cob shell | 16.9 | 16.67 | 16.785 | 20.1 | 22 | 21.05 | 26.16 | 23 | 24.58 | 35.28 | 38.33 | 36.805 | 45.98 | 51 | 48.49 | 61.56 | 62.67 | 62.115 |
| SE(m) | 0.27 | 0.24 | 0.255 | 0.35 | 0.34 | 0.345 | 0.34 | 0.32 | 0.33 | 0.62 | 0.56 | 0.59 | 0.84 | 0.91 | 0.875 | 0.97 | 0.86 | 0.915 |
| CD (5%) | 0.81 | 0.71 | 0.76 | 1.04 | 1.01 | 1.025 | 1.01 | 0.96 | 0.985 | 1.81 | 1.64 | 1.725 | 2.48 | 2.69 | 2.585 | 2.87 | 2.53 | 2.7 |

Values are expressed as means = standard deviation of three replications; Values with different small letters in the same row are significantly different at the level of 0.05.

**Total number of fruiting body:** As per the data given in Table 2 for total number of fruiting body was ranged between 69.45 to 98.7 days, 65.33 to 98.34 days and 67.39 to 97.99 days respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by rice straw where the fruiting bodies were 98.7 followed by wheat straw (97.64) and maize straw (90.34). However, when lentil straw, mustard straw, and wheat straw+ groundnut shell were used as substrate the number of fruiting body were relatively low. Among them, Lentil straw exhibited the poorest result where the number of fruiting bodies were 69.45 followed by mustard straw (73.24) and wheat straw+ groundnut shell (74.88). In the next year with the same substrates for number of fruiting bodies, wheat straw exhibited the best results where it produced

98.34fruiting bodies followed by rice (88.77) and gram straw (88.43). Among them the poorest result was exhibited by lentil straw (65.33) followed by mustard (72.33) and groundnut straw (72.67). Pooled data exhibited that wheat straw showed the best result with 97.99 fruiting bodies followed by rice straw (93.73) and pea straw (87.43). The poorest result was exhibited by lentil straw (67.39) followed by mustard (72.78) and groundnut straw (75.89).

**Maximum weight of fruiting body (gm):** As per the data given in Table 2 for Maximum weight of fruiting body was ranged between 15.99 to 26 gm, 16.17 to 25.67 gm and 16.08 to 25.84 gm respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by wheat straw where the weight of fruiting body was 26gm followed by sugarcane bagasse (21.88 gm) and gram straw (21.2 gm). However, when mustard straw, wheat straw+ groundnut shell and lentil straw were used as substrate the maximum weight of fruiting body was relatively low. Among them, mustard straw exhibited the poorest result where the Maximum weight of fruiting body was 15.99 gm followed by wheat straw + groundnut shell (17.81 gm) and lentil straw (18.11 gm). In the next year with the same substrates for maximum weight of fruiting body, wheat straw exhibited the best results where it weighed 25.67gm followed by sugarcane bagasse (22.56 gm) and groundnut straw (21.5 gm). Among them the poorest result was exhibited by mustard straw (16.17 gm) followed by wheat straw + groundnut shell (17.67 gm) and wheat straw + maize cob shell (18.67 gm). Pooled data exhibited that wheat straw showed the best result with 25.84gm weight followed by sugarcane bagasse (22.22 gm) and rice straw (21.19 gm). The poorest result was exhibited by mustard straw (16.08 gm) followed by wheat straw+ groundnut shell (17.74 gm) and lentil straw (18.64 gm).

**Minimum weight of fruiting body (gm):** As per the data given in Table 2 for Minimum weight of fruiting body was ranged between 4.91 to 7.44 gm, 5.33 to 8.24 gm and 5.12 to 7.84 gm respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by rice straw where the weight was 7.44 gm followed by wheat (7.24 gm) and pea straw (6.28 gm). However, when mustard straw, sugarcane bagasse and gram were used as substrate the Minimum weight of fruiting body was relatively low. Among them, mustard straw exhibited the poorest result where the Minimum weight of fruiting body was 4.91 gm followed by sugarcane (5.38 gm) and gram (5.5 gm). In the next year with the same substrates for Minimum weight of fruiting body, rice straw exhibited the best results where it weighed 8.24 gm followed by groundnut straw (7.61 gm) and wheat straw (7.53 gm). Among them the poorest result was exhibited by mustard straw (5.33 gm) followed by sugarcane bagasse (6.26 gm) and wheat straw + groundnut shell (6.37 gm). Pooled data exhibited that rice straw showed the best result with 7.84 gm weight followed by wheat straw (7.39 gm) and groundnut straw (6.69 gm). The poorest result was exhibited by mustard straw (5.12 gm) followed by sugarcane bagasse (5.82 gm) and wheat straw + groundnut shell (6.17 gm).

**Average Length of stalk (cm):** As per the data given in Table 2 for Average Length of stalk was ranged between 4.72 to 5.86cm, 5.38 to 9.84cm and 5.22 to 7.85cm respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by wheat straw where the length was 5.86 cm followed by rice (5.79 cm) and wheat straw + maize cob shell (5.51 cm). However, when wheat straw + groundnut shell, mustard straw and pea straw were used as substrate the Average length of stalk was relatively low. Among them, wheat straw + groundnut shell exhibited the poorest result where the Average length of stalk was 4.72cm followed by mustard straw (4.81cm) and pea straw (4.91 cm). In the next year with the same substrates for average length of stalk, wheat straw exhibited the best results where it weighed 9.84cm followed by rice straw (6.65 cm) and sugarcane bagasse (6.55 cm). Among them the poorest result was exhibited by lentil straw (5.38 cm) followed by pea straw (5.96cm) and wheat straw + maize cob shell (6.04cm). Pooled data exhibited that wheat straw showed best result with 7.85 cm followed by rice straw (6.22 cm) and sugarcane bagasse (5.88 cm). The poorest result was exhibited by lentil straw (5.22cm) followed by pea straw (5.44 cm) and wheat straw + groundnut shell (5.47cm).

**Average width of stalk (cm):** As per the data given in Table 2 for average width of stalk was ranged between 1.54 to 2.24 cm, 2.52 to 3.33 cm and 2.03 to 2.79 cm respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by wheat straw where the width was 2.24 cm followed by rice (2.19 cm) and maize straw (2.03 cm). However, when gram straw, mustard straw and groundnut straw were used as substrate the Average width of stalk was relatively low. Among them, gram straw exhibited the poorest result where the Average width of stalk was 1.54 cm followed by mustard straw (1.56 cm) and groundnut straw (1.91 cm). In the next year with the same substrates for average width of stalk, wheat straw exhibited the best results where it weighed 3.33 cm followed by maize straw (3.12 cm) and rice straw (3.03 cm). Among them the poorest result was exhibited by gram straw (2.52 cm) followed by mustard straw (2.58 cm) and wheat straw + groundnut shell (2.82 cm). Pooled data exhibited that wheat straw showed best result with 2.79 cm followed by rice straw (2.61 cm) and maize straw (2.58 cm). The poorest result was exhibited by gram straw (2.03 cm) followed by mustard straw (2.07 cm) and wheat straw + groundnut shell (2.40 cm).

**Average diameter of mushroom cap (cm):** As per the data given in Table 2 for average diameter of mushroom cap was ranged between 4.36 to 7.63 cm, 4.83 to 8.62 cm and 4.78 to 8.13 cm respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by wheat straw where the diameter was 7.63 cm followed by sugarcane bagasse (7.09 cm) and rice straw (6.99 cm). However, when groundnut straw, mustard straw and

lentil straw were used as substrate the Average diameter of mushroom cap was relatively low. Among them, groundnut straw exhibited the poorest result where the average diameter of mushroom cap was 4.36 cm followed by mustard straw (4.72 cm) and lentil straw (4.96 cm). In the next year with the same substrates for average diameter of mushroom cap, wheat straw exhibited the best results where it weighed 8.62 cm followed by rice straw (8.03 cm) and sugarcane bagasse (7.93 cm). Among them the poorest result was exhibited by mustard straw (4.83 cm) followed by wheat straw + groundnut shell (4.86 cm) and wheat straw + maize cobb shell (4.91 cm). Pooled data exhibited that wheat straw showed best result with 8.13 cm followed by rice straw (7.51 cm) and sugarcane bagasse (7.51 cm). The poorest result was exhibited by mustard straw (4.78 cm) followed by groundnut straw (4.82 cm) and wheat straw + groundnut shell (4.97 cm).

**Total diameter of mushroom (cm):** As per the data given in Table 2 for total diameter of mushroom was ranged between 10.19 to 13.09 cm, 10.43 to 12.92 cm and 10.31 to 12.96 cm respectively for 2020-21, 2021-22 and for pooled analysis. During the year 2020-2021, the best result was shown by wheat straw where the diameter was 13.09 cm followed by maize straw (3cm) and pea straw (12.36 cm). However, when wheat straw + groundnut shell, mustard straw and gram straw were used as substrate the Total diameter of mushroom was relatively low. Among them, wheat straw + groundnut shell exhibited the poorest result where the total diameter of mushroom was 10.19 cm followed by mustard straw (10.66 cm) and groundnut straw (11.02 cm). In the next year with the same substrates for total diameter of mushroom, maize straw exhibited the best results with 12.92 cm followed by wheat straw + maize cob shell (12.86 cm) and wheat straw (12.52 cm). Among them the poorest result was exhibited by wheat straw + groundnut shell (10.43 cm) followed by mustard straw (10.83 cm) and gram straw (10.85 cm). Pooled data exhibited that maize straw showed best result with 12.96 cm followed by wheat straw (12.81 cm) and wheat straw + maize cob shell (12.24 cm). The poorest result was exhibited by wheat straw + groundnut shell (10.31 cm) followed by mustard straw (10.75 cm) and gram straw (11.27 cm).

**Table 2: Evaluation of different substrates for fruiting bodies and their characteristics of Oyster mushroom (*P. ostreatus*) in 2020-21 and 2021-22.**

| Substrates | Mushroom growth period recorded in days after spawning | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total number of fruiting body | | | Maximum weight of fruiting body (gm) | | | Minimum weight of fruiting body (gm) | | | Average Length of stalk (cm) | | | Average width of stalk (cm) | | | Average diameter of mushroom cap (cm) | | | Total diameter of mushroom (cm) | | |
| | **2020-21** | 2021-22 | Pooled | **2020-21** | 2021-22 | Pooled | **2020-21** | 2021-22 | Pooled | **2020-21** | 2021-22 | Pooled | **2020-21** | 2021-22 | Pooled | **2020-21** | 2021-22 | Pooled | **2020-21** | 2021-22 | Pooled |
| Wheat straw | 97.64 | 98.34 | 97.99 | 26 | 25.67 | 25.84 | 7.24 | 7.53 | 7.39 | 5.86 | 9.84 | 7.85 | 2.24 | 3.33 | 2.79 | 7.63 | 8.62 | 8.13 | 13.09 | 12.52 | 12.81 |
| Rice straw | 98.7 | 88.77 | 93.73 | 21.14 | 21.23 | 21.19 | 7.44 | 8.24 | 7.84 | 5.79 | 6.65 | 6.22 | 2.19 | 3.03 | 2.61 | 6.99 | 8.03 | 7.51 | 12.07 | 11.73 | 11.90 |
| Maize straw | 90.34 | 82.57 | 86.45 | 20.99 | 20.2 | 20.60 | 5.95 | 6.71 | 6.33 | 4.96 | 6.25 | 5.61 | 2.03 | 3.12 | 2.58 | 6.87 | 7.64 | 7.26 | 13 | 12.92 | 12.96 |
| Pea straw | 88 | 86.87 | 87.43 | 18.82 | 20.63 | 19.73 | 6.28 | 6.65 | 6.47 | 4.91 | 5.96 | 5.44 | 2.02 | 2.83 | 2.43 | 5.85 | 6.71 | 6.28 | 12.36 | 11.84 | 12.10 |
| Sugarcane bagasse | 79.96 | 74.1 | 77.03 | 21.88 | 22.56 | 22.22 | 5.38 | 6.26 | 5.82 | 5.21 | 6.55 | 5.88 | 1.97 | 2.92 | 2.45 | 7.09 | 7.93 | 7.51 | 12.14 | 11.78 | 11.96 |
| Groundnut straw | 79.12 | 72.67 | 75.89 | 19.83 | 21.5 | 20.67 | 5.77 | 7.61 | 6.69 | 5.27 | 6.37 | 5.82 | 1.91 | 3.02 | 2.47 | 4.36 | 5.27 | 4.82 | 11.02 | 11.57 | 11.30 |
| Mustard straw | 73.24 | 72.33 | 72.78 | 15.99 | 16.17 | 16.08 | 4.91 | 5.33 | 5.12 | 4.81 | 6.24 | 5.53 | 1.56 | 2.58 | 2.07 | 4.72 | 4.83 | 4.78 | 10.66 | 10.83 | 10.75 |
| Gram straw | 82.73 | 88.43 | 85.58 | 21.2 | 20.78 | 20.99 | 5.5 | 6.97 | 6.24 | 4.91 | 6.46 | 5.69 | 1.54 | 2.52 | 2.03 | 6.87 | 7.24 | 7.06 | 11.69 | 10.85 | 11.27 |
| Lentil straw | 69.45 | 65.33 | 67.39 | 18.11 | 19.17 | 18.64 | 5.61 | 7.03 | 6.32 | 5.06 | 5.38 | 5.22 | 1.92 | 2.94 | 2.43 | 4.96 | 5.68 | 5.32 | 11.58 | 11.93 | 11.76 |
| Wheat straw + Groundnut shell | 74.88 | 82.33 | 78.60 | 17.81 | 17.67 | 17.74 | 5.97 | 6.37 | 6.17 | 4.72 | 6.22 | 5.47 | 1.97 | 2.82 | 2.40 | 5.07 | 4.86 | 4.97 | 10.19 | 10.43 | 10.31 |
| Wheat straw + Maize cob shell | 85.89 | 77.33 | 81.61 | 21.18 | 18.67 | 19.93 | 5.61 | 7.15 | 6.38 | 5.51 | 6.04 | 5.78 | 2 | 2.84 | 2.42 | 5.86 | 4.91 | 5.39 | 11.62 | 12.86 | 12.24 |
| SE(m) | **1.43** | **1.49** | 1.46 | **0.33** | **0.34** | 0.34 | **0.1** | **0.08** | 0.09 | **0.07** | **0.1** | 0.09 | **0.03** | **0.04** | 0.04 | **0.09** | **0.09** | 0.09 | **0.15** | **0.17** | 0.16 |
| CD (5%) | **4.21** | **4.39** | 4.3 | **0.97** | **1** | 0.99 | **0.3** | **0.24** | 0.27 | **0.2** | **0.29** | 0.25 | **0.09** | **0.11** | 0.10 | **0.27** | **0.27** | 0.27 | **0.43** | **0.51** | 0.47 |

Values are expressed as means = standard deviation of three replications; Values with different small letters in the same row are significantly different at the level of 0.05.

**1st Flush.** According to the information in Table 3, the data of first flush for 2020–21, 2021–22 and for pooled analysis was ranged between 282.43 g to 407.93 g, 316.2 to 383.43 g and 279.38 to 394.18, respectively. In 2020–21, mustard straw (282.43 g) and lentil straw (298.12 g) had the lowest yield, respectively, while wheat straw (407.93 g) had the highest yield, followed by rice straw (368.33 g) and maize straw (358.94 g). In the next year, the maximum yield was seen when rice straw (372.67 g) was utilized as a substrate, followed by gram straw (357.21 g) and pea straw (351.61 g). The lowest yield was observed in wheat straw (86.43), followed by mustard straw (276.33) and lentil straw (295.67 g). Wheat straw (247.18 g) had the lowest yield in the pooled data followed by mustard straw (279.38 g) and lentil straw (296.90 g), whereas rice straw (370.50 g) showed the highest yield followed by gram straw (357.13 g) and maize straw (352.31 g).

**2nd Flush.** According to the information in Table No.3, the data of second flush for 2020–21, 2021–22 and for pooled analysis was ranged between 209.5 g to 290.81 g, 203.85 to 294.67 g and 206.68 to 292.74, respectively. In 2020–21, lentil straw (209.5 g) and mustard straw (216.59 g) had the lowest yield, respectively, while wheat straw (290.81 g) had the highest yield, followed by rice straw (279.23 g) and gram straw (261.85 g). In the next year, the maximum yield was seen when wheat straw (294.67 g) was utilized as a substrate, followed by rice straw (291.2 g). The lowest yield was observed in lentil straw (203.85 g), followed by mustard straw (223.33) and sugarcane bagasse (234.53 g). Lentil straw (206.68 g) had the lowest yield in the pooled data followed by mustard straw (219.96 g) and sugarcane bagasse (234.83 g), whereas wheat straw (292.74 g) showed the highest

yield followed by rice straw (285.22 g) and gram straw (262.09 g).

**3rd Flush.** According to the information in Table 3, the data of first flush for 2020–21, 2021–22 and for pooled analysis was ranged between 129.49 g to 194.25 g, 124.33 to 197.33 g and 126.90 to 190.22 g, respectively. In 2020–21, mustard straw (129.49 g) had the lowest yield, followed by lentil straw (147.11 g) and wheat straw + groundnut shell (150.26 g) respectively, while rice straw (194.25 g) had the highest yield, followed by wheat straw (183.1 g), maize straw (172.89 g) and wheat straw + maize cob shell (172.5 g). In the next year, the maximum yield was seen when wheat straw (197.33 g) was utilized as a substrate, followed by rice straw (183.67 g). The lowest yield was observed in mustard straw (124.33 g), followed by lentil straw (136.67 g). Mustard straw (126.90 g) had the lowest yield in the pooled data followed lentil straw (141.89 g) and wheat straw + groundnut shell (148.40 g) whereas wheat straw (190.22 g) showed the highest yield followed by rice straw (188.96 g), wheat straw + maize cob shell (174.42 g) and maize straw (174.28 g).

**4th Flush.** According to the information in Table No. 3, the data of first flush for 2020–21, 2021–22 and for pooled analysis was ranged between 39.53 g to 91.14 g, 35.42 to 85.33 g and 37.48 to 88.24 g, respectively. In 2020–21, lentil straw (39.53 g) had the lowest yield followed by mustard straw (42.35 g), respectively, while wheat straw (91.14 g) had the highest yield, followed by rice straw (83.71 g) and maize straw (77.23 g). In the following year, the maximum yield was seen when wheat straw (85.33 g) was utilized as a substrate, followed by rice straw (77.33 g). The lowest yield was observed in lentil straw (35.42 g), followed by gram straw (46.67 g) and mustard straw (48.67 g). Lentil straw (37.48 g) had the lowest yield in the pooled data followed by mustard straw (45.51 g) and lentil straw (49.96 g), whereas wheat straw (88.24 g) showed the highest yield followed by rice straw (80.52 g) and maize straw (74.89 g).

**Total yield.** According to the Table 3, the data of total yield for 2020–21, 2021–22 and for pooled analysis was ranged between 662.32 to 980.73 g, 667.67 to 950.33 g and 665.00 to 965.53 g, respectively. In 2020–21, mustard straw (662.32 g) had the lowest yield followed by lentil straw (664.46 g) and wheat straw + groundnut shell (779.04 g), respectively, while wheat straw (980.73 g) had the highest yield, followed by rice straw (932.18 g). In the following year, the maximum yield was seen when wheat straw (950.33 g) was utilized as a substrate, followed by rice straw (921.67 g). The lowest yield was observed in mustard straw (667.67 g), followed by lentil straw (669.33 g) and wheat straw + groundnut shell (775.67 g). Mustard straw (665.00 g) had the lowest yield in the pooled data followed by lentil straw (666.90 g) and wheat straw + groundnut shell (777.36 g), whereas wheat straw (965.33 g) showed the highest yield followed by rice straw (926.93 g).

**Biological efficiency.** According to the information in Table 3, the data of total yield for 2020–21, 2021–22 and for pooled analysis was ranged between 66.8 to 96.47 %, 67.67 to 95.93 % and 67.24 to 96.20 %, respectively. In 2020–21, mustard straw (66.8 %) had the lowest yield followed by lentil straw (68.77 %) and wheat straw + groundnut shell (77.13 %), respectively, while wheat straw (95.93 %) had the highest yield, followed by rice straw (96.47 %). In the subsequent year, the maximum yield was seen when wheat straw (95.93 %) was utilized as a substrate, followed by rice straw (93.07 %). The lowest yield was observed in mustard straw (67.67 %), followed by lentil straw (67.83 %) and wheat straw + groundnut shell (78.47 %). Mustard straw (67.24 %) had the lowest yield in the pooled data followed by lentil straw (68.30 %) and wheat straw + groundnut shell (77.80 %), whereas wheat straw (96.20 %) showed the highest yield followed by rice straw (92.94 %).

**Table 3: Evaluation of different substrates for yield potential and biological efficiency of Oyster mushroom (*P. ostreatus*) in 2020-21 and 2021-22.**

| Substrates | 1st flush (g) | | | 2nd flush (g) | | | 3rd flush (g) | | | 4th flush (g) | | | Total yield (g) | | | Biological efficiency (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled |
| Wheat straw | 407.93 | 383.43 | 394.18 | 290.81 | 294.67 | 292.74 | 183.1 | 197.33 | 190.22 | 91.14 | 85.33 | 88.24 | 980.73 | 950.33 | 965.53 | 96.47 | 95.93 | 96.20 |
| Rice straw | 368.33 | 372.67 | 370.50 | 279.23 | 291.2 | 285.22 | 194.25 | 183.67 | 188.96 | 83.71 | 77.33 | 80.52 | 932.18 | 921.67 | 926.93 | 92.8 | 93.07 | 92.94 |
| Maize straw | 358.94 | 345.67 | 352.31 | 244.44 | 247.38 | 245.91 | 172.89 | 175.67 | 174.28 | 77.23 | 72.55 | 74.89 | 844.12 | 838.33 | 841.23 | 85.2 | 84.73 | 84.97 |
| Pea straw | 347 | 351.67 | 349.34 | 249.91 | 250.33 | 250.12 | 163.58 | 167.39 | 165.49 | 71.03 | 65.76 | 68.40 | 807.24 | 832.13 | 819.69 | 82.27 | 84.14 | 83.21 |
| Sugarcane bagasse | 319.71 | 320.1 | 319.91 | 235.12 | 234.53 | 234.83 | 170.58 | 164.67 | 167.63 | 72.78 | 69.33 | 71.06 | 823.02 | 785.63 | 804.33 | 80.77 | 79.43 | 80.10 |
| Groundnut straw | 320.13 | 316.2 | 318.17 | 259.22 | 262.69 | 260.96 | 158.26 | 163.67 | 160.97 | 64.67 | 67.67 | 66.17 | 804.54 | 806.33 | 805.44 | 80.33 | 81.53 | 80.93 |
| Mustard straw | 282.43 | 276.33 | 279.38 | 216.59 | 223.33 | 219.96 | 129.46 | 124.33 | 126.90 | 42.35 | 48.67 | 45.51 | 662.32 | 667.67 | 665.00 | 66.8 | 67.67 | 67.24 |
| Gram straw | 357.04 | 357.21 | 357.13 | 261.85 | 262.33 | 262.09 | 168.31 | 177.67 | 172.99 | 53.24 | 46.67 | 49.96 | 872.9 | 831.67 | 852.29 | 83.93 | 84.07 | 84.00 |
| Lentil straw | 298.12 | 295.67 | 296.90 | 209.5 | 203.85 | 206.68 | 147.11 | 136.67 | 141.89 | 39.53 | 35.42 | 37.48 | 664.46 | 669.33 | 666.90 | 68.77 | 67.83 | 68.30 |
| Wheat straw + Groundnut shell | 315.09 | 328.67 | 321.88 | 239.88 | 249.64 | 244.76 | 150.26 | 146.53 | 148.40 | 56.5 | 58.33 | 57.42 | 779.04 | 775.67 | 777.36 | 77.13 | 78.47 | 77.80 |
| Wheat straw + Maize cob shell | 325.61 | 339.33 | 332.47 | 235.64 | 236.67 | 236.16 | 172.5 | 176.33 | 174.42 | 65.41 | 56.24 | 60.83 | 794.81 | 805.33 | 800.07 | 81 | 81.43 | 81.22 |
| SE(m) | **5.94** | **1.23** | 3.59 | **3.89** | **2.7** | 3.30 | **3.23** | **2.45** | 2.84 | **1.06** | **0.25** | 0.66 | **8.12** | **2.31** | 5.22 | | **4.21** | 4.21 |
| CD (5%) | **17.53** | **2.14** | 9.84 | **11.47** | **3.41** | 7.44 | **9.54** | **4.27** | 6.91 | **3.12** | **1.24** | 2.18 | **23.95** | **4.24** | 14.10 | | **5.11** | 5.11 |

Values are expressed as means = standard deviation of three replications; Values with different small letters in the same row are significantly different at the level of 0.05.

## CONCLUSIONS

During the two consecutive years of continuous investigation, wheat straw followed by rice straw was found to be the best substrate for Oyster mushroom production whereas Mustard straw followed by lentil straw was the poorest performing substrate among eleven substrates tested.

## FUTURE SCOPE

After evaluating the data recorded for both years, it was found that for some of the traits Sugarcane bagasse and Maize straw exhibited better results than rice straw so that based on this research further research should be done to utilize maize and sugarcane as substrates with some modification to get the potential yield of oyster mushroom.

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