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Effect of different agro-waste substrates and their combinations on the yield and biological efficiency of *Pleurotus sajor- caju*

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Abstract: *Pleurotus sajor-caju Singer (Fr.) was cultivated on different agro-wastes viz. soybean straw, wheat straw, paddy straw, sugarcane bagasses, sun flower stalks, maize stalks, domestic waste, used tea leaves, fruit waste, semal flowers, news paper, bamboo leaves, saw dust and their combinations in 1:1 proportion to determine the effect of these agro waste on yield, growth and biological efficiency. Soybean straw showed significantly highest yield (with 93.3% B.E.). Semal flowers required lesser time for spawn run (14.33 days) and pin head appearance (18.33 days). Among all the combinations soybean straw + wheat straw showed significantly highest yield (with 87.3% B.E.) and soybean straw + saw dust showed significantly lesser yield (with 43.8% B.E.). Except Saw dust and News paper other test substrates were found suitable for the growth of Pleurotus sajor-caju.*
Key words: *Waste, Agro-wastes, straw, biological efficiency.*

I. Introduction:

Oyster mushroom (i.e. *Pleurotus spp*.) is commonly called as Dhingri in India because of its oyster like shape. Genus *Pleurotus* belongs to family Tricholomataceae and has about 40 well-recognized species, out of which 12 species are cultivated in different parts of country. *Pleurotus* is an efficient lignin- degrading mushroom and can grow well on different types of lignocellulolosic materials. Cultivation of this Mushroom is very simple and low cost production technology, which gives consistent growth with high biological efficiency. Different species of *Pleurotus* can grow well in variable temperature conditions; hence they are ideally suited for cultivation throughout the year in various regions of tropical country like India (Ahmed *et al.,*2009). For many reasons the fungi of the *Pleurotus* genus have been intensively studied in many different parts of the world; they have high gastronomic value. They are able to colonize and degrade a large variety of lignocellulosic residues, they require shorter growth time when compared to other edible mushrooms, they demand few environmental controls, their fruiting bodies are not very often attacked by diseases and pests and they can be cultivated in a simple and cheap way (Patrabansh and Madan, 1997).

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, flavor and nutritive value (Quimio, 1978; Bano and Rajarathanam, 1982; Jain and Vyas, 2003). Oyster mushroom posses the appropriate enzymatic mechanism for the transformation of complex organic macromolecules into simple compounds have been exploited as the means for biodegradation of a wide range of plant litter due to their particular ability for selective delignification (Mayson & Verachtert, 1991; Martinez *et al.*, 1994). Most agricultural residues are rich in lignocelluloses compounds whose handling and disposal often problematic. Wheat straw, Soybean straw, Paddy straw and Sugarcane bagasses are the substrates of interest, Since they are produced in large quantities and rich in cellulose and lignin. The potential of bioconversion of lignocelluloses waste into value added products is emphasized in earlier studies (Philippoussis & Zervakis 2000; Poppe, 2000). The large amount of agricultural wastes and congenial climatic conditions provide tremendous scope for oyster mushroom cultivation in Sagar, M.P. (Vyas *et al,* 2009). In this study we took various conventional substrates viz. soybean straw (SS), wheat straw (WS), paddy straw (PS), Sun flower stalks (SFS), Sugarcane bagasses (SB), Maize stalks (MS) and non-conventional substrates viz. domestic wastes (DW), Fruit waste (FW), used tea leaves (UTL), Semal flowers (SF), news paper waste (NPW), Bamboo leaves (BL), Saw dust (SD) for the cultivation of *Pleurotus sajor-caju.*

II. Materials and Methods:

Spawn preparation: Clean whole grains were taken for the purpose. The grains were pre-wetted by boiling in water for 20-30 min (Jain, 2005). After boiling, excess water was drained off by spreading the grains on a wire mesh. Grains were now mixed with gypsum (calcium sulphate) and chalk powder (calcium carbonate) at the rate of 2% and 0.5%, respectively on dry weight basis. The grains were filled in flasks, and plugged then sterilized in autoclave at 22 Lb pressure for 1.5-2 hours. The grains were allowed to cool in room temperature for overnight. Next day flasks were inoculated with two bits of agar medium colonized with the mycelium of pure cultures.

About 7-10 days after inoculation, flasks were shaken vigorously. Three weeks after incubation, the stock culture becomes ready for further multiplication of spawn. Inoculated flasks were incubated at 26±2°C.

Cultivation: A medium was prepared using conventional viz. soybean straw (SS), wheat straw (WS), paddy straw (PS), Sun flower stalks (SFS), Sugarcane bagasses (SB), Maize stalks (MS)and non-conventional substrates viz. domestic wastes (DW), Fruit waste (FW), used tea leaves (UTL), Semal flowers (SF), news paper waste (NPW), Bamboo leaves (BL), Saw dust (SD). All substrates were washed in fresh water. The chopped straw substrates were steeped in water containing 75 ppm bavistin + 500 ppm formaldehyde for 18 hours (Jain, 2005) for preventing mould infestation due to various other competiting fungi. Supplements were sterilized with 25 ppm bavistin for 12-18 hrs. Excess water was drained and was dried in shed to retain 65-70% moisture content by squeezing with hands and then allowed to cool down for a certain period (1hr.). Spawning was done @ 2% wet weight basis of substrate by thoroughly mixing. Spawned substrate was filled up in perforated polythene bags (60 × 40 cm) and polythene mouth was closed with rubber band. These bags were transferred to crop room for spawn run. Three replications were maintained for each substrate. For spawn run, temperature and relative humidity were maintained between 25-30°C and 65-90%, respectively. Polythene bags were cut open when the mycelial run was completed. The substrate beds were moistened by sprinkling of water thrice a day which was stopped a day before harvesting. Average values of observation with respect to duration of spawn run, time taken for first harvest yield and total yield was recorded. Biological efficiency of mushroom on fresh weight basis was calculated by using formula given by Chang and Miles (1989).

$$\textbf{Biological efficiency (\%)} = \frac{\text{Yield of fruiting body (gm)}}{\text{Total weight of substrate used (gm)}} \times 100$$

III. Results:

In present study six substrates generally regarded as conventional are used viz. soybean straw (SS), wheat straw (WS), paddy straw (PS), sugarcane bagasses (SB), sun flower stalks (SFS), maize stalks (MS) and non conventional are used viz. Domestic waste (DW), used tea leaves (UTL), fruit waste (FW), semal flowers (SF), news paper (NP), bamboo leaves (BL), saw dust (SD), for cultivation of *P. sajor-caju.* Table 1 shows that among these conventional substrates, SS was found best because of greater yield and BE was 933.4 gm and 93.3%. Early spawn run (17.6 days) and pin head appearance (22.33 days), stipe length (2.8 cm), cap diameter (7.8 cm) found. Besides SS, WS (800.0 g kg^{-1}) and PS (743.4 g kg^{-1}) were found good substrates in terms of yield of mushroom. MS was found poor substrate in comparison to other conventional substrate because here yield was 530 g kg^{-1} was obtained. Though SB required comparatively more time for spawn run (26.6 days) and pin head appearance (32 days) yet yield was good (641.66 g kg^{-1}). However, all the substrates was found suitable for cultivation of *Pleurotus sajor - caju.*

As it is clearly evident from the data presented in the table 2 that among the non- conventional test substrate, BL required lesser time for spawn run (17 days) and pin head appearance (21.4 days) but average yield (521.7 g kg^{-1}) was obtained. On the other hand DW was found to be best substrate because of higher yield (718.4 g kg^{-1}) and BE (71.8%) obtained. Besides DW, UTL produces good yield (655.0 g kg^{-1}). SD was found unsuitable and poor substrate because it not only require more time for spawn run (31.7 days) and pin head appearance (34.7 days) but also produces lowest yield (321.7 g kg^{-1}) with 32.1% BE. In NP also more time (30.7 days) for spawn run and pin head appearance (34.7 days) was observed, but maximum stipe length (2.7) cm and cap diameter (6.2) cm measured with 558.4 g kg^{-1} yield and 55.8% BE. Except SD and NP other test non conventional substrates were found suitable for the growth of *Pleurotus sajor-caju.*

Table 3 shows results of *P. sajor- caju* cultivated on different conventional substrates in combination with SS (w/w, 1:1). Among all the test substrate combinations, SS+WS produces maximum yield (873.33 g kg^{-1}) and required 17 days for spawn run, 21 days for pin head appearance, stipe length measured 3.1 cm. and cap diameter (8.06 cm). Besides SS+WS combination, SS+PS was also found good substrate in terms of yield and other growth parameter. SS+MS combination was found comparatively less suitable combination because not only lesser yield was obtained but also spawn run time and pin head appearance took maximum time.

Table 4 shows growth and yield of *P. sajor- caju* on different non conventional substrates in combination with SS (w/w, 1:1). Among all the test combinations, SS+DW combination was showed best results therefore higher yield viz. 826.7 g kg-1 with 82.6% BE was recorded. 22 days for spawn run, 26.0 days for pin head appearance are required which are minimum among the test combinations. Stipe length (3.2 cm), cap diameter (6.6 cm) measured. SS+BL combination showed 12 days for spawn run and 16 days for pin head appearance and stipe length measured 2.7 cm. and cap diameter was (6.2cm) measured and yield recorded 570 g kg-1 with 57.0% BE. SS + SD was found unsuitable substrate because it required more time (29 days) for spawn run and (33.4 days) for pin head appearance. Though, stipe length (2.8 cm) and cap diameter (6.9 cm) were measured are good yet yield was obtained lesser (438.33g kg^{-1} with 43.8% BE).

IV. Discussion:

Among various species of mushrooms**,** cultivation of *Pleurotus* spp is picking very fast due to its easy cultivation technology, adaptability to wide range of temperature and ability to grow on a variety of lignocellulosic substrates (Gogoi and Adhikary, 2002). According to Singh *et al.,* (2007) *Pleurotus* sp. through their extracellular enzyme degrades vegetable waste utilize the substrate for growth**.** *Pleurotus sajor- caju* was found to utilize all the agricultural wastes and were observed suitable for spawn run, yield and biological efficiency (Das *et al*., 2000). In recent past many workers have reported cultivation of *Pleurotus* species on various substrates**.** Kumar *et al.*, 2004, Chandra *et al.,* 1998 reported the successful cultivation of *Pleurotus* sp. on conventional substrates. Jain and Vyas, 2005 reported Soybean and paddy straw found good for the cultivation of *Pleurotus*. Sangeetha and Theradimani (2007), Bano and Shrivastava, (1962); Jandaik and Kapoor (1974); Khanna and Garcha (1982) reported paddy straw are better substrate for *Pleurotus* cultivation. Sharma and Jandaik (1981) reported that *P. sajor-caju* cultivation on wheat straw took 32 days for the first harvest. *Pleurotus* has also been reported to grow readily on a number of non- conventional substrates (Das *et al*., 2000; Mukherjee and Nandi, 2002; Shah *et al.*, 2004; Nageshwaran *et al.,* 2003;). Used tea leaves was used for production of *Pleurotus sajor-caju* with low biological efficiency in India (Pani *et al*., 1997).

Mushroom cultivation on waste paper was recorded by Baysal and Paker in 2001.Yamashita *et al.,* (1983) reported cultivation of *Pleurotus sajor caju* on lawn grass. Ingale and Ramteke (2010) reported cultivation and biological efficiency of mushrooms grown on different agro-residues Mane *et al*., (2007) grew *P. sajor caju* in several agro-industrial residues: cotton processing residue, wheat straw, soy straw, pea stalk and peanut stalk. Pandey *et al.,* (2008) reported performance of oyster mushroom (*P. sajor-caju*) on different agricultural wastes. The lower performance and yield of different agricultural wastes might be due to low lignolytic and cellulytic activity (Pathak and Goel, 1988). However high and significant performance of other substrates ensures the possibilities of utilizing the locally available substrates for *Pleurotus sajor-caju* cultivation.

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Table: 1 *Pleurotus sajor- caju* cultivated on different conventional substrates.

Substrates	Spawn run (days)	Pin head appearance (days)	Stipe length (cm.)	Cap diameter (cm.)	Total harvest yield (gm./Kg.)	Biological efficiency (BE%)
Soybean straw	17.6	22.33	2.8	7.8	933.4	93.3
Wheat straw	19.0	23.33	2.7	8.1	800.0	80.0
Paddy straw	21.33	25.33	2.8	8.0	743.4	74.3
Sun flower stalks	20.66	24.33	2.5	6.9	655.0	65.5
Sugarcane bagasses	26.66	32.0	2.9	6.4	641.7	64.1
Maize stalks	20.0	26.0	2.6	6.9	530.0	53.0
S Em (±)	0.68	0.68	0.07	0.17	12.24	1.1
CD (0.05%)	2.09	2.09	0.22	0.53	37.73	3.7

Table: 2 *Pleurotus sajor caju* cultivated on different non-conventional substrates.

Substrates	Spawn run (days)	Pin head appearance (days)	Stipe length (cm.)	Cap diameter (cm.)	Total harvest yield (gm./Kg.)	Biological efficiency (BE%)
Domestic waste	24.6	29	2.4	6.8	718.33	71.8
Fruit waste	30.33	35.0	2.5	6.2	635.0	63.5
Used tea leaves	25.6	31.66	2.3	5.6	655.0	65.5
Semal flowers	14.33	18.33	3.46	4.8	623.4	62.3
News paper	30.66	34.66	2.7	6.2	558.33	55.8
Bamboo leaves	17.0	21.33	2.3	5.6	521.66	52.1
Saw dust	31.66	35.0	2.5	5.2	321.66	32.1
S Em (±)	0.72	0.74	0.07	0.09	23.08	2.3
CD (0.05%)	2.19	2.26	0.22	0.29	7.61	0.7

Values are given in average of three replicates in both tables.

Table: 3 *Pleurotus sajor- caju* cultivated on different conventional substrates combination with Soybean straw.

Substrates	Spawn run (days)	Pin head appearance (days)	Stipe length (cm.)	Cap diameter (cm.)	Total yield (gm./Kg.)	Biological efficiency (BE%)
SS control	17.6	22.33	2.8	7.8	933.4	93.3
SS + WS	17.0	21.0	3.1	8.1	873.4	87.3
SS + PS	20.0	23.7	2.7	8.0	853.4	85.3
SS + SFS	21.7	26.7	2.6	6.8	700.0	70.0
SS + SB	23.7	27.4	2.9	6.8	666.7	66.6
SS + MS	24.0	29.4	2.7	7.1	621.7	62.1
S Em (±)	0.78	0.83	0.06	0.06	10.58	0.6
CD (0.05%)	2.40	2.58	0.20	0.20	32.61	2.1

Table: 4 *Pleurotus sajor- caju* cultivated on different non-conventional substrates combination with Soybean straw

Substrates	Spawn run (days)	Pin head appearance (days)	Stipe length (cm.)	Cap diameter (cm.)	Total harvest yield (gm./Kg.)	Biological efficiency (BE%)
SS control	17.6	22.4	2.8	7.8	933.4	93.3
SS + DW	22.0	26.0	3.2	6.6	826.7	82.6
SS + UTL	23.83	28.0	2.5	6.1	730.0	73.0
SS + FW	28.33	33.0	2.8	6.0	728.4	72.8
SS + SF	15.4	19.4	3.6	5.5	691.7	69.1
SS + NP	27.33	32.4	3.0	6.7	583.3	58.3
SS + BL	12.0	16.0	2.7	6.2	570.0	57.0
SS + SD	29.0	33.4	2.8	6.9	438.4	43.8
S Em (±)	0.57	0.71	0.06	0.12	14.70	1.4
CD (0.05%)	1.72	2.14	0.19	0.36	44.08	4.4

Values are given in average of three replicates in both tables.