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Suitability of sugarcane industry waste amended with agricultural wastes for oyster mushroom cultivation

Muhammad Rashid Arshad*[1], Muhammad Arshad[2], Nasir Ahmad Khan[3], Muhammad Irfan Ullah[2], Samiya Mahmood Khan[1], Yasir Iftikhar[4], Muhammad Zohaib Anjum[4], Jaime Molina-Ochoa[5,6], John Edward Foster[6]

[1]*Department of Plant Pathology, University College of Agriculture, Bahauddin Zakariya University, Multan, Pakistan*

[2]*Department of Entomology, College of Agriculture, University of Sargodha, Pakistan*

[3]*Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan*

[4]*Department of Plant Pathology, College of Agriculture, University of Sargodha, Pakistan*

[5]*Facultad de Medicina Veterinaria y Zootecnia, Universidad de Colima, Coordinación General de Investigación Científica, Centro Universitario de Investigación y Desarrollo Agropecuario, Crucero de Tecomán, Tecomán, Colima, México.*

[6]*Department of Entomology, University of Nebraska-Lincoln, Lincoln, NE, USA*

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Abstract

Cultivation of mushroom is a lucrative agribusiness. Different species of *Pleurotus* can grow well in variable temperature conditions. Hence they can be ideally suited for cultivation throughout every season in various regions of tropical nations like Pakistan. To determine the suitability for cultivation of Oyster mushroom, an experiment was carried out to investigate the effect ofsugarcane industry waste amended with supplementary materials (cotton waste and sorghum waste). Our results showed that T_4 (75% Cotton waste + 25% Sugarcane industry waste) gave the best results in 100% mycelial growth (21 days) and pinhead formation (06.50 days) after mycelial growth. In case of maturity of fruiting bodies, minimum number of days (14.00days) was taken on T4 compared to other substrates. Furthermore, maximum yield was obtained by T_4 (327.2g) and minimum yield (166.52g) was obtained by T_1 (Sugarcane industry waste 100%). These results revealed that 75% Cotton waste + 25% Sugarcane industry waste are suitable substrate for the cultivation of Oyster mushrooms as compared to other substrates.

* **Corresponding Author:** Muhammad Rashid Arshad ✉ rashidqazee@gmail.com

Introduction

Oyster mushrooms (*Pleurotus ostreatus* Jacq. P. Kumm) are a diverse group of saprotrophic fungi belonging to the genus *Pleurotus* (Kong, 2004). Mushroom cultivation is a small but very important agribusiness in many countries (Khan *et al.,* 1980). Mushrooms are a good source of non-starchy carbohydrates, with high content of dietary fiber and moderate quantity of proteins, including most amino acids, minerals, and vitamins (Croan, 2004). Mushrooms possess 1.6% sugar, 20.3-42% proteins, 0.5-3.5% fats, generally glycerides and glycolipids, 0.5-1.5% vitamins (Shukla *et al.,* 2005). They were once used as vegetables at the beginning of human civilization (Ponmurugam, 2007).

Pleurotus species, commonly known as oyster mushrooms, usually are edible fungi cultivated throughout the world especially in south East Asia, India, Europe and Africa. China produces 64% of all edible mushrooms worldwide and 85% of all oyster mushrooms (*Pleurotus* spp.) Oyster mushroom is the 3rd largest commercially produced mushroom in the world (Tesfaw *et al.,* 2015). Oyster mushrooms (*Pleurotus* spp.), belonging to class Basidiomycetes and family Pleurotaceae, grow naturally in the temperate and tropical forests upon dead and decaying timber logs (Tan, 1981).

Within Pakistan, the local people know the oyster mushroom as "Dhingri" (Jiskani *et al.,* 2007). The oyster mushrooms naturally grow on wood logs and stumps of trees and shrubs under cool and succulent conditions. Mostly it develops naturally in forests associated with Khyber Pakhtunkhwa and Azad Kashmir but in the farms of Punjab and Sindh. Especially in the last twenty years it has gained much importance. Within the last ten years its production enhanced from 169,000 to 876,000 metric tons that was about 14.4% of the total world production (Ali *et al.,* 2004). Mushroom could turn out to be an important additions to farmers searching for a value added product and strategy to supplement farm income even though making use by products or co-products from all other crops. Mushroom production in rural communities can alleviate poverty and improve the diversification of agricultural production (Godfrey *et al.,* 2010).

Probably the most well-known species of *Pleurotus* are usually *P. flabellatus, P. ostreatus, P. cornucopie, P. eryngii, P. cystidiosis, P. florida and P. sajor-caju* (Mathew *et al.,* 1996). It may be cultivated within a wide range of conditions on different natural resources and agricultural wastes. This is because these species have been identified as an excellent source of food, flavor, texture and nutritional value in developing countries. The entire production of mushroom crop residues from the cereal crops in Pakistan is predicted to be about 36 million tons and this waste can be utilized for mushroom cultivation by means of recycling mechanism (Asghar *et al.,* 2007). Khan *et al.* (1980) studied the particular cultivation of oyster mushrooms on different substrates. It was observed that after spawn running pinhead formations took 7-8 days and sporocarps were produced after 10-12 days. Cotton waste gave the highest yield. Formation of pinhead as well as fruiting bodies per bag was also more in cotton waste. Crop residues such as wheat straws, rice straws, banana leaves, corn cobs, sawdust, and bean straws can be utilized as substrates to grow oyster mushrooms (Poppe, 2000). Oyster mushrooms can utilize a wide range of crop residues due to their great adaptability and has short growth cycle. The oyster mushroom cultivation on crop residues or wastes is considered as potential source of income, an alternative food production, provision of employment, and for recycling of agricultural wastes (Mamiro and Mamiro, 2011).

Keeping in view the importance of mushroom, the main objectives of this experiment were (1) to study the percentage level of spawning in sugarcane industry waste with some supplementary materials, (2) to study the primordial formation of Oyster mushroom on various supplementary materials, (3) to study the yield performance of oyster mushroom using sugarcane industry waste with some supplementary materials and (4) to study the biological efficiency of sugarcane industry waste with some supplementary materials.

Materials and methods

Substrates and place of work

The study was conducted in the Mushroom Laboratory, in the Department of Plant Pathology, at the University of Agriculture, Faisalabad. The Oyster mushroom, *P. ostreatus*, was grown on cotton waste, sugarcane industry waste and sorghum waste. The species of oyster mushroom *P. ostreatus* was obtained from the Mushroom Laboratory.

Preparation of substrates

The substrates were soaked in water and then 2-4 g/kg-l lime was mixed. The mixture was then piled up, covered with a plastic sheet and allowed to ferment for 3-5 days. The substrates were spread on the ground to remove the excessive water; finally the substrate had moisture up to 70%. Then the material was filled into heat resistant polypropylene bags (Bernabé-González and Cayetano-Catarino, 2009). The polypropylene bags of (8 × 10) inch size were filled with agitated substrates. A total of 400g of wastes were filled in each bag and bags were sealed with rubber bands. The bags containing fermented substrates were sterilized in a 220 L drum at 70°C for one hour. Heating and maintenance of temperature was carried out by providing continuous flame using commercial gas burner. The prepared spawn of oyster mushroom was collected from Mushroom Laboratory. The sterilized bags containing fermented substrates were inoculated with 8 g of spawn per bag. The spawned bags were kept in a growth room under controlled room temperature and moisture. Temperature and humidity were maintained at 25-30°C, and 80-90%, respectively. Humidity was maintained by sprinkling water on the growth room floor five times a day. After development of mycelia (bags became whitish when mycelia were established). The holes were made in bags. Moisture level of bags was observed visually and was maintained by sprinkling fresh water twice a day.

Data recording and analysis

Time was recorded in days for the completion of 25%, 50%, 75% and 100% growth of mycelium and pinhead formation on all the treatments in the polypropylene bags. The total yield was recorded in g for all treatments. Data collected on different parameters of mushroom were analyzed statistically by using the MSTAT Programme and the means were compared using Least Significant Differences (LSD) test at p=0.05.

Results

Pinhead formation

The comparison of means revealed that there was great variation in the performance of the *P. ostreatus* on sugarcane industry waste and its combined effects with cotton waste and sorghum waste for mycelial growth against all treatments. Among all the agro-waste substrates the most efficient substrate was T4=75% Cotton waste + 25% Sugarcane Industry waste which tooka minimum of 6.50 days followed by T2=50% Cotton waste + 50% Sugarcane Industry waste needed about 10.00 days; T5= 25% Sorghum waste + 75% Sugarcane Industry waste, and T3 = 50% Sorghum waste + 50% Sugarcane Industry waste needed 13.00 and 15.50 days, respectively, being the least efficient T1= Sugarcane Industry waste 100% which required 17.50 days (Table 1).

Table 1. Comparison of means for pinhead formation and fruiting bodies (No. of Days) on Sugarcane Industry waste amended with Cotton waste and Sorghum waste.

Treatments	Pinhead formation	Fruiting bodies
T1=Sugarcane industry waste 100%	17.50^{e}	30.50^{e}
T_2= 50% Cotton waste + 50% Sugarcane Industry waste	10.00^{b}	17.00^{b}
T_3= 50% Sorghum waste + 50% Sugarcane Industry waste	15.50^{d}	24.50^{d}
T_4= 75% Cotton waste + 25% Sugarcane Industry waste	06.50^{a}	14.00^{a}
T_5= 25% Sorghum waste + 75% Sugarcane Industry waste	13.00^{c}	20.00^{c}

Mean within a column followed by the same letters are not significantly different at p=0.05 LSD test.

Fruiting bodies

Highly significant differences were obtained in the period for fruiting bodies of oyster mushroom in different substrates. The lowest period was recorded in the T4 (75% cotton waste +25% sugarcane industry waste) with 14.00 days; meanwhile, the longest period was exhibited by the T1 (sugarcane waste 100%) with 30.50 days (Table 1).

Mycelial growth

The results regarding the best substrates for mycelial growth showed that (Table 2) among all the agro waste substrates the most efficient substrate was T4=75% Cotton waste + 25% Sugarcane Industry waste which took minimum days (21.00) to complete 100% mycelial growth; and least efficient was T1= Sugarcane Industry waste 100% with 28.00 days.

The results of the present study revealed that 25% to 100% mycelial growth occurred at minimum days in case of T4 (75% cotton waste + 25% sugarcane industry waste) (Table 2).

Table 1. Comparison of means for pinhead formation and fruiting bodies (No. of Days) on Sugarcane Industry waste amended with Cotton waste and Sorghum waste.

Treatments	Pinhead formation	Fruiting bodies
T1=Sugarcane industry waste 100%	17.50^{e}	30.50^{e}
T_2= 50% Cotton waste + 50% Sugarcane Industry waste	10.00^{b}	17.00^{b}
T_3= 50% Sorghum waste + 50% Sugarcane Industry waste	15.50^{d}	24.50^{d}
T_4= 75% Cotton waste + 25% Sugarcane Industry waste	06.50^{a}	14.00^{a}
T_5= 25% Sorghum waste + 75% Sugarcane Industry waste	13.00^{c}	20.00^{c}

Mean within a column followed by the same letters are not significantly different at p=0.05 LSD test.

Total yield

The total fresh weight of mushrooms collected from five treatments is shown in Table 3 According to the result, different substrate showed significant effect on the total weight of the mushrooms. According with the DMS separations, the treatment T4 produced the highest yield with 327.2g. A second category was obtained by T2 with 290.32g; the third category was paired by T3 and T5 with 250.82g, and 242.88g, respectively; and the lowest yield was obtained by T1 with 166.52g (Table 3).

Table 3. Comparison of Means for Total Yield (g) on Sugarcane Industry waste amended with Cotton waste and Sorghum waste.

Treatments	Total yield (g)
T1=Sugarcane industry waste 100%	166.52^{d}
T_2= 50% Cotton waste + 50% Sugarcane Industry waste	290.32^{b}
T_3= 50% Sorghum waste + 50% Sugarcane Industry waste	250.82^{c}
T_4= 75% Cotton waste + 25% Sugarcane Industry waste	327.2^{a}
T_5= 25% Sorghum waste + 75% Sugarcane Industry waste	242.88^{c}

Mean within a column followed by the same letters are not significantly different at P=0.05 LSD test.

Discussion

The results of the present study clearly showed that 75% of the cotton waste amended with the 25% of the sugar industry waste proved the best substrate for pinhead formation of oyster mushroom at minimum number of days as compared to other substrates. Several workers reported different timings for pin-head formation of different mushroom species. Iqbal *et al.*(2005) reported that cotton waste proved a better substrate in case of pin-head formation. It was observed that time taken for the first appearance of pinhead after completion of mycelial growth was 6

days of *P. ostreatus*. Khan *et al.* (2011) reported cotton waste substrate took a minimum number of days (9.20 days) to produce pinheads in mushroom. Fan *et al.* (2000) observed that first pinhead formation occurred after 20-23 days of inoculation whereas, our results showed that first pinhead formation occurred in 25-27 days after spawn running.

Similarly in the case of development of fruiting bodies of oyster mushroom 75% cotton waste + 25% sugarcane industry waste proved a best substrate in which fruiting bodies develop in minimum days as compared to other substrates. Khan *et al.* (2001) conducted the oyster mushroom cultivation on different substrates. This was observed that pinhead formation took 7-8 days and sporocarps formed in 10-12 days after spawn running. Similar results were reported by Obodai *et al.* (2003). They reported a period of 6 days and 10 to 12 days for the same developmental stages.

The proportion 75% cotton waste amended with 25% of other by-products or crop wastes, were previously reported by Ahmad *et al.* (2011) with 75% Cotton Waste + 25% Banana leaves, they reported a period of 33.60 days to complete mycelia growth in *P. ostreatus*. Saghir (1998) obtained maximum mycelial growth on cotton waste with similar results.

In order to find out the most suitable substrates for total yield of oyster mushroom, the results revealed that maximum yield was obtained in 75% cotton waste amended with 25% sugarcane industry waste. The results of present study supported by many researchers like Manan (2000) studied the cultivation of oyster mushrooms on cellulose material of paper waste, straw waste and cotton waste. He observed that cotton waste gave the highest yield 198.67 g and wheat straw gave the minimum yield of 58.95 g. Jadhav *et al.* (1996) studied the effect of different substrate on the yield of oyster mushroom. Cotton stalks and leaves gave the best results whereas lowest yield was obtained on ground nut creeper. Khan *et al.* (2001) studied the different aspect of oyster mushroom on industrial waste. Cotton waste recorded the highest yield of 197.67 g while wheat straw gave 129.2 g yield.

Conclusion

Pleurotus ostreatus grown and developed efficiently in the treatment 75% cotton waste+25% sugarcane industry waste (T4). The shortest period to pinhead formation and fruiting bodies (6.5 and 14 days) were obtained with this treatment. The shortest period for mycelial growths of *P. ostreatus* from 25% to 100% were obtained with the T4 with a range of 8 to 21 days. The highest total yield of *P. ostreatus* was obtained with T4, with 327.2g.Most suitable substrate for the cultivation of oyster mushrooms was 75% cotton waste + 25% sugarcane industry waste (T4).

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