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UTILIZING LOCALLY ACCESSIBLE SUBSTRATE, TO MAXIMIZE OYSTER MUSHROOM (*Pleurotus ostreatus*) GROWTH AND BIOCONVERSION EFFICIENCY IN AMBO, CENTRAL ETHIOPIA

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A B S T R A C T

The effect of different locally available wastes as the substrates on oyster mushroom growth and bioconversion efficiency was investigated. *P. ostreatus* was grown on different substrates prepared from corn cob, sorghum stem, faba bean straw, pea straw, coffee husk, and sawdust alone (100%), and all with cottonseed waste in (1:1) ratio. Cottonseed waste alone was used as a control. Spawn run days, harvest days, average mushroom weight, fruiting body, cap diameter, stipe length, total yield, and biological efficiency were evaluated. All the quantitative data gathered were analyzed by SPSS statistical software for Windows version 25. Pea straw alone (T7) and pea straw:cotton seed waste (1:1) ratio (T8) with 15±2 and 15±3.1 days, had the shortest mycelia run, whereas sawdust alone (T11) took longer with 33±6.7 days for mycelia run. T7 had the shortest incubation to the first harvest 24±5.2 days, while T11 had the longest incubation to the first harvest 46±8.1 days. T11, 90±12 days, took the longest total production cycle, while T7, 63±6.6 days had the shortest total production cycle. T7 produced the greatest, number of fruiting bodies (254±48.5), whereas T11 produced the fewest fruiting bodies (20±5). The highest and lowest yield was obtained from the T7 substrate with 1614±17.1g and T11 substrate with 384±37.9g, respectively. The best substrate was found to be the T7; with mycelia run 15±2 days; incubation to 1st harvest 24±5.2 days, shortest production cycle 63±6.6 days, fruiting bodies 254±48.5, the highest total yield of 1614±17.1g and biological efficiency of 323±48.9%.

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1. Introduction

Mushrooms have a high protein, vitamin, and mineral content (Kimenju et al., 2009; Turfan et al., 2018). They are composed of 85-95% water, 3% protein, 4% carbohydrates, 0.1% lipids, and 1% minerals and vitamins (Palapala et al., 2006). It contains a high concentration of essential amino acids to near what the human body requires. Mushrooms are also easily digested and cholesterol-free (Oei, 2003). The bioactive substances extracted from medicinal mushrooms would help people's immune systems and improve their quality of life (Chang and Miles, 2004). The spent substrate left after mushroom harvesting, which is entangled with countless mushroom mycelia, can be used as animal feed (much more palatable), bio-fertilizer for soil fertility enrichment, and biogas (Alice and Kustudia, 2004). Besides, mushroom growing has been touted as a potential means of reducing poverty in underdeveloped nations due to its low production costs, large profit margins, and speedy returns (Masarirambi et al., 2011).

The oyster mushroom (*Pleurotus ostreatus*) is a tasty and flavorful edible mushroom. It has no starch, low sugar content, and a high amount of fiber, hence it serves as the least fattening food (Oei, 1996). It is the most widely cultivated mushroom species because it is easy to produce and grows well on a variety of agricultural by-products such as rice straw, sawdust, wheat straw, maize silk, sugarcane bagasse, and other cellulose-rich plant fibers (Pokhre et al., 2013); which shows *P. ostreatus* have good mycelial development with high saprophytic colonization potential (Nadir et al., 2016).

Ethiopia's economy is mostly based on agriculture, with crops accounting for a large portion of the country's output. Crop wastes are common as agricultural refuse after harvest. It is vital to dispose of agricultural waste in a green and environmentally friendly manner in this era of climate change. The utilization of organic material in mushroom production is an alternate way of using agricultural residues/wastes (Poppe, 1995). Despite Ethiopia's favorable climate, a relative abundance of land and manpower, and reasonably decent water resources, the cultivation, and use of mushrooms have been neglected in the past. As a result, the country has not reaped the benefits of mushrooms as the rest of the world has (Kiflemariam, 2008).

On the other hand, in Ethiopia, the most common substrate used for the production of *P. ostreatus* is cottonseed waste, which is both expensive and scarce (Abera et al., 2019). As a result, it's critical to develop a low-cost, high-quality mushroom fruiting body-stimulating substrate or substrate blend using locally available organic wastes. Agricultural by-products are plentiful in central Ethiopia, making mushroom cultivation a viable option. Furthermore, one of the biggest hurdles to mushroom farming in Ethiopia is a lack of understanding of the culinary and dietary relevance of mushrooms, as well as the monotonous traditional meals and conservative eating habits of Ethiopians. As a result, increasing mushroom cultivation technology transfer is an urgently needed intervention option. However, because there appears to be a wide range of agricultural crop leftovers on which the oyster mushroom can be grown, determining the best substrate for a high yield and high bioconversion efficiency can be difficult. With this rationalization, the current study was designed to look into the usability of various organic wastes, maize cobs, sorghum stems, bean straw, pea straw, coffee husk, and sawdust alone and cottonseed waste (1:1) ratios, on oyster mushroom production potential (growth performance and yield and biological efficiency) at Ambo, central Ethiopia.

2. Materials and methods

2.1. Source of culture and preparation of spawn

The study was conducted at Ambo University mushroom growing house, Western Ethiopia, Ambo. The *P. ostreatus* was received from Addis Ababa University, Department of Biology, Mycology laboratory and sub-cultured on freshly made potato dextrose agar (PDA). The *P. ostreatus* spawn was made using yellow sorghum grains as a major substrate, together with wheat bran and calcium sulfate ($CaSO_4$) in an 88:10:2 ratio (w/w) (Abera et al., 2019). Overnight, the sorghum grain was soaked in a sufficient amount of water. The excess water was then drained the next day, and the broken and floating grains were washed away with the water. The grain was then thoroughly mixed with the required amount of wheat bran and calcium sulfate.

The mixed spawn substrate was filled up to 75% into a capped bottle, leaving room for air exchange, and sterilized in the autoclave at 15 psi, 121°C for 1 hour. After sterilization, the spawn substrate was cooled in a safety cabinet before being inoculated with 20 pieces of 1 x 1cm block of *P. ostreatus* culture of 15-day-old and incubated at 28±2 °C for 21 days. Every five days, it was inspected for growth, and presence of contamination, and the bottle that showed signs of contamination was removed from the incubator.

2.2. Substrate collection and preparation

The corn cob, sorghum stem, faba bean straw, and pea straw were collected from farmers' fields around Ambo town in western Ethiopia. Coffee husk was collected from a dry coffee processing firm from Eastern Wollega, Ethiopia. Sawdust was collected from the wood processing shop of Ambo Town. Cottonseed waste was purchased from Addis Ababa, the capital city of Ethiopia. The wheat bran was purchased from the wheat processing factory. The calcium carbonate was obtained from the microbiology laboratory department of Biology, at Ambo University. All the substrates were transported to Ambo University, Department of Biology Microbiology Laboratory. For different treatments, the above-listed major substrates were prepared together with 10% of wheat bran 1% calcium carbonate otherwise mixed 50:50 (w/w) ratio with the cottonseed waste and as indicated in Table 1. The different substrates were soaked in water for 24 h and excess water was drained subsequently the wet substrate was filled into heat-resistant polyethylene bags in 0.5kg batches (yellow-coloredkurtupestal). The bags were sterilized in an autoclave at 121°C for 1 hour before being transferred into transparent production bags and allowed to cool to room temperature.

2.3. Spawning, incubation, and harvesting

After inoculating with 10% (w/w) spawn, the bagged substrates were placed in a disinfected dark room. To promote mycelia growth, the spawn was completely mixed with the substrate. Rubber bands were used to tie the bags. The inoculated bags were incubated at room temperature in the darkroom until the primordial phase began. Each treatment was replicated three times. For fruiting, the bags were relocated to the mushroom growing house. The bags were cut at the primordial formation site for the emergence of fruiting bodies once the primordial was commenced. The mushroom bags were watered in the morning and the evening until the harvest was completed. Temperature and humidity were regulated by wetting the concrete floor and spawning bags.

Table 1. The composition of the different substrates per treatment bag

Treatment	Composition per bag (w/w)
Treatment 1 (T1)	Corn cob (500g)
Treatment 2 (T2)	Corn cob (250g) + cotton seed waste(250g)
Treatment 3 (T3)	Sorghum stem (500g)
Treatment 4 (T4)	Sorghum stem (250g) + cotton seed waste (250g)
Treatment 5 (T5)	Faba bean straw (500g)
Treatment 6 (T6)	Faba bean straw (250g) + cotton seed waste (250g)
Treatment 7 (T7)	Pea straw (500g)
Treatment 8 (T8)	Pea straw (250g) + cotton seed waste (250g)
Treatment 9 (T9)	Coffee husk (500g)
Treatment 10 (T10)	Coffee husk (250g) + cotton seed waste (250g)
Treatment 11 (T11)	Sawdust (500g)
Treatment 12 (T12)	Sawdust (250g) + cotton seed waste (250g)
Treatment 13 (T13)	Cotton seed waste (500g)

NB. All the treatments received the recommended 10% wheat bran and 2% calcium carbonate added.

2.4. Data collection and analyses

The mycelia run in days, incubation to 1st harvest days, days between harvests, dates required for the total production cycle, number of bunches, number of fruiting bodies, number of aborts, cap diameter, stipe length, fresh weight, and biological efficiency were recorded for four consecutive harvests that took from 63-90 days. The biological efficiency (BE) of each treatment was calculated using the following formula.

$$BE = \frac{\text{Total fresh weight of mushroom (g) per substrate} \times 100}{\text{Dry weight of the substrate (g)}}$$

All quantitative data collected were analyzed by using SPSS version 25.0 by one-way analysis of variance (ANOVA). All of the statistics were performed at the 0.05 significance level and were presented as mean ± standard deviation (M±SD). The pairwise comparison was done and rearranged according to Tukey.

3. Results and discussion

3.1. Mycelia run and periods of different harvests

The effect of different substrates and their mixtures with cottonseed waste was investigated and found to influence the time taken to spawn run, incubation to the first harvest, and time taken between harvests, as well as the overall number of days taken for the complete production cycle. The time required for the spawn run showed a significant difference between treatments (P≤0.001). The shortest day was recorded for T7 and T8, 15±2 and 15±3.1 days, respectively, followed by T3 and T4, 16±4 and 16±3 days, respectively. T11 took the longest days for mycelia run 33±6.7 days (Table 2). The results of this study were at par with the results reported in the literature. Sitaula et al. (2018) reported the period required for the mycelia run was highest for the maize+paddy straw (20.50 days) and sugarcane bagasses+paddy straw (20.00 days), while it was lowest for the paddy straw (18.25 days) and sawdust+paddy straw (19.00 days). Chandra (2016) reported the fastest colonization period (34 days) of *P. ostreatus* from available substrates which was much more than the present study except for the sawdust substrate. The days taken for a spawn to colonize a specific substrate varies depending on the fungus strain, growth conditions, and substrate type (Chang and Miles, 2004). The slow colonization of sawdust may be due to the presence of more lignin than cellulose and hemicelluloses, which will be slowly degraded to release soluble sugars, whereas the rapid colonization of pluses straw (pea straw and faba bean straw) may be due to the high nitrogen content of these nitrogen-fixing crops. The factor affecting the overall low yield values from sugarcane bagasse and sawdust is the low breakdown of lignocellulosic compounds by *P. ostreatus* (Sharma et al., 2013). The time elapsed for the different major substrates and their mixture with cottonseed waste showed great variation from incubation to the first harvest together with the spawn run (P≤0.000). T7 had the shortest incubation to first harvest 24±5.2 days followed by T8, 26±1 days, and T9, 27±3.7 days. The lengthy incubation to 1st harvest was observed for T11; 46±8.3 days followed by T12, 44±4.5 days (Table 2). Chandra (2016) reported the period for the first harvest (40.20 days) for corn cob with rice bran supplement and the slowest was (48.70 days) for the vegetable residue (control). The time taken from 1st harvest to 2nd showed slight differences from 15 days for T7 and 24 days for T11. From 2nd to 3rd harvest was from 13 days for T7 and 20 days for T11 and T12. While that of the 3rd to fourth was 11 days for T7 and 16 days for T2 and T3 (Table 2). The longest days for the total production cycle were for T11, 90±12 days, while the shortest days for the total production cycle were for T7, 63±6.6 days (Table 2).

3.2. Effect of different substrate compositions on yield attributes of *P. ostreatus*

The average number of fruiting bodies 254±48.5 recorded on T7 differed remarkably (P≤0.000), followed by T8, 200±36. While, the average number of fruiting bodies from, T11 20±5, T1, 27±0.8; T2, 32±2, T12, 32±5.3 was very low (Table 3). This result was at par with the results reported by Sitaula et al. (2018). According to these authors, the substrate of T2 produced (108) fruiting bodies on average, followed by T1 (80) and T3 (20). The maximum number of effective fruiting bodies 74.25 was recorded on sawdust substrate and the minimum, was 12.75 on banana leaves (Mondal et al., 2010). In this study, more bunches were observed on T5, 7±0.99

followed by T8, 6±2.1, while fewer bunches were observed on T11 and T13, 3±1.5. The highest number of aborts was recorded from T7, 190±10 followed by T8, 150±25.5, and the fewer aborts were recorded from T10, 9±1, T11, 10±2, T13, 11±4.2 and T9, 12±1.5. The largest cap diameter was observed from T9, 14±2.5cm, followed by T5, 13±3cm, T10, 12±2cm, T13, 12±1cm, while the cap diameter from T1, T2, T3, T4, and T11, was smaller (Table 3). The results of the yield attributes of the different parameters observed in this study were comparable with the results reported in the literature. Mondal et al. (2010) reported the highest (7.79 cm) pileus diameter on sawdust substrate and the lowest (4.13cm) on banana leaves and rice straw (1:3) ratio. According to the study reported by Abera et al. (2019), different substrates had different effects on the yield-related parameters of oyster mushrooms. The largest cap diameters and stipe length of oyster mushrooms grown on these substrates were recorded on the bags received 30:30:40% wheat straw: waste paper and cotton seed waste and 40:40:20% the same substrate composition, while the smallest cap diameter of 6.23cm was measured from wheat straw 25%:waste paper 25% and cotton seed waste 50%. The smallest stipe length was measured from 20:20:60% wheat straw: waste paper: cotton seed waste. In this study, the stipe length of the oyster mushroom grown on different substrates showed slight variation from 3.5-2.00 cm. This observation was quite different from the stipe length reported by Patil et al. (2010), who indicated the average length of the stalk for *P. eryngii* (6.43cm) followed by *P. florida* (6.30 cm), *P. ostreatus* (5.94cm), *P. sajor-caju* (5.71cm) and a minimum length of stalk from *P. flabellatus* (5.05cm). The presence of glucose, fructose, and trehalose in the substrate may result in a higher number of functional fruiting bodies. *P. ostreatus* was able to better utilize favorable nutrients such as cellulose and hemicellulose from various agricultural residues, resulting in improved oyster mushroom output. The quality of the oyster mushroom *P. florida* is determined by the length of the stalk; the longer the stalk, the poorer the mushroom quality (Patil et al., 2010). In this study, the sporophores and quality of the oyster mushroom fruiting bodies were depicted in Figure 1.

Table 2. Days required for mycelia colonization, incubation to the first harvest, days required between harvests, and days for the total production time of oyster mushroom

Treatments	Period for colonization	Incubation 1st harvest	1st to 2nd harvest	2nd to 3rd harvest	3rd to 4th harvest	Total production time (days)
T1	25±3.0^{bc}	33±0.8^{cd}	20±2.0^{cd}	18±2.5^{bc}	15±1.0^{bc}	86±10.0^{ef}
T2	22±4.0^{ab}	30±1.0^{abcd}	19±3.0^{abc}	18±3.1^{bc}	16±2.0^{c}	83±5.0^{de}
T3	16±4.0^{ab}	30±1.5^{abcd}	18±1.8^{abcd}	18±2.0^{bc}	16±3.1^{c}	85±9.5^{jdef}
T4	16±3.0^{abc}	30±2.0^{abcd}	18±2.0^{abcd}	18±1.8^{bc}	15±2.9^{bc}	85±5.6^{def}
Ts	18±3.1^{abc}	30±3.5^{abcd}	18±4.1^{abcd}	18±1.9^{bc}	15±2.5^{bc}	82±6.2^{d}
T6	21±2.5^{abc}	34±4.1^{ab}	21±2.2^{de}	19±2.8^{bc}	16±1.5^{c}	90±11.6^{g}
T7	15±2.0^{a}	24±5.2^{a}	15±1.9^{a}	13±2.0^{a}	11±1.8^{a}	63±6.6^{a}
T8	15±3.1^{a}	26±1.0^{ab}	17±2.8^{abc}	15±3.2^{ab}	12±2.3^{ab}	70±6.8^{b}
T9	25±8.7^{bc}	27±3.7^{abc}	19±2.1^{b}	16±2.8^{abc}	13±3.3^{abc}	76±9.2^{c}
T10	23±1.0^{bc}	28±4.2^{abc}	16±1.9^{ab}	14±3.0^{a}	12±1.0^{a}	70±7.2^{a}
T11	33±6.7^{d}	46±8.3^{e}	24±5.2^{e}	20±5.2^{d}	-	90±12.0^{g}
T12	20±2.0^{abc}	44±4.5^{e}	22±3.8^{e}	20±2.2^{d}	-	88±13.0^{fg}
T13	18±3.0^{cd}	26±3.5^{ab}	19±1.8^{b}	16±2.9^{abc}	13±2.0^{abc}	76±8.0^{c}
Sign	0.001	0.003	0.000	0.000	0.002	0.005

NB. The figures followed by the same letter in the column are not significantly different from each other

Table 3. Number of mature aborts, number of bunches, cap diameter, and stipe length of the oyster mushroom grown on different substrates

Treatments	No. mature	No. of bunches	No. of aborts	Cap diameter (cm)	Stipe length (cm)
T1	27±0.8^{h}	4±0.5^{ab}	15±2.1^{e}	6±2.0^{c}	2±0.6^{a}
T2	32±2.0^{gh}	4±1.0^{ab}	13±2.7^{e}	6±0.5^{c}	3±0.1^{a}
T3	55±6.0^{ef}	4±2.0^{ab}	20±5.0^{de}	6±1.1^{c}	3±0.8^{a}
T4	85±10.0^{c}	4±1.5^{ab}	35±3.0^{c}	6±2.0^{c}	3±0.5^{a}
Ts	65±5.0^{de}	7±0.1^{a}	15±3.5^{e}	13±3^{a}	2±0.2^{a}
T6	70±8.0^{d}	5±2.0^{ab}	30±4.1^{cd}	10±1.5^{bc}	2.5±0.5^{a}
T7	254±48.5^{a}	5±1.1^{ab}	190±10.0^{a}	11±3.2^{ab}	3.5±0.9^{a}
T8	200±36.0^{b}	6±2.1^{ab}	150±25.5^{b}	11±2.0^{ab}	2.5±0.7^{a}
T9	42±3.0^{fg}	4±1.0^{ab}	12±1.5^{e}	14±2.5^{a}	3.5±0.8^{a}
T10	52±6.6^{ef}	5±1.6^{ab}	9±1.0^{e}	12±2.0^{ab}	3.5±0.6^{a}
T11	20±5.0^{h}	3±1.5^{c}	10±2.0^{e}	6±2.0^{c}	3.5±0.2^{a}
T12	32±5.3^{gh}	5±1.2^{ab}	21±2.1^{cde}	7±1.3^{bc}	3±0.7^{a}
T13	45±8.2^{fg}	3±1.5^{c}	11±4.2^{e}	12±1^{ab}	3.5±0.9^{a}
Sign	0.000	0.016	0.000	0.000	0.009

NB. The figures followed by the same letter in the column are not significantly different from each other

3.3. The yield per flush, total biomass, and biological efficiency of *P. ostreatus* grown on different substrates

In all of the flushes, the yield of oyster mushrooms varied greatly depending on the substrate (P≤0.000). In the first flush, the maximum yield (848±86.3g) was obtained on pea straw alone, followed by pea straw: cottonseed waste (1:1w/w) (680±6.2g), while the lowest yield (166±10g) was produced on sawdust. Pea straw (456±55.9g) yielded the most in the second flush, followed by a mixture of bean straw and cottonseed waste (350±5g), cottonseed alone (308±2g), and the mixture of pea straw and cottonseed (304±16.8g). Sorghum stems 100% gave the lowest yield (113±17.5g) in the same flush, followed by sawdust (140±14.7g) and corn cob alone (186±12g) (Table 4). Cottonseed waste (210±15g) produced the maximum yield in the third flush, followed by pea straw (204±28g). Sorghum stems produced the lowest yield of 62±12g in the same flush, followed by sawdust (80±5g) and corncob (90±14g) (Table 4). Cottonseed waste (180±10) produced the best yield in the fourth flush, followed by pea straw (106±15). The lowest yield of 32±5g was obtained on sorghum stem during the same flush, whereas sawdust and sawdust cotton seed waste mixture produced nil yield in the fourth flush (Table 4). The results of this study show similarities with the results reported in the literature. Maheswari et al. (2020) reported the total fresh weight of the first and second flush was highest for maize cob+paddy straw (718.7g) followed by sugarcane bagasses+paddy straw (527.8g), sawdust+paddy straw (459.0g), and lowest for paddy straw(408.3g). The highest total biomass of 1614±17.1g was recorded from pea straw followed by faba bean straw: cottonseed waste (1:1w/w), 1234±15.3g, and pea straw cotton seed waste (1:1w/w), 1165±26.0g, while the smallest total biomass was recorded from, sorghum stem 374±36g and sawdust 384±37.9g (Table 4). Mondal et al. (2010) reported the maximum biological yield (159.3 g) from rice straw and the minimum biological yield (36.35 g) was obtained from banana leaves and rice straw (1:1 w/w) in the first flush. Rice straw produced the highest biological yield (164.49g) in the case of the second flush.

The highest yield was obtained in T3 (761.5±7.5g) followed by 507±5 g and 317.7±3.1g in T1 and T2, respectively (Maheswari et al., 2020).

There was a significant variation in oyster mushroom biological efficiency under different treatments. Pea straw had a much higher biological efficiency (323±48.9%) followed by a mixture of faba bean straw (247±18.9%), cottonseed waste (245.2±33.4%), and pea straw + cottonseed waste (233±18.0%). The lowest biological efficiency of oyster mushrooms was found on sorghum stem at 76.8±18.8% and sawdust at 78.8±10.5% (Table 4) The result of biological efficiency of this study was much more than the results reported in the literature. Paddy straw showed significantly highest biological efficiency (96.29%) followed by maize cob+paddy straw (74.09%), sugarcane bagasses+paddy straw (71.90%), and lowest sawdust+paddy straw (71.05%) (Mondal et al., 2010). Sitaula et al. (2018) reported, that the maximum biological efficiency in T2 (92.08±0.89%) as compared to T3 (87.39±0.85%) and T1 (72.37±0.7%). Chandra (2016) reported the biological efficiencies of *P. ostreatus* which ranged from 91.99 to 109.50% in corn cob, 69.81 to 88.36 % in paper waste, and 52.26 to 65.22% in vegetable residue. The enhanced yield and biological efficiency observed in most of the treatments in this study could be due to the presence of favorable nutrients such as cellulose and hemicellulose from crop and pulse straw which were utilized better by *P. ostreatus*. The reduced amount of yield in sawdust and sorghum stem treatments could be attributed to rich lignin content and the deprived inability of *P. ostreatus* to degrade lignin. The highest yield on pea straw appeared to be due to the comparatively better availability of nitrogen, carbon, and minerals from this substrate. The low yield and biological efficiency of *P. ostreatus* on sawdust and sorghum stem could probably be due to the inability of the mushroom mycelia to produce appropriate enzymes that could hydrolyze and convert the substrates for its vegetative and reproductive growth.

Table 4. The yield of different harvests, total biomass, and biological efficiency of oyster mushrooms grown on different substrates

Treatments	1st flush (g/bag)	2nd flush (g/bag)	3rd flush (g/bag)	4th flush (g/bag)	Total biomass (g/bag)	BE (%)
T1	312±15.5^{i}	186±12.0^{i}	90±14.0^{fg}	52±5.0^{d}	640±55.0^{h}	128±22.0^{g}
T2	395±35.5^{f}	274±19.1^{e}	106±11.3^{de}	49±8.2^{d}	824±55.5^{f}	164.8±28.6^{e}
T3	167±44.0^{j}	113±17.5^{k}	62±12.0^{h}	32±5.0^{e}	374±36.0^{i}	78.8±10.5^{h}
T4	424±13.5^{e}	225±22.8^{f}	115±9.8^{d}	87±8.1^{c}	881±36.5^{d}	176.2±18.5^{d}
Ts	350±9.9^{h}	150±6.0^{j}	110±10.5^{de}	90±4.0^{c}	697±16.9^{g}	139±21.5^{f}
T6	600±10.0^{c}	350±5.0^{b}	180±9.0^{b}	100±4.0^{bc}	1234±15.3^{b}	247±18.9^{b}
T7	848±86.3^{a}	456±55.9^{a}	204±28.0^{a}	106±15.0^{b}	1614±17.1^{a}	323±48.9^{a}
T8	680±6.2^{b}	304±16.8^{c}	128±14.5^{c}	50±12.0^{d}	1165±26.0^{c}	233±18.0^{c}
T9	375±19.2^{g}	287±28.9^{d}	105±15.2^{de}	86±12.3^{c}	853±61.3^{e}	170.6±24.5^{d}
T10	393±22.9^{f}	204±13.3^{h}	117±13.6^{cd}	87±10.0^{c}	802±9.2^{f}	161±17.5^{e}
T11	166±8.6^{j}	140±14.7^{j}	80±5.0^{g}	-	384±37.9^{i}	76.8±18.8^{h}
T12	300±19.7^{i}	220±5.0^{g}	100±10.0^{df}	-	620±0.1^{h}	124±0.1^{g}
T13	530±5.0^{d}	308±2.0^{c}	210±15.0^{a}	180±10.0^{a}	1226±16.52^{b}	245.2±33.4^{b}
Sign	0.000	0.000	0.000	0.000	0.000	0.000

NB. The figures followed by the same letter in the column are not significantly different from each other

Figure 1. Sporophores of the oyster mushroom grown on different substrates: A) Primordial formation B) Sporophores on the cottonseed waste, C) Sporophores on pea straw, D) Sphorophores maize cob E) Sporophores on the coffee husk, F) Sporophores on faba bean straw

4. Conclusions

For countries like Ethiopia, where agriculture has historically been the main source of income, the promotion of mushroom production technology is most importance for enhancing community nutrition, health, and income. *P. ostreatus* is a type of specialty mushroom that can be grown on a variety of organic substrates, but it's important to choose a substrate or a combination of substrates that will produce the highest mushroom output and biological efficiency. One of the most important considerations when choosing a suitable substrate is the variety of substrates that are available in the area. According to the results of the current study, oyster mushrooms (*Pleurotus ostreatus*) can be grown on a variety of organic wastes, including sawdust, coffee husks, pea straw, bean straw, and cottonseed waste otherwise mixed in a 1:1 ratio. In terms of the number of days needed for a full spawn run, a combination of cotton seed waste, bean, and pea straw, performed better as compared to other substrates tested. The enormous amount of agricultural waste products that are currently available may be resolved by using bean and pea straws as substrates for oyster mushroom growing. However, more research must be done to determine the potential effects of diverse agricultural wastes on the growth of oyster mushrooms.

Compliance with Ethical Standards

Conflict of Interest

As the author of article declare that there are no conflicts of interest with respect to the research, authorship, and/or publication of this article.

Authors' Contributions

Asefa KENENI: Investigation, Conceptualization, Writing - original draft, Formal analysis, Data curation.

Ethical approval

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Data availability

Not applicable.

Consent for publication

We humbly give consent for this article to be published.

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