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Evaluation of agricultural substrates for morphological traits and yield performance of *Pleurotus florida* mushroom

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Abstract
The present study Evaluation of agricultural substrates on morphological traits and yield performance of *Pleurotus florida*", was conducted to assess how effective and sustainable it is to use various locally available substrates for cultivating *Pleurotus florida*. Morphological characters such as stipe length, stipe size, pileus diameter were observed across six treatments using soybean straw, wheat straw, paddy straw, sugarcane bagasse, sugarcane trash, and pigeonpea straw. Average fruit body weight, number of fruits/kg dry substrate, yield performance, biological efficiency was also measured. Morphological characteristics varied: Pileus diameter ranged from 6.64 to 9.44 cm. Treatment T_1 (soybean straw) resulted in the largest pileus diameter, measuring 9.44 cm. In contrast, T_5 (sugarcane trash) exhibited the smallest diameter, 6.64 cm. Stipe length varied from 2.38 to 4.35 cm. Among substrates, T_4 (sugarcane bagasse) had the longest stipe (4.35 cm), whereas the shortest (2.38 cm) was observed on sugarcane trash. Stipe size ranged from 1.25 to 4.11 cm. The maximum was recorded on soybean straw (4.11 cm), the minimum on sugarcane trash (1.25 cm). The heaviest average fruit body weight (11.13 g) was recorded in T_1, followed by T_2 (10.38 g) and T_4 (10.06 g), while T_5 had the lightest (8.10 g). The number of fruiting bodies per bed ranged from 174.79 to 239.98, with T_1 producing the highest (239.98), and the lowest in T_6 (174.79). Yield per kilogram of dry substrate ranged from 853.37 g to 1095.85 g, highest in T_1 and lowest in T_4. In conclusion, T_1 (soybean straw) proved to be the most effective substrate for cultivating *Pleurotus florida*. It showed maximum pileus diameter, highest number of fruiting bodies, best biological efficiency and productivity.

Keywords: *Pleurotus florida*, stipe length, pileus diameter, fruit body weight, yield.

Introduction
The cultivation of mushrooms has gained significant popularity in recent times. A mushroom is described as a macrofungus that possesses a distinctive fruiting body, which may grow either on the surface of the ground or beneath it. Macrofungi are characterized by their fruiting bodies, which are sufficiently large to be visible to the naked eye and can easily be harvested by hand. Mushroom cultivation has expanded to nearly every region of the world, with global mushroom production experiencing a growth rate of approximately 10% over the past few decades. In India, the diverse agro-climatic conditions and the plentiful availability of farm waste have facilitated the cultivation of various types of mushrooms, including temperate, tropical, and subtropical varieties, across the country (Shah *et al.*, 2004) [21].
Oyster mushroom generally grows on decaying substrate like paddy straw and wheat straw which was a good source of cellulose and lignin (Poppe, 2004 and Das, 2000) [17, 5] Oyster mushroom enjoys worldwide distribution from temperate to tropical regions growing saprophytically at a temperature range of 12-32 °C (Zadrazil, 1976) [24] An attractive feature of oyster mushrooms is that they can utilize a large variety of agricultural waste products and transform the lignocelluloses biomass in to high quality food, flavour and nutritive value (Bano and Rajarathanam, 1982) [2]. Among the numerous species of mushroom, oyster mushrooms (*Pleurotus florida*) are more advantages in terms of easiness in cultivation, role in biodegradation and bio-remediation, production of extracellular enzymes and nutraceuticals (Rashad *et al.*, 2009) [18].

Pleurotus florida, commonly referred to as dhingri in India and belonging to the *Pleurotaceae* family, is a popular edible mushroom recognized for its rich flavor and taste. It is noted for its high productivity within a relatively short cultivation time and offers greater protein yield per unit area than many conventional crops. Moreover, *Pleurotus florida* is a source of bioactive compounds with notable medicinal and pharmacological properties, such as antioxidants, antimicrobial agents, immune boosters, and substances with antitumor effects *(*Nayana & Janardhanan, 2000; Elamastas, 2007) [14, 9].

This study focused on assessing the growth performance, morphological characters and yield (biological efficiency) of *Pleurotus florida* cultivated on different agricultural residues such as soybean straw, wheat straw, paddy straw, sugarcane bagasse, sugarcane trash, and pigeon pea straw. These substrates, being abundantly available as agricultural by-products, present a low-cost and eco-friendly alternative for mushroom cultivation within agro-industrial systems. The objective was to explore the effectiveness of locally sourced materials for the successful and sustainable production of *Pleurotus florida* mushrooms.

Materials and Methods

The research work entitled Studies on cultivation of *Pleurotus florida* mushroom on different substrates**"** was accomplished at the All India Coordinated Research Project on Mushroom, College of Agriculture, Pune. The pure culture of *Pleurotus florida* was sourced from the ICAR-Directorate of Mushroom Research in Chambaghat, Solan (HP).

Master Spawn Preparation

Wheat grains were used as base for preparing the master spawn. The grains were first cleaned and soaked overnight, then boiled for 25-30 minutes. After boiling, they were drained and mixed with 4% calcium carbonate (based on the wet weight). The treated grains were then filled up to three-fourth of the volume in either conical flasks or 500 g polypropylene bags. These containers were sterilized at 20 pounds pressure for 1.5 hours. Once cooled, inoculation was done using a culture of *Pleurotus florida* in a UV-sterilized laminar flow chamber to maintain sterile conditions.

Commercial Spawn Preparation

To prepare the commercial spawn, the master spawn was transferred into sterilized polypropylene bags containing autoclaved wheat grains. This process was carried out under aseptic conditions in a laminar airflow cabinet. Around four to six spatula full of master spawn were added to each bag with 500 grams of moist, sterilized grains. After inoculation, the bags were sealed and gently shaken to distribute the spawn evenly. The inoculated bags were incubated at 25±1 °C for 7 to 10 days until fully colonized by mycelium, at which point the commercial spawn was ready for use.

Substrate Preparation and Sterilization

The cultivation of *Pleurotus florida* was carried out using different agricultural residues including wheat straw, soybean straw, paddy straw, sugarcane bagasse, sugarcane trash, and pigeonpea straw. These substrates were chopped into 3-5 cm pieces and soaked in gunny bags immersed in a chemical solution of Bavistin (7.5 g) and formaldehyde (125 ml) per 100 litres of water for 16-18 hours. After soaking, excess water was drained before use.

Bed Preparation and Spawning

Spawning was conducted in a room sanitized with 2% formaldehyde solution and left undisturbed for 48 hours. Once the substrate achieved about 65% moisture content, spawning was done by mixing in wheat grain spawn at a 2% rate on a wet weight basis. The treated substrate was packed into high-density polyethylene bags (17×23 inches), each holding 3 kg of moist substrate (equivalent to 1 kg of dry straw). The bags were tied securely and punctured with 20-25 small holes for aeration, with additional holes at the base for drainage.

Incubation and Spawn Run

The spawn-filled bags were arranged on iron racks inside the incubation chamber, where controlled conditions were maintained: temperature between 26-28 °C, relative humidity between 70-85%, with adequate light and ventilation. After 20-22 days, the bags showed complete mycelial colonization, turning fully white, indicating readiness for the next phase.

Cropping and Harvesting

Optimal conditions were provided for pinhead initiation and fruit body development. Ventilation for 2-3 hours daily ensured proper CO_2 management. Temperature and humidity during cropping were maintained between 20-25°C and 65-85%, respectively. Beds were watered daily throughout the fruiting period, except one day before harvest. Mushrooms were harvested 20-22 days after spawning by gently twisting mature fruiting bodies to prevent damage to nearby pins. Each mushroom was counted and weighed separately for every replication, and total yield was recorded to calculate biological efficiency, thereby assessing overall productivity.

Biological efficiency (%)

The biological efficiency was calculated by using the following formula,

$$\text{Biological efficiency (\%)} = \frac{\text{Fresh weight of mushrooms}}{\text{Dry weight of substrate used}} \times 100$$

Statistical analysis

The data collected for various observations was analyzed using CRD. The standard statistical methods as described by Panse and Sukhmate (1985) [15]. and an online OPSTAT application were followed for statistical significance.

Result and Discussion

Fruit body observations of *Pleurotus florida* mushroom (Morphological characters)

Colour

The pileus colour of *Pleurotus florida* mushrooms vary from white to creamish white; while the stipe is creamy white.

Odour

Pleurotus florida mushrooms are famous for their rich umami flavor, which is sometimes compared to the flavor of seafood or scallops. The umami taste in this mushroom is due to the presence of glutamic acids and related compounds. When cooked, they have a deep, meaty aroma

that enhances a variety of cuisines. No any odour change was noticed in any of the straws.

Stipe length

The stipe length of *Pleurotus florida* was evaluated across all substrate treatments, with measurements ranging from 2.38 cm to 4.35 cm. The longest stipe was recorded in treatment T_4 (sugarcane bagasse), which showed a significantly greater length of 4.35 cm compared to other treatments. On the other hand, the shortest stipe length of 2.38 cm was observed in the substrate composed of sugarcane trash (Table 1 and Figure 1). Treatment T_1 (soybean straw) reported 3.79cm of stipe length. These results are in agreement with the observations made by Kumar and Singh (2021), who reported a maximum stipe length of 3.94 cm when *Pleurotus florida* was cultivated on a substrate mix of 80% wheat straw and 20% paddy straw. Mshandete and Kivaisi (2013) [13]. Observed morphological characteristics for *Pleurotus* HK-37 on different substrate formulations. The stipe length ranged from 1.21 to 6.18 cm on varied substrate composition.

Stipe size

The data on stipe size of *Pleurotus florida* mushrooms revealed statistically significant differences among treatments. The stipe size varied between 1.25 cm and 4.11 cm across all substrates. The largest stipe, measuring 4.11 cm, was observed on the soybean straw substrate, whereas the smallest stipe size of 1.25 cm was recorded on sugarcane trash (Table 1 and Fig. 1). Similarly, Patil *et al.* (2017) [16]. reported that the stipe circumference in different wild mushroom isolates ranged from 1.19 cm to 2.92 cm, with the smallest size found in isolate PNP-4 and the largest in PNP-10. Further supporting these findings, Deshmukh *et al.* (2024) [7] recorded that the stipe size of king oyster mushrooms ranged from 5.06 cm to 7.17 cm. The highest stipe size of 7.17 cm was recorded on soybean straw, while the lowest measurement of 5.06 cm occurred on spent mushroom substrate. These results highlight the influence of substrate type on morphological traits like stipe development.

Pileus diameter

According to the data in Table 1, treatment T_1 (soybean straw) recorded the largest pileus diameter of *Pleurotus florida*, measuring 9.44 cm. This was followed by treatment T_4 (sugarcane bagasse), which showed a pileus diameter of 8.79 cm. On the other hand, the smallest pileus diameter, 6.64 cm, was observed in treatment T_2 (wheat straw).

Findings of Deshmukh *et al.* (2024) [7] Stated that the treatment T_3 soybean straw had the largest pileus diameter (6.72 cm), followed by the treatment T_4 paddy straw (6.63 cm), and the treatment T_7 spent mushroom substrate (4.99 cm) had the smallest pileus diameter. According to Patil *et al.* (2017) [16]. The pileus diameter of fruit bodies was ranged from 4.81 to 6.36 cm in different isolates under study and the maximum pileus diameter was noticed in PNP-10 (6.36 cm). Shukla and Jaitley (2011) [22] reported that the stipe length for Pleurotus sajor caju was 4.7 cm, pileus length 6.42 cm, pileus width 7.25 cm and grey colour of the fruit body. Mshandete and Kivaisi (2013) [13]. observed morphological characteristics for *Pleurotus HK-37* on different substrate formulations. The size of the caps ranged from 1.85 to 6.57 cm.

Table 1: Morphological character of *Pleurotus florida* mushroom on different substrates.

Treatment	Stipe length (cm)	Pileus Diameter (cm)	Stipe size (cm)
T_1-Soybean Straw	3.79	9.44	4.11
T_2-Wheat straw	3.28	6.44	2.12
T_3-Paddy straw	3.64	7.76	3.07
T_4-Sugarcane bagasse	4.35	8.79	3.86
T_5-Sugarcane trash	2.38	6.66	1.25
T_6-Pigeonpea Straw	3.89	7.86	2.59
SE(m)±	0.02	0.05	0.27
CD (0.05)	0.06	0.16	0.82

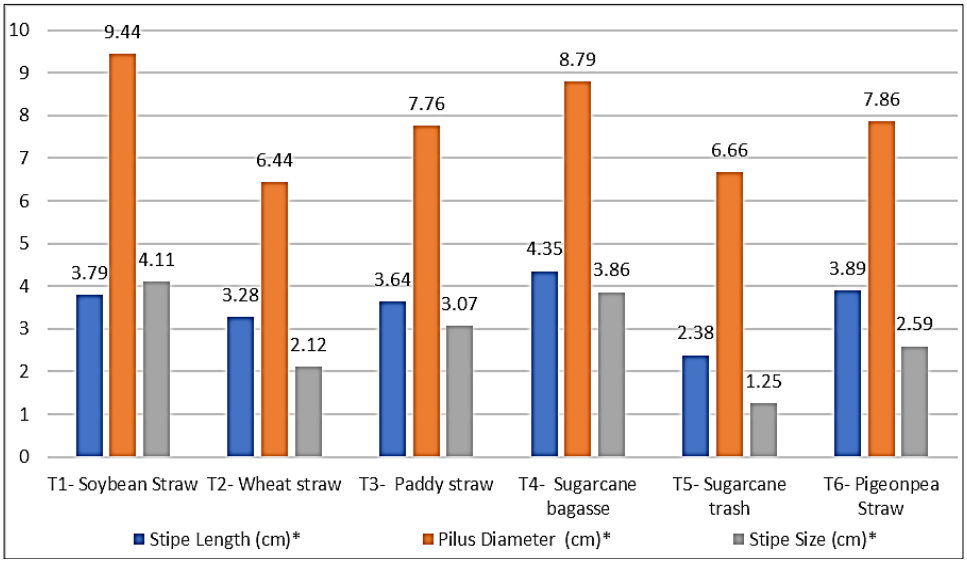
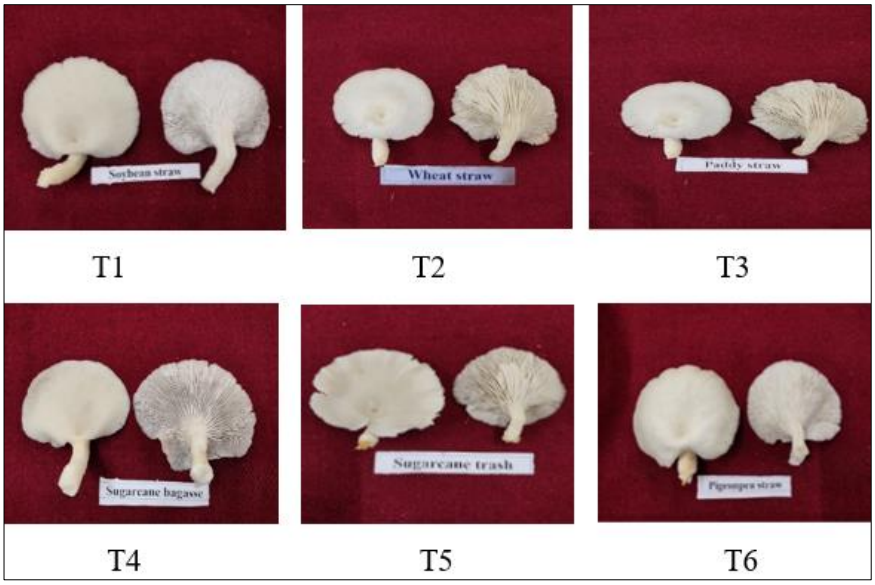


Fig 1: Morphological characters of *Pleurotus florida* mushroom on different substrates



T_1-Soybean straw, T_2-Wheat straw, T_3-Paddy straw, T_4-Sugarcane bagasse, T_5-Sugarcane trash, T_6-Pigeonpea straw

Fig 1: Morphological character of *Pleurotus florida* mushroom on different substrates

Average fruit weight

The average fruit body weight (g) was determined by randomly selecting 10 mature fruiting bodies from each treatment group, with the results summarized in Table 2. Across all treatments, the average fruit body weight ranged from 8.10 g to 11.13 g. Treatment T_1 (soybean straw) yielded the heaviest fruiting bodies, with an average weight of 11.13 g, followed by T_2 (wheat straw) at 10.38 g and T_6 (pigeonpea straw) at 10.20 g. Conversely, the lowest average weight was recorded in treatment T_5 (sugarcane trash), measuring only 8.10 g. Similar findings were reported by Hassan *et al.* (2010), [10] who observed that the average fruit body weight of *Pleurotus ostreatus* in Peshawar ranged between 2.3 and 9.7 g, depending on agroecological conditions. Additionally, Sharma and Jandaik (1983) [6] noted that *Pleurotus* spp. typically produced fruit bodies weighing between 5.0 and 5.8 g, characteristic of smaller flush types. Khade *et al*. (2019) [11] observed that the average fruit body weight of *Hypsizygus ulmarius* varied between 2.72 to 10.64 g. Deora *et al*. (2021) [6] reported for *Pleurotus eryngii* an average fruit body weight ranging from 25.3 to 96.4 g, indicating species-specific variations and the influence of substrate environmental conditions.

Table 2: Effect of different substrates on average fruit body weight (g) of *Pleurotus florida* mushroom

Treatment	Average fruit body weight (g)
T_1-Soybean Straw	11.13
T_2-Wheat straw	10.38
T_3-Paddy straw	8.68
T_4-Sugarcane bagasse	10.06
T_5-Sugarcane trash	8.10
T_6-Pigeonpea Straw	10.20
SE(m)±	0.59
CD (0.05)	1.21

Number of fruiting bodies per kg dry substrate

The total number of fruiting bodies per bed was recorded at each harvest, and the results are presented in Table 3 Treatments T_1 (soybean straw) and T_2 (wheat straw) produced nearly same numbers of fruiting bodies, averaging 239.98 and 239.81 per bed, respectively. These were followed by T_3 (paddy straw) with 201.13, T_4 (sugarcane bagasse) with 193.56, and T_5 (sugarcane trash) with 185.91 fruiting bodies per bed. The lowest count was observed in T_6 (pigeonpea straw), which produced only 174.79 fruiting bodies per bed. A higher number of fruiting bodies generally reflects greater substrate suitability for mushroom cultivation. The superior performance of soybean and wheat straw indicates their favorable role in supporting fruiting initiation and development. In a related study, Deshmukh *et* 2024) reported that the average fruit body weight of *Pleurotus eryngii* ranged from 21.35 g to 30.18 g across different substrates. The highest average weight (30.18 g) was recorded on paddy straw, followed by soybean straw (29.26 g) and wheat straw (28.71 g), while the lowest (21.35 g) was observed on spent mushroom substrate.

Table 3: Effect of different substrates on number of fruiting bodies of *Pleurotus florida* mushroom.

Treatment	No. of fruits per kg dry substrate
T_1-Soybean Straw	239.98
T_2-Wheat straw	239.81
T_3-Paddy straw	201.13
T_4-Sugarcane bagasse	193.56
T_5-Sugarcane trash	185.91
T_6-Pigeonpea Straw	174.79
SE(m)±	9.86
CD (0.05)	29.52

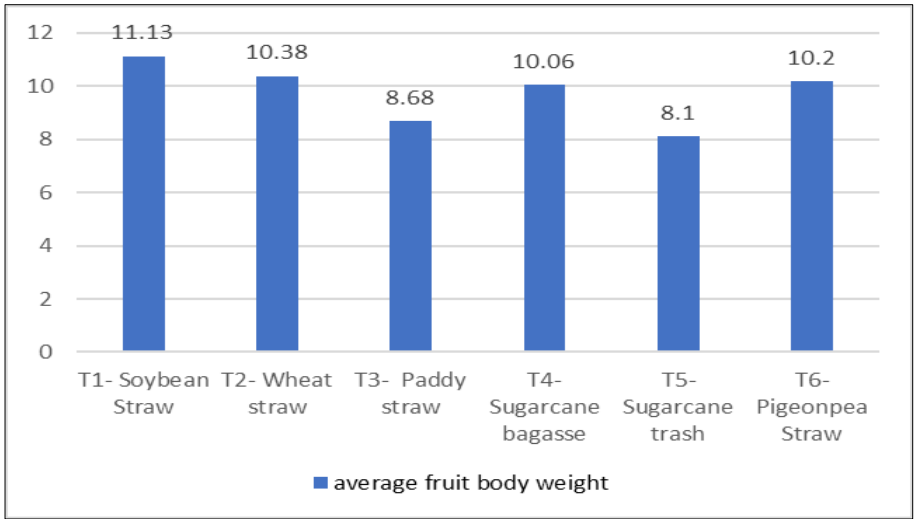


Fig 3: Effect of different substrates on number of fruiting bodies of *Pleurotus florida* mushroom**.**

Yield: The yield performance of each treatment was evaluated independently across the first, second, and third harvests. Total yield (g) per kilogram of dry substrate is shown in Table 4 and Figure 4. Treatment T_1 (soybean straw) recorded the highest yield at 1095.85 g/kg, followed by T_3 (paddy straw) with 965.65 g/kg, T_2 (wheat straw) at 924.99 g/kg, and T_6 (pigeonpea straw) with 886.63 g/kg. The lowest yields were observed in T_4 (sugarcane bagasse) and T_5 (sugarcane trash), with 853.37 g/kg and 858.95 g/kg, respectively. These findings align with Babar *et al*. (2016) [2], who reported a maximum yield of 1360 g/kg on wheat straw. In all treatments, the first flush produced the highest yield, followed by a gradual decline in subsequent flushes. Similarly, Dhobale and Jadhav (2023) [8] recorded yields of *P. sajor-caju* on wheat straw ranging from 706.82 g/kg to 1306.82 g/kg. Sawant *et al.* (2022) [20] observed yields of 752.64 g/kg on soybean straw, 654.01 g/kg on wheat straw, and 635.14 g/kg on sugarcane trash. Khade *et al*. (2019) [11] reported yields of *Hypsizygus ulmarius* on wheat straw ranging between 320 g/kg and 831.11 g/kg, while Patil *et al.* (2010) found *Pleurotus* spp. yielded 720.66 g/kg on wheat straw.

Biological Efficiency

The biological efficiency of *Pleurotus florida* under different treatments was calculated using the formula proposed by Chang and Miles (1989) [4] with results presented in Table 4 and Figure 4. Treatment T_1 (soybean straw) demonstrated the highest biological efficiency at 109.59%, significantly outperforming all other treatments. Treatments T_2 (wheat straw) and T_3 (paddy straw) recorded 92.49% and 96.47%, respectively, and were statistically similar. The lowest efficiency was recorded in T_4 (sugarcane bagasse) at 85.33%. Agarwal and Topwal (2018) [1] found wheat straw to be both efficient and economically viable, yielding 1327 g over three flushes and achieving 132.7% biological efficiency. Salame (2021) [19] reported a wide range of biological efficiency for *Pleurotus* spp. on wheat straw, from 45.87% to 191.37%. Singh and Singh (1991) reported biological efficiency between 47.30% and 87.50% for *P. florida* cultivated on soybean, wheat, and paddy straw. Similarly, Babar *et al*. (2016) [2] observed the highest biological efficiency of 136% on wheat straw. Also highlighted soybean straw as a favorable substrate, yielding 87.56% efficiency.

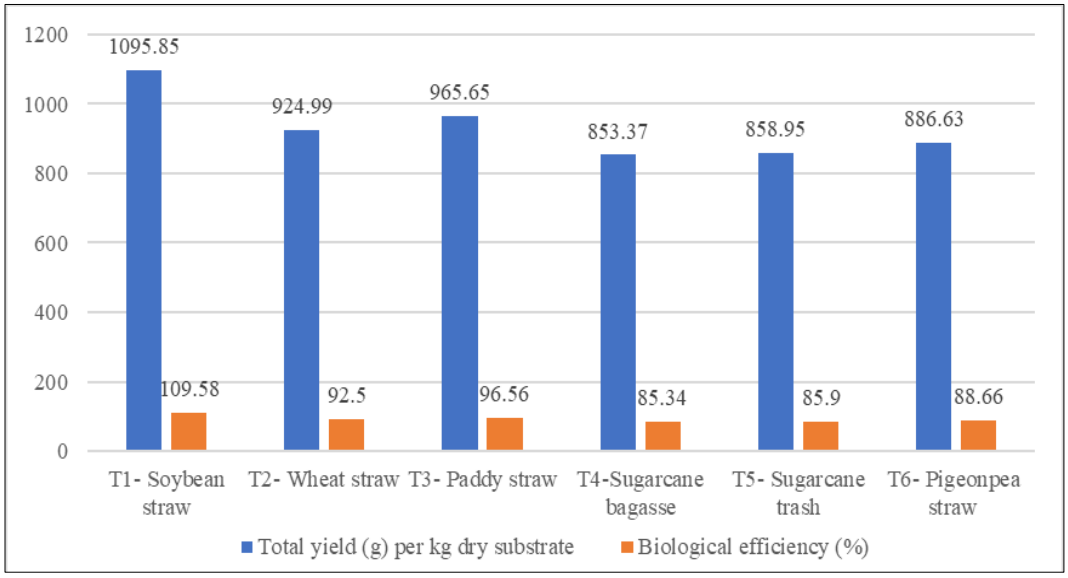
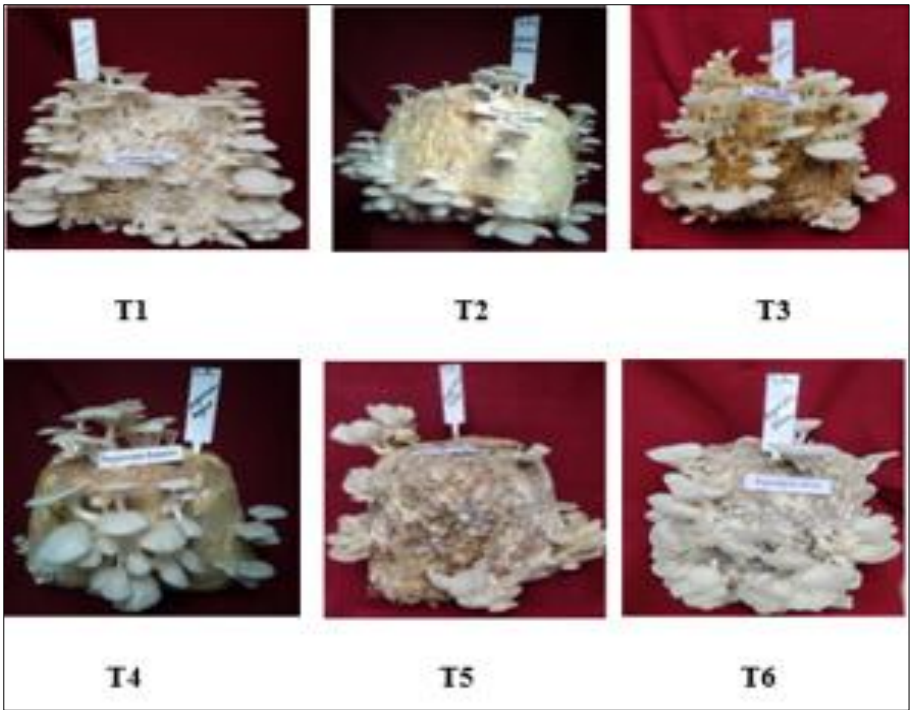


Fig 4: Effect of different substrates on total yield (g/kg dry substrate) and biological efficiency (%) of *Pleurotus florida* mushroom.

Table 4: Effect of different substrates on yield (g/ kg dry substrate) and biological efficiency (%) of *Pleurotus florida* mushroom.

Treatment	Total yield (g) per kg dry substrate	Biological efficiency (%)
T_1-Soybean straw	1095.85	109.59
T_2-Wheat straw	924.99	92.50
T_3-Paddy straw	965.65	96.57
T_4-Sugarcane bagasse	853.37	85.34
T_5-Sugarcane trash	858.95	85.90
T_6-Pigeonpea straw	886.63	88.66
SE(m)±	22.82	2.28
CD (0.05)	68.33	6.83



T_1-Soybean straw, T_2-Wheat straw, T_3-Paddy straw, T_4-Sugarcane bagasse, T_5-Sugarcane trash, T_6-Pigeonpea straw

Plate 2: Yield of *Pleurotus florida* mushroom on different substrates

Conclusion

The present investigation revealed that the choice of substrate has a significant impact on the morphological traits and yield performance of *Pleurotus florida*. Among the six agricultural substrates, soybean straw (T_1) consistently gave superior results. It recorded the largest pileus diameter (9.44 cm), the heaviest average fruit body weight (11.13 g), the highest number of fruiting bodies (239.98 per kg dry substrate), the maximum total yield (1095.85 g/kg) and biological efficiency of 109.59%, confirming soybean straw as the most favorable substrate for cultivating *P. florida*. Wheat straw (T_2) and paddy straw (T_3) also performed well, with comparable biological efficiencies and fruit body development, though slightly lower than soybean straw. In contrast, sugarcane bagasse, sugarcane trash, and pigeonpea straw resulted in lower yield and efficiency, and smaller morphological dimensions like pileus diameter and stipe size.

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