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RESEARCH ARTICLE

Appraisal of agricultural wastes for cultivation of *Pleurotus eous* (Berk.) Sacc.

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SUMMARY

Pleurotus eous (Berk.) Sacc. was cultivated on different agro-wastes *viz.,* rice straw, wheat straw, maize stalks, sugarcane leaves, banana leaves, cotton stalks, pigeonpea straw and, soybean straw to find out the most suitable substrate for its cultivation. Parameters assessed included the spawn run period, number of days from spawning till appearance of pinheads, the days from spawning to first flush and, fresh yield of sporophores. Biological efficiency was also determined. The results indicated that spawn run was most expeditious in the beds prepared using cotton stalks and pigeonpea straw, which was found to be completed earlier by 2 to 4.7 and 1.6 to 4.3 days, respectively whereas, pinheads in these beds were found to be induced earlier by 2 to 5 and 1.7 to 4.7 days, respectively in comparison with the rest of substrates tried. First flush of sporophores with these beds was ready for harvest in 12.7 and 13 days, respectively as against 14.7 to 17.7 days with the rest of substrates tried in the investigation. Cotton stalks yielded 10.7 to 35.3 per cent more yield whereas increase in yield with pigeonpea straw, wheat straw and soybean straw ranged between 7.6 to 28.2 per cent in comparison with the rest of substrates.

Key Words : *Pleurotus eous,* Oyster mushroom, Substrates

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Mushroom cultivation is the most efficient and economically -viable biotechnology for the conversion of lignocellulosic waste materials into high-quality protein food and this will naturally open up new job opportunities especially in rural areas and may be prepackage by food industry and exported to other countries as food conditions and for revenue generation. Mushrooms are important source of edible protein for human consumption. The use of these may contribute significantly in overcoming protein deficiency in the developing nations, where good quality proteins from animal sources are either unavailable or unacceptable for religious beliefs. Edible mushrooms have been recommended by the FAO as food contributing to the protein nutrition of the developing countries depending largely on cereals (Sohi, 1992). On dry weight basis, mushrooms are positioned well above most foods such as cereals/vegetables or fruits including animal products but below most meats.

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Species of *Pleurotus* (oyster mushroom) are well known edible mushrooms in different parts of the world. Their cultivation is becoming popular due to desirable attributes like rapid mycelial growth, greater ability for saprophytic colonization, simple and cheap cultivation techniques, time advantage over other cultivated mushrooms and easy post harvest storage. Oyster mushroom production accounted for 14.2 per cent of the total world yield (6,161,000 t) of all edible mushrooms in 1997 (Chang, 1999). Oyster mushrooms also have high productivity as compared to button mushrooms, which have around one-fifth the productivity of oyster mushrooms. Gastronomically, oyster mushrooms are the only cultivated mushrooms classified among first quality mushrooms. Button mushrooms and shiitake are classified as mushrooms of second quality (Kohli, 1999).

Oyster mushrooms belong to family Tricholomataceae which includes many species such as *P. flabellatus, P. sojar - caju, P. eryngii, P. ostreatus, P. florida, P. eous* and *P. sapidus*. Among the various species of *Pleurotus, P. sajor-caju* is known to produce very high yield. However, consumer acceptability of *P. sajor-caju* has not been appreciable widely due to tough texture of stipe, brown to gray colour of the pileus and moderate aroma (Prabhu Dessai *et al.,* 1991). *Pleurotus eous* (Berk.) Sacc. is a conspicuous species and because of its attractive bright pink sporophores, firm crisp and melting texture, it ranked higher in sensory evaluation *vis-à-vis P. sajor-caju. Pleurotus eous* also has yield potential comparable to that of *P. sajor-caju* and also it comes to yield earlier (Prabhu Dessai *et al.,* 1991). *Pleurotus eous* has highest percentage of protein content (46%) followed by *Pleurotus sajor-caju* and *Pleurotus florida*. The fat content of three different species indicates that *Pleurotus florida* has highest percentage of fat content (1.9%) as compared to *Pleurotus sajor-caju* (1.7%) and *Pleurotus eous* (1.2%). *Pleurotus eous* has highest crude fibre (12%) as compared to *Pleurotus florida* (11.5%) and *Pleurotus sajor-caju* (10.9%). The highest mineral concentration was found in case of *Pleurotus eous* as compared to *Pleurotus sajor-caju* and *Pleurotus florida* when grown on soybean as substrate. The higher mineral content of *Pleurotus eous* makes it suitable for food supplement in diet (Ingale and Ramteke, 2010). It is likely that, *Pleurotus eous* mushroom has good future market. In spite of these attributes, perusal of available literature indicates that the data on various aspects of commercial production of *Pleurotus eous* in India are meagre. Proper scientific technology for commercial cultivation of *Pleurotus eous* has to be developed and passed to the growers to get assured yields. Availability of a good strain of mushrooms, suitable substrate for cultivation and control of saprophytic and parasitic microorganisms are the three most important aspects for mushroom cultivation. Crop residues such as wheat straw, rice straw, banana leaves, corn cobs, sawdust and bean straws can be utilized as substrates to grow oyster mushrooms (Poppe, 2000). Large quantities of crop residues are generated by Indians who live in rural areas and depend on agriculture for crops such as sugarcane, sorghum, pearlmillet, maize, wheat, paddy, small millets, cotton, soybean, pigeonpea, horticultural crops and livestock keeping as a source of livelihood. But these crop residues have not been so far put into any proper use. The present study deals with the cultivation of *P. eous* on some common and abundantly available agricultural wastes available for conversion in food which otherwise is left for natural degradation.

MATERIALS AND METHODS

The present investigation was conducted at the Department of Plant Pathology and Agricultural Microbiology, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.). Pure culture of *Pleurotus eous* was isolated from sporophore which appeared on the straw bed inoculated with the spawn material from All India Coordinated Research Project on mushroom, College of Agriculture, Pune; by tissue culture technique and was maintained on potato dextrose agar. Eight substrates *viz.,* rice (*Oryza sativa*) straw, wheat (*Triticum aestivum*) straw, maize (*Zea mays*) stalks, sugarcane (*Saccharum officinarum*) leaves, banana (*Musa paradisiaca*) leaves, cotton (*Gossypium hirsutum*) stalks, pigeonpea (*Cajanus cajan*) straw and, soybean (*Glycine max*) straw were tried as bedding material to find out most suitable substrate for the cultivation of *Pleurotus eous.*

Freshly harvested well-dried straws were used for the cultivation. The cultivation substrates were prepared by hot water treatment as described by Singh and Dwivedi (1991). All the instruments were sterilized with dilute solution of potassium permanganate and alcohol. The spawning was done in pre-fumigated room (48 h with 2% formaldehyde). Each pasteurized cultivation substrate was layer spawned separately in high-density polythene bag of size 45 cm x 55 cm (100 gauge). Wheat grain based spawn of *P. eous*, prepared by the method recommended by Garcha and Kalra (1979), was inoculated at 2 per cent of the wet weight of cultivation substrates. These bags had 25-30 pinhole perforations all over for ventilation of substrate. Few pinholes were also made at bottom of the bags for drainage. Each bag contained 3.5 kg wetted straw (one kg dry straw). Mouth of each bag was closed with a rubber band. Each treatment was laid out according to completely randomized design with three replications. After spawning the bags were incubated in dark at an ambient temperature of 24-28^{0}C in partially underground permanent mushroom house. No light and cross ventilation were allowed during spawn run. After the spawn had colonized the substrates fully with fungal mycelium, the polythene bags were removed to expose the substrate surface for initiation of sporophores. These were then kept on wooden racks in cropping room of the mushroom house for fruiting. Water was sprayed regularly (twice a day) on compact cylinder mass of the substrate to keep them wet. The temperature of cropping room ranged from 22-28^{0}C during the experimental period. Humidity of the cropping room was maintained at 85-90 per cent by frequent sprays of water on the walls and floor. For cropping 2-3 hours of light (with the help of fluorescent tube of 40 watts) and 2-3 hours of cross ventilation per 24 hours (by opening doors and windows) were provided. Watering was withheld a day before harvesting. Harvesting of sporophores was done before spore shedding. Fresh weight of mushroom was recorded immediately after harvesting. Small portion of straw all over the surface of bed was scrapped after every picking in order to obtain each next crop. Three flushes of the sporophores were harvested from all the beds. Data recorded included the spawn run period *i.e.* the number of days from spawning to complete colonization of the cultivation substrate by the mycelia, number of days from spawning till appearance of pinheads, the days from spawning to first flush and fresh yield of sporophores. Biological efficiency (BE) was also determined using the relation (Chang *et al.,* 1981):

$$\text{B.E.}(\%) = \left[\frac{\text{Weight of fresh mushrooms harvested}}{\text{Dry weight of substrate}}\right] \text{x } 100$$

Data were tested for their significance by employing completely randomized design.

RESULTS AND DISCUSSION

This chapter reports the results on days required for spawn running, pinning and harvesting and; yield of *Pleurotus eous* grown on different locally available agricultural residues and have been presented under following heads:

Days taken for complete spawn run :

Days required for complete spawn run varied significantly with the cultivation substrate used (Table 1). Among the different cultivation substrates used in the investigation, *P. eous* mycelium colonized the cotton stalks and pigeonpea straw completely in 7.3 and 7.7 days, respectively. In contrast, spawn run was much delayed with sugarcane leaves, maize stalks and rice straw, which took 12, 12 and 11.7 days, respectively. These values explicitly substantiate superiority of cotton stalks and pigeonpea straw wherein the spawn-running period was curtailed by 2 to 4.7 and 1.6 to 4.3 days, respectively in comparison with the rest of substrates.

The *Pleurotus* spp. are able to grow on a wide spectrum of lignocellulosic waste materials due to their ability to secrete a range of degradatory enzymes *viz.*, cellulases, hemicellulases, xylanases, lignin peroxidase, manganese peroxidase and laccases (Madan and Bisaria, 1983; Buswell and Chang, 1993; Rajarathnam *et al.*, 1998). Geetha and Sivaprakasam (1998) while studying the degradative potential of *Pleurotus* spp. found that the fungus prefers the substrates rich in cellulose. Balasubramanya and Khandeparkar (1989) reported high cellulose content in the cotton stalks to the tune of 35 per cent. The expeditious spawn run with cotton stalks observed in our investigation may be due to its high cellulose content.

Days taken for pinhead formation :

Significant variation in the days required for pinhead formation was observed with the different substrates used for cultivation of *Pleurotus eous* (Table 1). The pinheads appeared earlier in the beds prepared using cotton stalks and pigeonpea straw than the rest of substrates tried. These two substrates induced pinning in 10 and 10.3 days, respectively as against 12 to 15 days with the rest of substrates. Period required for appearance of pinheads in the beds prepared using cotton stalks and pigeonpea straw was, thus, found to be abridged by 2 to 5 days and 1.7 to 4.7 days, respectively in comparison with the rest of substrates. Wheat straw and soybean straw was the next best set of performers, with which the period required for pinning was shortened by 1.3 to 3 days and 1.6 to 2.3 days, respectively in comparison with the rest of substrates. Pinning was much delayed in the beds prepared using sugarcane leaves, maize stalks and rice straw. Early pinning with cotton stalks and pigeonpea straw whereas, delayed pinning with the rest of substrates could be due to correspondingly early or delayed spawn running with these substrates.

Days taken for first harvest :

Significant variation in the days required for the first harvest of sporophores was observed with different substrates used for cultivation of *Pleurotus eous* (Table 1). Beds prepared using cotton stalks and pigeonpea straw were ready for the first harvest in 12.7 and 13 days, respectively as against 14.7 to 17.7 days with the rest of substrates. The data, thus, substantiate that the period required for first picking of sporophores with cotton stalks and pigeonpea straw was shortened by 2 to 5 days and 2.3 to 4.7 days, respectively in comparison with the rest of substrates. Wheat straw was the next best substrate to cotton stalks and pigeonpea straw. However, it differed insignificantly from pigeonpea straw. In

Table 1: Effect of different cultivation substrates on number of days taken for spawn run, pinhead formation, first harvest and yield and biological efficiency of *Pleurotus eous*

Cultivation substrates	Number of days taken for			Average yield of fresh sporophores (g/kg dry straw)	Biological efficiency (%)
	Complete spawn run	Pinhead formation	First harvest		
Rice straw	11.7	14.3	17.0	747.7	74.8
Wheat straw	9.3	12.0	14.7	885.7	88.6
Maize stalks	12.0	14.7	17.3	748.0	74.8
Sugarcane leaves	12.0	15.0	17.7	709.7	71.0
Banana leaves	11.0	13.3	16.0	819.0	81.9
Cotton stalks	7.3	10.0	12.7	980.3	98.0
Pigeonpea straw	7.7	10.3	13.0	928.3	92.8
Soybean straw	10.0	12.7	15.3	881.0	88.1
S. E. ±	0.23	0.40	0.63	17.80	-
C.D. (P=0.05)	0.70	1.20	1.90	53.7	-

Data are mean of three replications

contrast, the first picking was considerably prolonged with sugarcane leaves, maize stalks, rice straw and banana leaves.

Yield and biological efficiency :

Yield data were pooled from all the three harvests of each replication and expressed as g/kg dry straw. Yield of sporophore varied significantly in response to different substrates used for the cultivation (Table 1). It was proved from our study that cotton stalks and pigeonpea straw were superior in influentially enhancing the yield. Beds prepared using cotton stalks gave the highest yield (980.3 g/kg dry straw), which was 10.7 to 35.3 per cent more than that obtained with the rest of substrates. It also supported the highest biological efficiency of 98.0 per cent. It was followed insignificantly by pigeonpea straw, which gave 928.3 g sporophores/kg straw. Pigeonpea straw also differed insignificantly from wheat and soybean straws, which were the next best substrates to pigeonpea straw. Increase in yield with pigeonpea, wheat and soybean straws ranged between 7.6 to 28.2 per cent in comparison with the rest of substrates. These substrates also supported the biological efficiency to the tune of 92.8, 88.6 and 88.1 per cent, respectively. Sugarcane leaves, maize stalks and rice straw were the poor yielders, the lowest being the sugarcane leaves.

Differential response to substrates is not uncommon and need to be exploited for a given condition and agro-climatic regions (Marimuthu *et al.,* 1994). Cellulose rich organic substances have been reported to be good substrates for the cultivation of mushrooms (Quimio, 1978; Geetha and Sivaprakasam, 1998). High cellulose content would result in enhanced cellulase enzyme production (Norkrans, 1967) and the enzyme production is positively correlated with the yield of sporophores (Ramasamy and Kandasamy, 1976). Hence, the substrates giving high enzyme activity produce more mushrooms (Geetha and Sivaprakasam, 1998). Overall, cellulose degradation enhances the availability of glucose, an easily utilizable source of carbon and energy for the fungus. In our study, higher yield obtained with cotton stalks, pigeonpea straw, wheat straw and soybean straw could be explained on this basis. Chang *et al.* (1981), Cho *et al.* (1981) and Leong (1982) found cotton waste substrate as superior to paddy straw. Patil and Jadhav (1991) reported 150 per cent biological efficiency of cotton stalks. Cotton stalks, pigeonpea stalks and wheat straw alone or in combination were found to be more suitable than groundnut haulms and soybean straw for the cultivation of *P. sajor-caju* (Mane *et al.,* 2007). Lignin is found to affect the activity of cellulases (Dhillon and Chahal, 1978). The substrate with high lignin and phenolics content decreases the activity of cellulases (Sivaprakasam, 1980). Substrates with less lignin content would favour increased enzymatic activity with higher yield of sporophores. Lower yield potential of sugarcane leaves reported in our study may be due to its higher lignin content. Pani *et al.* (1998) also reported lowest biological efficiency of sugarcane leaves. High yield potential of pigeonpea and soybean straw over cereals may be attributed to their nitrogen content as claimed by Anastazia *et al.* (1982). He reported the superiority of legumes over cereal straws, which also hold true in this study.

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