European Journal of Medicinal Plants
1(1): 10-17, 2011

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Yield, Fruit Body Diameter and Cropping Duration of Oyster Mushroom (*Pleurotus sajor caju*) Grown on Different Grasses and Paddy Straw as Substrates

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Research Article

Received 12th January 2011
Accepted 19th January 2011
Available online 29th January 2011

ABSTRACT

The present experiment aimed at finding the suitability of some grasses as cost effective alternative substrates, for cultivation of one species of oyster mushroom viz., *Pleurotus sajor caju* (Fr.) Singer in eastern India. Relative efficacy three grasses viz., kash grass (*Saccharum spontaneum* L.), sabai grass (*Eulaliopsis binata* C.E. Hubb (Retz.)) and lemon grass (*Cymbopogon citrates* Stapf.) was tested by using each of them either as whole substrate or in combination with the conventional substrate i.e., paddy straw in 3:1, 1:1, and 1:3 ratios. Results revealed that the maximum yield of mushroom was recorded under paddy straw with biological efficiency of 85.9%. However, no significant difference in yield was found when 25% or 50% of the conventional substrate (paddy straw) was replaced by lemon grass and sabai grass. The results indicated that grasses which are available in plenty in the forests and wastelands of lateritic uplands of eastern India can be utilized successfully as promising substrate for the commercial cultivation of *Pleurotus sajor caju.*

Keywords: Pleurotus sajor caju, Saccharum spontaneum, Eulaliopsis binata, Cymbopogon citrates, Paddy straw;

1. INTRODUCTION

Historically, mushrooms have long had medicinal uses and have been a subject of modern medical research since the 1960s, where most modern medical studies concern the use of mushroom extracts, rather than whole mushrooms. Studies show that glucan containing mushroom extracts primarily change the function of the innate and adaptive immune systems, functioning as bioresponse modulators, rather than by directly killing bacteria, viruses, or cancer cells as cytocidal agents (Borchers et al., 2008). In some countries, extracts like polysaccharide-K, schizophyllan, polysaccharide peptide, and lentinan

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(Borchers et al., 2008), are government-registered adjuvant cancer therapies (Anonymous, 2008; Smith et al., 2002).

Mushroom farming in India is becoming successful and also popularized day by day because of its very low input, which can bring a significant change in rural economy. The climatic conditions of the region have been found to be ideal for such an attempt. Research and field experiments on production and marketing of several varieties of mushrooms have proved its significant potentiality as a major source of income for rural people. Generally lignocellulosic materials like paddy straw, wheat straw, maize stalks etc. are used as substrates for the commercial production of oyster mushrooms in our country (Jain and Vyas, 2002). In India, only paddy straw is widely used for cultivation of oyster mushroom. Though a huge quantity of paddy straw is available in the rice growing areas of eastern India, its availability for mushroom cultivation is gradually becoming restricted because of its use for several other purposes like cattle feed, thatching, roofing, mud plastering, fuel etc. in rural areas. Moreover, with the advancement of agriculture, the indigenous tall *indica* varieties of paddy are being replaced rapidly by high yielding varieties. The straw of such high yielding varieties has proved to be less suitable compared to that of indigenous one because of its faster decomposability, poor leaf stem ratio, less water holding capacity, etc.

The above conditions led to less availability of suitable substrate for mushroom cultivation and as a result it is felt necessary to find out certain alternative substrate materials, which should be available in sufficient quantity throughout the year at relatively cheaper price. Though cereal straws are popular substrates for cultivation of oyster mushroom (Bano and Srivastava, 1962; Bano et al., 1978) but several studies have been carried out to utilize wild grasses as a suitable and alternative substrate for the cultivation of oyster mushroom (Das et al., 2000). A number of wild grass species are found to be grown in uplands and medium lands of South West Bengal. Kash grass (*Saccharum spontaneum* L.), sabai grass (*Eulaliopsis binata* C.E. Hubb (Retz.)) and lemon grass (*Cymbopogon citrates* Stapf.) are among them. Kash grass creates hazards both in agriculture as well as in afforestation programs. It competes with the agriculture crops and tender plants for grabbing the natural resources like light, moisture and nutrients. Removal or destruction of this grass becomes a costly affair for agricultural farming as well as afforestation. Since this grass contains sufficient lingo-cellulosic material and is available in plenty in this area, there is a possibility of using it as a substrate for growing mushroom.

Sabai grass is cultivated in the lateritic upland region for several purposes like its thin, long, strong and non-stiff leaves are excellent raw material for paper mill, for making rope and other rope based handicraft materials like furniture, doormats, shoe, bag etc. During initial processing and grading, huge quantities of unused leaves are left in the field itself and get decomposed as a natural process. Those residual materials possessing most of the desirable properties to support growth and development of mushrooms may be used effectively as a substrate for growing oyster mushroom. According to Das et al. (2002) sabai grass is a potential substrate for cultivation of oyster mushroom (*Pleurotus sajor caju)*. Lemon grass, another species belonging to grass family is widely cultivated in the less fertile lands for the purpose of extracting essential oil from the leaves. Oil is extracted by steam distillation method. Huge quantities of leaves are produced as residue after extraction. On analysis it was found lingo-celluosic content of the leaves remain unchanged and therefore it seems that this grass may be used as substrate for mushroom cultivation particularly in those areas where it is cultivated. Moreover, as the leaves are distilled it seems to be ready for spawning without further sterilization and thus save the cost of production to a great extent.

Keeping these facts in mind we sought to evaluate the possibility of these grasses alone and in combination with paddy straw as substrate for growing *Pleurotus sajor caju* during winter season.

2. MATERIAL AND METHODS

2.1 STUDY AREA

The experiments were conducted at Mushroom Experimental Farm of Rural Development Centre of Indian Institute of Technology (IIT) Kharagpur as well as near by areas to the south of campus, in the

lateritic belt of the South-Western region of the West Bengal, India, at $87^0 19^/$ E longitude and $22^0 19^/$ N latitude. The area has an average elevation of 44m above the Mean Sea level (MSL) and is about interior North West of the Eastern Sea Coast of the Bay of Bengal. The climate of this region is warm and humid.

2.2 TREATMENT COMPOSITION

The pure culture of *Pleurotus sajor caju* (Fr.) Singer was obtained from Regional Mushroom Research Centre (OUAT), Bhubaneswar, Orissa. The wheat grain spawn of *Pleurotus sajor caju* was prepared in autoclavable polythene packets following the standard methods (Chang et al., 1978). Just after flowering, the aerial parts of the grasses viz., lemon grass, sabai grass and kash grass were collected and sun dried for 3-4 days. Paddy straw and dried grasses were chopped into small pieces of 3-5 cm and thoroughly washed in fresh water. They were then soaked in a solution of bavistin (75 ppm) and formalin (500 ppm) for 18-24 hours. Physical characteristics of different types of grasses used as substrate for *Pleurotus sajor caju* cultivation have been presented in Table 1.

Table 1: Physical characteristics of paddy straw and different types of grasses used as substrate for *Pleurotus sajor caju* cultivation

Characteristics	Paddy Straw	Lemon Grass	Kash Grass	Sabaigrass
Water retention	Very good	Good	Not good	Good
Decomposability	Slow	Fast	Fast	Slow
Maintenance of temperature inside the bed	Very good	Moderate	Moderate	Good
Operational advantage	Very good	Moderate	Moderate	Good
Cost/value	Medium	Free	Free	Free
Compactness of the bed	Very good	Good	Not good	Moderate
Availability	Whole year	Whole year	October to January	Whole year

Total amount of substrate used for each bed was 2000 g. Paddy straw and three grasses were used as either sole substrate material or supplementation of 25%, 50% and 75% of paddy straw with each of the grasses i.e., in 1:3, 1:1 and 3:1 ratios. The treatment details are presented in Table 2. The treatments were designed under randomized complete block design with three replications. Transparent polythene sheets of 200µ thickness were used for making bags (30 cm X 50 cm) or beds. Each bed was inoculated with three layers of spawn. The spawn-substrate ratio was maintained 1:10 and no other nutrient sources were added. The bags were tied at the top and perforated with 1 cm diameter holes at 10-15 cm apart on the walls of the polythene bag. Immediately after spawning the beds were incubated in a dark room at an ambient temperature ranging from 20 ^{0}C to 25 ^{0}C. After a spawn run period of two weeks the beds were removed from the polythene bags and transferred in the cropping room for fruiting. The room temperature of the room was between 20-25 ^{0}C and relative humidity about 80%. After complete colonization of the mycelia masses for 20-25 days, sufficient numbers of pinheads were observed and they were allowed to mature for 3-4 days. The mushrooms were harvested at 7-10 days interval between two to five flushes. The data on period of spawn running, moisture retention capacity of substrates, yield and biological efficiency (BE) of mushroom were recorded during the study.

Yield performance of different treatment combinations was calculated by the BE and expressed in percentage. BE was calculated by using the following formula:

$$\text{BE (\%)} = \frac{\text{Fresh weight of harvest}}{\text{Dry weight of substrate}} \times 100$$

Table 2: Treatments of the experiment

Treatments	Ratio of materials	Quantity of materials (g)				Total substrate (g)
		PS	LG	SG	KG	
PS (sole)		2000				2000
LG (sole)			2000			2000
SG (sole)				2000		2000
KG (sole)					2000	2000
PS+LG	3:1	1500	500			2000
PS+LG	1:1	1000	1000			2000
PS+LG	1:3	500	1500			2000
PS+SG	3:1	1500		500		2000
PS+SG	1:1	1000		1000		2000
PS+SG	1:3	500		1500		2000
PS+KG	3:1	1500			500	2000
PS+KG	1:1	1000			1000	2000
PS+KG	1:3	500			1500	2000

Note: PS: Paddy Straw; LG: Lemongrass; KG: Kashgrass; SG: Sabaigrass.

2.3 STATISTICAL ANALYSIS

The recorded data were analyzed with the help of analysis of variance (ANOVA) for randomized complete block design. Least significant differences (LSD) were conducted at a 5% level of probability, where significance was indicated by F-test (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

3.1 MOISTURE RETENTION CAPACITY OF SUBSTRATES

The moisture retention capacity of the substrates is presented in Table 3. It is clear from the data that at the time of spawning moisture content in the beds of paddy straw was higher over grasses. Moisture content in lemon grass was comparable to that of sabai grass. However, on an average kash grass recorded nearly 15-17% less moisture content than the other grasses. Moisture content of the materials depends on the pores and holes or hollow fine channels present in the leaves and stems of the grasses. It was also observed that moisture content decreased when the beds were opened for sporophore initiation.

3.2 YIELD PARAMETERS AND YIELD

It was observed that Paddy straw alone or in combination with grasses under 3:1 or 1:1 ratio showed a faster rate of spawn run and pinhead initiation by 2-4 days as compared to 1:3 ratio or grasses alone as substrate (Table 4). Singh et al. (1995) and Das et al. (2000) also reported similar finding and thereby corroborated our results. The present study also revealed that total cropping duration of *Pleurotus sajor caju* was higher for sole paddy straw substrate as compared to other substrates. Third harvesting could be obtained from sole paddy straw or in combination with grasses at 3:1 ratio. Though 1:3 ratio recorded higher cropping duration than did 1:1 ratio, but did not result in remarkable yield. This was due to the fact that more time was required in fruiting of *Pleurotus sajor caju* under 1:3 ratio over 1:1 ratio. Among three grasses tested, lemongrass showed the maximum yield followed by sabaigrass when used in sole as well as in combination with paddy straw and in sole treatment it resulted in 33.1% yield difference.

Table 3: Moisture retention capacity of different materials used as substrate

Treatments	Moisture content at spawning (%)	Moisture content at opening (%)
PS (sole)	68.0	67.1
KG (sole)	57.9	53.8
LG (sole)	53.8	50.9
SG (sole)	47.5	42.4
PS+LG (3:1)	58.1	58.1
PS+LG (1:1)	54.4	54.2
PS+LG (1:3)	48.4	47.8
PS+KG (3:1)	65.2	63.9
PS+KG (1:1)	60.9	59.6
PS+KG (1:3)	56.1	53.2
PS+SG (3:1)	64.8	63.3
PS+SG (1:1)	59.1	57.4
PS+SG (1:3)	51.7	50.9
CD (5%)	**15.5**	**18.8**

Note: PS: Paddy Straw; LG: Lemon Grass; KG: Kash Grass; SG: Sabai Grass.

Table 4: Sporophore initiation, harvesting time and total cropping duration of *Pleurotus sajor caju* as influenced by different substrates

Substrates	Days after spawning				Total cropping duration (days)
	Sporophore initiation	First harvesting	Second harvesting	Third harvesting	
Paddy straw (PS)	20	24	26	31	81
Lemon grass (LG)	21	22	29	-	51
Sabaigrass (SG)	22	23	28	-	51
Kash grass (KG)	25	25	31	-	56
PS:KG (3:1)	22	25.5	30.5	37	93
PS:KG (1:1)	23	24.5	32.5	-	57
PS:KG (1:3)	24.5	28	34.5	-	62.5
PS:LG (3:1)	22	23.5	28	34	85.5
PS:LG (1:1)	22.5	24	30	-	54
PS:LG (1:3)	23	26.5	33	-	59.5
PS:SG (3:1)	21	22	28.5	33	83.5
PS:SG (1:1)	22	23	30	-	53
PS:SG (1:3)	23	25	32.5	-	57.5

Note: PS: Paddy Straw; LG: Lemon Grass; KG: Kash Grass; SG: Sabai Grass.

Different combination of the substrate influenced the yield parameters and yield of mushroom (Table 5). The data on different yield parameters of *Pleurotus sajor caju* indicated that the number of fruit bodies produced per bed and their diameter were significantly higher in sole paddy straw bed than all other substrates. Replacement of paddy straw with lemon grass and sabai grass by 25% and 50% resulted in encouraging performance over 75% or 100% replacement with these two grasses. Maximum value of yield parameters were recorded with paddy straw and it was statistically at par with combination of paddy straw with the grasses at 3:1 ratio. It was also reported that the yield parameters of mushroom in sole paddy straw was higher than the combination of paddy straw with any other substrates (Sangwan and Saini, 1995; Singh et al., 1995). Das et al. (2000) also found better yield parameters of *Pleurotus sajor caju* under sole paddy straw substrate as compared to three grass species viz., *Pennisetum polystachyon*, *Aristada abscendus*, *Panicum humile* and *Demostachya bipinata* as sole substrate. However, they found comparable result (as sole paddy straw) for paddy straw + *Pennisetum polystachyon* or *Demostachya bipinata* in 1:1 ratio as substrate.

Table 5: Yield parameters and yield of *Pleurotus sajor caju* grown on different substrates

Substrates	Diameter of fruit body (cm)	No. of fruit bodies/bed	Fresh weight of fruit bodies (g/bed)	Biological efficiency (%)
Paddy straw (PS)	8.43	32	1700	85.9
Lemon grass (LG)	7.33	27	1041	54.6
Sabaigrass (SG)	7.25	26	782	52.0
Kash grass (KG)	6.19	21	522	39.1
PS:KG (3:1)	7.75	28	1350	65.5
PS:KG (1:1)	7.13	26	1240	60.8
PS:KG (1:3)	6.45	22	974	51.6
PS:LG (3:1)	8.25	30	1590	75.5
PS:LG (1:1)	8.02	28	1444	68.2
PS:LG (1:3)	7.31	25	1223	57.6
PS:SG (3:1)	8.18	29	1522	70.4
PS:SG (1:1)	7.95	28	1390	65.5
PS:SG (1:3)	7.13	24	1150	59.5
CD (5%)	**1.01**	**4**	**404**	**19.8**

Note: PS: Paddy Straw; LG: Lemon Grass; KG: Kash Grass; SG: Sabai Grass.

It is clear from Table 5 that among the various substrates tried, the yield of *Pleurotus sajor caju* was significantly influenced by different type of substrates as compared to the conventionally used substrate i.e., paddy straw. Though paddy straw as sole substrate recorded maximum yield, however, no significant difference was found when lemon grass and sabai grass were mixed with equal quantities of paddy straw or 25% of these grasses were replaced by paddy straw i.e., 1:1 or 3:1 ratio (Paddy straw:Grasses) respectively. In case of combination with kash grass only 3:1 ratio gave comparable yield. Paddy straw has been reported to be an ideal substrate for *Pleurotus* cultivation by many researchers (Das et al., 2000). Combination of grasses and paddy straw gave significantly higher yield over sole grasses as substrate. This might be due to the fact that in the combination, paddy straw supplemented the nutritional requirements during spawn running as well as sporophore formation stages (Das et al., 2000). Similar result was also reported by Singh et al. (1995), where sugarcane trash in combination with cereal straw resulted higher yield of *Pleurotus florida* as compared to trash alone. Total replacement of paddy straw by any of the grasses could not encourage promising results. The probable reason may be that the nutrients for the mushroom particularly for its spawn run and pinhead development were supplied from paddy straw, which decomposed a little quicker than the grasses as reported by Das et al. (2000).

On the other hand, grasses, which decomposed slowly than paddy straw, provided the nutritional requirement for the later stage of growth period. The variation in water retention capacity of the grasses and paddy straw might have been responsible for this result. A positive and significant correlation between moisture retention and yield of mushroom further confirmed this finding (Figure 1).

3.3 BIOLOGICAL EFFICIENCY (BE)

Maximum BE value of 85.9% was obtained with sole paddy straw, which was followed by different combination of paddy straw with other grasses tested. However, no significant difference was found when the paddy straw was mixed with lemon grass and sabai grasses in 3:1 and 1:1 ratios and with kash grass in 3:1 ratio only. Higher yield of *Pleurotus sajor caju* was responsible for such results. Use of lemon grass or sabaigrass or kash grass alone resulted to a BE of 54.6%, 52% and 39.1% and the values were less than the BE of combined substrate. Among three combination ratios 3:1 ratio gave better performance than the other two ratios in terms of BE. Among the three grasses tested, kash grass showed the lowest BE value.

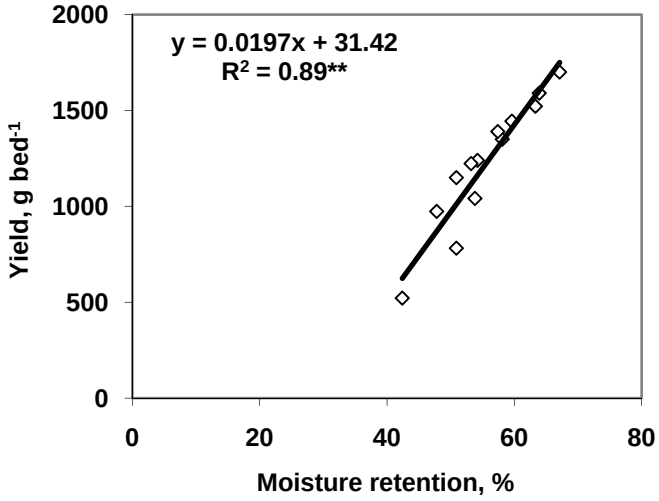

Fig. 1: Correlation and regression between moisture retention of beds and yield of *Pleurotus sajor caju* (Significant at 1% level)**

4. CONCLUSION

The present study indicates that the substrates made with three non-conventional plant residues resulted to considerable yield of oyster mushroom only when combined with paddy straw in different ratios. *Cymbopogon citrates* and *Eulaliopsis binata* in combination with paddy straw in 3:1 or 1:1 ratio and *Saccharum spontaneum* in 3:1 ratio will be of equally effective for successful cultivation of oyster mushroom. It confirms that wild grasses, which are available in huge quantity in red lateritic zone of eastern India can be safely considered as a cost free lingo-cellulosic resource for production of high value edible mushroom *Pleurotus sajor caju*.

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