J. Mycopathol. Res. ***53(1)*** *: 75-82, 2015;* (ISSN 0971-3719)

Influence of different substrates and environmental factors on yield of two strains of *Calocybe indica*

RAVINDER KUMAR*, GOPAL SINGH AND PRASHANT MISHRA
Department of Plant Pathology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut 250110, Uttar Pradesh
**Division of Plant Protection, Central Potato Research Institute (ICAR), Shimla 171001, Himachal Pradesh*

Received : 27.12.2013 RMS Accepted : 15.12.2014 Published : 27.04.2015

The present work was carried out to find out the effect of different agricultural wastes alone or in combination and environmental factors on yield of two strains (CI-6 and CI-4) of (*Calocybe indica*). Minimum time (17.7 and 17 days) was recorded for spawn run in wheat straw (WS) substrate alone, while days for pinhead formation (13 and 12) and days for first harvesting (20.3 and20) were observed in the combination of WS+paddy straw (PS) substrate with the ratio of 2:1 in strains CI-4 and CI-6, respectively. Maximum yield per kg dry substrate was harvested in case of CI-4 (536.3 g) with WS+ brassica straw (BS) (1:2) and CI-6 (611.3g) with WS+BS (2:1) combination. However, maximum average weight per fruit body was recorded in WS+BS (1:1) combination from strain CI-4 (26.1g) and CI-6 (31g). In environmental studies, the minimum time was observed during June-August 2008-09 for spawn run (19 and 18 days), while for pin head formation (12 and 11 days) and first harvesting (20.0 and 19.7 days) were noticed during July-September from strain CI-4 and CI-6, respectively. Maximum numbers of pinhead initiation (66.0 and 66.7/bag) were recorded during April-June and numbers of fruiting bodies (22 and 23.3/bag) were harvested during September-November in CI-4 and CI-6 strains, respectively. However, maximum yield per kg substrate (575.3 and 607g) and average weight per fruit body (28.3 and 27.6 g) were recorded during July-September from strain CI-4 and CI-6, respectively.

Key words: Milky mushroom, *Calocybe indica,* month, strains, substrate, yield, pinhead formation, first harvesting, pinhead initiation, fruiting body.

INTRODUCTION

In India, a prominent characteristic of the agricultural sector is by-products and wastes greatly exceed the harvestable or marketable components. These wastes are consisted of lignocellulosic materials, as abundant and renewable source of carbohydrates that can be converted into added value products. Mushrooms are seemed to be the most suitable organisms for the conversion of cellulosics and after the harvesting mushroom crop the remaining material can be used as a valuable additive for increasing soil fertility potential for the production of further agricultural and horticultural crops. Although mushrooms have long been appreciated because of their good favour, texture or medicinal properties including high content of good quality protein and

all essential amino acids. It is unfortunate that in India mushrooms have not caught the imagination of the public on a large scale to become an important food item, perhaps due to their lack of availability at low prices and a lack of consumer knowledge. However, mushroom cultivation requires a short duration crop and land saving, and so can be welcomed by the poor farmer ((Kurtzman 1979; Chang and Miles, 1992; Shah *et al.* 2004). *Calocybe indica*, commonly known as the milky white mushroom, is a relatively new introduction to the world of edible mushrooms from India (Purkayastha and Chandra, 1976). Its simple production techniques, sustainable yield, high shelf life, colour and shape have attracted mushroom growers to popularize cultivation of this variety. Having high temperature optima of 30–35 ^{0}C, it can be abundantly grown throughout the summer season (Krishnamoorthy *et al.*, 1998). The main substrate used for the commercial cultivation of mushrooms is wheat straw and information on the potential use of other locally available resources is lacking. However, in recent years, potential shortages of wheat straw have highlighted the need to identify alternatives that may be used for sustainable cultivation of milky mushrooms in future. Recently, farmers have been searching for an alternative substrate that may be more readily available and more cost effective, or that may provide higher yields and better mushroom quality. In addition, for a substrate to be used for commercial purposes, it is very important to determine the nutrient composition of the substrate (Oei, 2005). Nutrient composition is one of the factors limiting the saprobiotic colonization and fruiting of milky mushrooms.. The production of several mushroom species has already been tested in some lignocellulosic wastes (Baysal *et al.*, 2003; Bonatti *et al.*, 2004; Dundar *et al.* 2009; Philippoussis *et al.*, 2001). Substrates play an important role for cultivation of any mushroom as emphasized by Singh and Dwivedi (1991) and Rangunathan *et al.,* (1996). Milky mushroom can also be grown on different types of substrates to produce fruiting bodies viz. paddy straw, maize stalks, sorghum stalks, sugarcane bagasse, soybean hay and groundnut haulms. However, paddy straw and maize stalk straw found most suitable substrate for commercial production of *C. indica* (Krishnamoorthy, 1995; Krishnamoorthy *et al.,* 2000, Krishnamoorthy and Muthusamy, 1997, Kochuthresiomma *et al.,* 1998). Kumar *et al.* (2006) reported that among the seven substrates, paddy straw and wheat straw gave significantly higher yield followed by sugarcane bagasse, maize straw and pea straw for *C. indica*. The average number of fruit bodies per bag was found maximum in wheat straw followed by sugarcane bagasse and paddy straw. However, wheat straw proved to be the best substrate giving high yield and minimum days taken for spawn run, pinhead development and higher number of fruiting bodies (Tandon and Sharma, 2006; Bhatt *et al.,* 2007; Singh *et al.,* 2009). Wheat production generates a considerable amount of straw every year and an enormous underutilized energy resource, but of great potential as feed for ruminants, and as raw material for the cultivation of edible mushrooms (Zadrazil *et al.*, 1996). Sugarcane bagasse is one of the largest cellulosic by products, a fibrous residue of cane stalk left over after the crushing and extraction of the juice from sugarcane in tropical plains of India. Use of bagasse is advantageous due to its low ash content compared to rice straw and wheat straw. Rice straw and wheat straw have 17.5% and 11.0% ash contents respectively for usage in bioconversion processes using microbial cultures (Pandey *et al.*, 2000). Wheat straw degradation is achieved by the influence of enzymes from *P. ostreatus*, particularly of cell-wall components, cellulose and lignin (Adamovic *et al.*, 1998). Three factors are important for mushroom cultivation i.e. temperature, humidity and light and have a significant effect on growth and formation of fruiting bodies on a number of physical, chemical and biochemical parameters (Zadrazil, 1978). Thus, the present work was carried out with an objective of using agricultural wastes such as wheat straw, paddy straw, sugarcane bagasse, sugarcane leaves and their combinations on yield of the milky mushroom and environmental factors to find the best condition for efficiently increasing mushroom productivity.

MATERIALS AND METHODS

Strains and Culture media

The different cultures of *C. indica* viz. CI-3, CI-4, CI-5 were collected from GBPUA&T, Pantnagar and CI-6, CI-10 from NDUA&T, Faizabad. For the present investigations two strains namely CI-6 and CI-4 were selected on the based of better performance in laboratory experiments in terms of cultural studies like temperature, media, pH and

supplement requirements. The experiments were conducted in at SVPUA&T, Meerut, Uttar Pradesh during the years 2008-09 and cultures of different strain of *C. indica* were purified by single hyphal tip and maintained on malt extract agar medium (MEA) for further use in experiments.

Spawn preparation

The spawn was prepared according to the procedure given by Tandon *et al.* (2004). The grains were taken in 500 ml glass bottles. plugged with non absorbent cotton and covered with butter paper. These bottles were then sterilized at 121°C (15 lbs pressure) for 60 minutes on two consecutive days and inoculated with 5 mm disc of a vigorously grown 7 days old culture of *C. indica*. Inoculated bottles were incubated at 28±1°C and shaking was done after 7 days. Entire grains were covered with fine mycelial growth after 15 days.

Cultivation technique

The substrates were chemically treated with carbendazim 7.5gm and formalin 100 ml / 100 lit of water for overnight. The tank was covered with polythene sheet to prevent the evaporation of formalin. The substrate was then spawned @ 4 % on wet weight basis and filled in polythene bags @ 1kg dry substrate per bag. These bags were placed in the mushroom crop room at 80-85% RH and 28±2 C temp. After 15-17 d of spawning, casing was done. Casing mixture was prepared by mixing of farm yard manure + vermi-compost + garden soil (1:1:1 w/w) each 2-yr-old and treated with formalin (4%) solution and kept covered for 48-72 h. The pH of casing was maintained at 8.5 using calcium carbonate and calcium sulphate. A 2.5 cm thick layer was applied uniformly on substrate. Pin head initiation started after 10-12 d of casing. The sporophores were harvested after the maturity.

Effect of different substrates on cropping

Cultivation of *C. indica* strains CI-4 and CI-6 on different substrates were tried such as wheat straw (WS), paddy straw (PS), sugarcane leaves (SL) and sugarcane bagasse (SB), which were used alone while WS was used in combination with SB, SL, brassica straw (BS) and PS in 2:1, 1:1 and 1:2 ratios (Table 1). All the substrates were washed in fresh water and thereafter chemically treated by soaking in a solution of carbendazim @ 75 ppm and formalin @ 100 ml/100 lit of water for 18 hrs. Spawning and cultivation were done as described earlier.

Effect of environmental factors on yield

The experiment was laid out to find out the effect of environmental factors like temperature and relative humidity on cropping period and total yield of two strains of milky mushroom during different periods of 2008 and 2009. The crops were taken during different month's like April-June, May-July, June-August, July-September, August-October and September-November in north India environmental conditions.

The experiments were conducted twice during 2008-09 on CI-4 and CI-6 strains of *C. indica* with three replications and Completely Randomized Block (CRB) with three replications Design. The observations were recorded on total yield (g/kg dry straw), days for spawn run (DFSR), days for pinhead formation (DFPF), days for first harvesting (DFFH), number of pinhead initiation (NOPI) and average weight of fruiting body (g/FB) as average of two crops. Biological efficiency was calculated using the following formula.

Biological Efficiency (BE) % = (fresh weight of fruiting bodies/ dry weight of substrate) ×100

RESULTS AND DISCUSSION

Effect of different substrates on cropping

C. indica is being cultivated mostly in India on PS or WS where it has been in progress. An experiment was conducted to find some other suitable substitutes of substrate for cultivation of milky mushroom strains i.e. CI-6 and CI-4 in north India. The results shown in Table 1, that both strains utilized all the substrates (i.e. WS, PS, SL, SB) alone or in combinations for growth and sporophore production of milky mushroom. Different combinations of substrate showed different period for DFSR, DFPF, DFFH and cropping. WS alone was the suitable substrate for mycelial run and formed a white mat within 17-18 days in both strains. The results revealed that WS substrate took significantly less time for DFPF and DFFH, simultaneously higher yield and number of sporophore in case of both strains. The minimum time

Table 1 : Effect of different substrates on spawn run, cropping period and yield of *C. indica* using CI-4 and CI-6 strains (Average of two years i.e. 2008 and 09).

Substrates	DFSR		DFPF		DFFH		NOPI		NOFB		Yield (g/kg dry substrate)		Average Weight (g/FB)		Biological efficiency (%)	
	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6
WS+SB (2:1)	20.0	19.3	14.0	13.0	22.0	22.0	62.3	61.3	20.7	22.7	525.3	517.0	25.4	22.8	52.5	51.7
WS+SB (1:1)	18.7	18.0	14.7	14.3	24.0	25.0	53.3	50.0	22.3	24.0	475.0	487.3	21.3	20.3	47.5	48.7
WS+SB (1:2)	25.0	24.7	15.7	15.0	27.0	27.7	47.0	46.3	20.0	21.0	464.0	467.3	23.2	22.3	46.4	46.7
WS+SL (2:1)	22.3	21.3	16.3	15.7	27.0	27.0	42.0	40.0	21.3	21.0	466.0	462.7	21.8	22.0	46.6	46.3
WS+SL (1:1)	23.3	23.0	15.7	15.3	27.0	27.3	39.3	38.0	20.0	19.7	426.7	438.7	21.3	22.3	42.7	43.9
WS+SL (1:2)	24.3	25.7	16.0	16.0	29.3	29.0	33.0	36.0	19.3	19.0	384.3	387.7	19.9	20.4	38.4	38.8
WS+BS (2:1)	21.0	21.0	13.7	13.0	21.3	21.0	57.7	60.0	21.0	21.0	509.7	611.3	24.3	29.1	51.0	61.1
WS+BS (1:1)	22.3	22.3	14.3	14.0	20.7	20.3	55.7	57.3	20.0	19.7	522.3	608.7	26.1	31.0	52.2	60.9
WS+BS (1:2)	23.3	23.0	17.0	17.0	22.3	21.7	58.3	54.7	24.0	24.0	536.3	566.7	22.4	23.6	53.6	56.7
WS+PS (2:1)	19.7	19.3	13.0	12.0	20.3	20.0	52.0	52.3	23.3	23.0	505.7	516.7	21.7	22.5	50.6	51.7
WS+PS (1:1)	20.7	20.0	13.3	14.0	22.0	22.3	50.0	52.0	26.3	26.7	493.3	502.7	18.7	18.9	49.3	50.3
WS+PS (1:2)	24.0	22.7	14.3	15.0	24.7	25.0	48.0	48.3	25.7	25.3	451.7	450.0	17.6	17.8	45.2	45.0
Wheat straw (WS)	17.7	17.0	14.0	13.3	24.0	23.3	60.0	61.0	23.3	23.0	504.7	513.7	21.6	22.3	50.5	51.4
Sugarcane bagasse (SB)	25.7	25.0	15.0	14.7	27.0	27.0	45.0	50.7	23.3	24.0	437.3	437.3	18.7	18.2	43.7	43.7
Sugarcane leaves (SL)	30.7	29.0	19.7	19.3	31.3	32.3	38.7	39.7	22.0	23.7	369.3	362.7	16.8	15.3	36.9	36.3
Paddy straw (PS)	26.3	24.0	15.0	15.0	24.3	24.0	40.7	45.3	20.0	22.0	444.3	447.7	22.2	20.4	44.4	44.8
CD at 5%	2.83	3.11	2.36	2.29	3.17	3.70	6.08	8.32	2.98	3.15	29.59	31.67	3.16	3.06	-	-
SE (d)	1.38	1.52	1.16	1.12	1.55	1.81	2.97	4.07	1.46	1.54	14.46	15.48	1.54	1.50	-	-

DFSR= Days for spawn run, DFPF= Days for pinhead formation, DFFH= Days for first harvesting, NOPI= Number of pinhead initiation, NOFB= Number of fruiting body

Table 2 : Effect of different months on spawn run, cropping period and yield of C. indica using CI-6 strain (Average of two years i.e. 2008 & 09)

Cropping Months	DFSR		DFPF		DFFH		NOPI		NOFB		Yield (g/kg dry substrate)		Average Weight (g/FB)		Biological efficiency (%)	
	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6	CI-4	CI-6
April- June	19.7	19.0	15.0	14.7	23.7	23.3	66.0	66.7	20.0	19.7	462.7	492.0	23.1	25.0	46.3	49.2
May-July	19.7	17.7	15.0	14.7	21.7	23.7	58.0	61.3	20.3	21.7	527.3	540.7	25.9	25.0	52.7	54.1
June-August	19.0	18.0	13.7	13.3	22.3	23.0	52.7	56.0	21.7	22.7	535.0	572.3	24.7	25.3	53.5	57.2
July-September	19.0	18.3	12.0	11.0	20.0	19.7	50.0	52.3	20.3	22.0	575.3	607.0	28.3	27.6	57.5	60.7
August-October	20.3	18.7	13.0	11.7	21.0	20.3	49.7	50.7	21.7	21.0	526.7	468.3	24.3	22.3	52.7	46.8
September-November	23.3	22.0	13.7	14.0	25.7	25.3	53.0	54.3	22.0	23.3	466.7	460.3	21.2	19.7	46.7	46.0
CD at 5%	N. S.	2.32	1.90	2.36	3.23	3.65	4.68	9.25	N.S.	N.S.	57.46	52.80	2.45	4.64	-	-
SE (d)	1.35	1.05	0.86	1.07	1.47	1.66	2.13	4.20	1.26	1.87	26.10	23.97	1.11	2.11	-	-

DFSR= Days for spawn run, DFPF= Days for pinhead formation, DFFH= Days for first harvesting, NOPI= Number of pinhead initiation, NOFB= Number of fruiting body

was recorded for DFPF (13 and 12) and DFFH (20.3 and 20) with the combination of WS+PS (2:1), while maximum time for DFPF (19.7 and 19.3) and DFFH (31.3 and 32.3) was noticed in SL alone in strains CI-4 and CI-6, respectively. Maximum NOPI were found in WS+SB (2:1) (62.3 and 61.3/bag) followed by WS alone (60 and 61/bag) in strains CI-4 and CI-6, respectively. Maximum NOFB per bag were harvested from CI-4 and CI-6 strains with

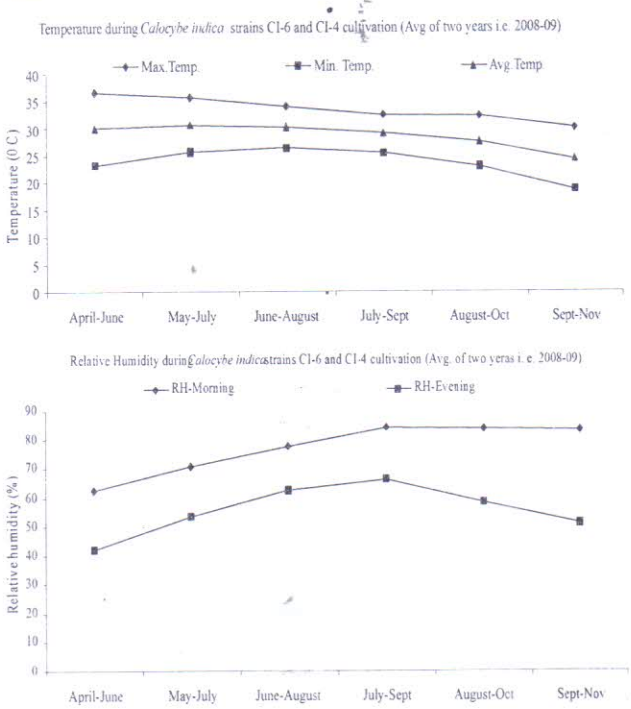

Fig. 1 : Environmental conditions for cultivation of *C. indica* strains CI-6 and CI-4 during different months of 2008 and 2009

WS+PS (1:1) (26.3 and 26.7) followed by WS+PS (1:2) (25.7 and 25.3), respectively. Maximum yield was harvested from the strains CI-6 (611.3 g/kg of dry substrate) with WS+BS (2:1) and CI-4 (536.3 g/kg of dry substrate) with WS+BS (1:2). The least yield was harvested from both the strains when these grew in SL alone. However, maximum average weight per fruit body was recorded in CI-6 strain with WS+BS (1:1) (31g) followed by WS+BS (2:1) (29.1g) and CI-4 strain WS+SB (2:1) (26.1g) followed by WS+SB (2:1) (25.4 g).

Most of the mushroom species possess the ability to degrade lignin, cellulose and hemicellulose and to produce fruiting bodies containing valuable protein at a low cost (Chang *et al.*, 1999). These findings are accordance with Krishnamoorthy *et al.* (2000), who reported higher yield of *C. indica* on paddy straw which accounts to 142.6 to 150% bio-efficiency. Salam *et al.* (2004) revealed that the

retted, non-retted and composted coir pith were used as substrates for *C. indica* in combination with 9 treatments, i.e. rice straw and spent mushroom substrate, each at 25, 50 and 75%; cellulose and starch (2%); and neem cake (4%). The highest yield and sporophore production were obtained with non-retted coir pith in combination with 75% rice straw. Yadav *et al.* (2006) tested five different locally available substrates like paddy straw, wheat straw, sunflower stalks, sugarcane trash and sorghum stalks tested for their potential in enhancing the yield and quality of *C. indica*. Sunflower stalks gave the highest yield (267.5g) per bed on dry weight basis followed by WS. Kumar *et al.* (2006) reported that among the seven substrates tried PS and WS gave significantly higher yield (1012.5 and 1000.8 g) per two kg dry substrate, respectively followed by SB, maize straw and pea straw. The average number of fruit bodies formed per bag was found maximum in WS (26.7) followed by SB (25.3) and PS (25). Tandon and Sharma (2006) evaluated four different substrates and three supplements for the sporophore yield of *C. indica*. WS proved to be best substrate giving 520 g yield per 3 kg wet substrate. Mane *et al.* (2007) studied the several agro wastes viz. cotton stalks, groundnut haulms, soybean straw, pigeon pea stalks and leaves and WS alone or in combinations for cultivation of *P. sajor-caju*. The bioconversion of lignocellulosic biomass by *P. sajor-caju* offers a promising way to convert low quality biomass into an improved human food. Bhatt *et al.* (2007) showed that among the tested substrates for cultivation of *C. indica*, WS took minimum period for spawn run (14 days) which was at par with WS+PS (2:1) but significantly lesser than the period taken by other substrate. Singh *et al.* (2009) evaluated five different substrates viz., WS, PS, gram straw, BS and SB for cultivation of *C. indica* and maximum yield, minimum DFSR, DFPF and NOFB was obtained in PS.

Effect of environmental factors on yield

The major environmental factors that affect stalk height, stalk diameter and cap size in mushroom are temperature, humidity and fresh air. The results showed in Table 2 that minimum days were observed during June-August for spawn run (19 and18) followed by July–September (19 and18.3), while significantly least DFPF (12 and11) and DFFH (20 and19.7) were recorded during July–September as compared to other months from strains CI-4 and CI-6, respectively. The maximum NOFB per bag were harvested during September-November (22 and 23.3), however maximum NOPI were notice during April-June (66 and 66.7) from CI-4 and CI-6 strains respectively. The maximum yield (575.3 and 607g) and average weight per fruit body (28.3 and 27.6) were recorded during July-September from strain CI-4 and CI-6, respectively. During the present investigations, the mean maximum and mean minimum temperatures and the relative humidity were observed at experimental site (Fig.1). The experimental site is located at Meerut of western Uttar Pradesh with an altitude of 718 m above sea level. The differences in the spawn running time (Mycelium growth) in the different months indicated a strong positive relationship between temperature and the growth of mycelium, i.e., the higher the temperature, the faster the growth of the mycelium resulting in to shorter spawn running time. Lower temperatures and relative humidity could be the plausible explanation for the longer time required for the formation of fruiting bodies after opening of bags under Meerut conditions. Our results are well supported by an earlier report defining both temperature and humidity playing an important role in the spawn development (Bano and Srivastava, 1974) and verifying that certain variations in season seriously affect the number, weight and crop production period of mushroom. In addition, further it was reported that favorable temperature and moisture conditions enhanced the production of fruiting bodies of mushroom (Das *et al.*, 1987, 1991; Alexander *et al.,* 2002). Kalita *et al.* (2000) reported that *P. citrinopileatus* was suitable for cultivation during March to April which had slightly higher environmental temperature while *P. sajor caju* performed better in the month of October and January. Kushwaha *et al.* (2000) observed that low temperature of December and January resulted in maximum period for spawn run and fruiting of *Pleurotus* species. Dubey (2003) reported that mycelial growth was good and the time required for initiation of pinhead and production of first flush was less when grown between March to November (except May and June). In western plain zone of Uttar Pradesh suitable period for the growth of *Pleurotus* species (*P. sajor-caju* and *P. sapidus*) was observed during January to April and October to December. Sharma and Kumar (2007) was conducted a experiment on milky mushroom in the months of April and May 2005 and 2006 and revealed that the APK-2 strain grew successfully under tempera-

ture ranges from 30-49^{0}C. Rawat *et al.* (2007) yield performance of *C. indica* was demonstrated in Nainital and Almora districts of Uttarakhand during the year 2004-06. Varshney (2007) reported that strain CI-4 took minimum (13 days) period for spawn run and maximum yield was observed in strain CI-10. Based on the results of current study, it was concluded that the environmental conditions of Meerut during April to October are favourable for cultivation of milky mushroom.

REFERENCES

Adamovic, M., Grubic, G., Milenkovic, I., Jovanovic, R., Protic, R., Sretenovic, L. and Stoicevic, L. 1998. The biodegradation of wheat straw by *Pleurotus ostreatus* mushrooms and its use in cattle feeding. *Anim. Feed Sci. Tech.* **71**:357–362.

Alexander, S.J., Weigand, J.F. and Blatner, K.A. 2002. Value estimate of commercial mushroom and timber in the Pacific Northwest. *J Environ Manage.* **30**:129–141.

Bano, Z. and Srivastava, H.C. 1974. Studies on the cultivation of *Pleurotus* spp. on paddy straw. *J Food Sci.* **12**:363–365.

Baysal, E., Peker, H., Yalinkilic, M.K. and Temiz, A. 2003. Cultivation of oyster mushroom on waste paper with some added supplementary materials. *Bioresource Technol.* **9**:95–97.

Bhatt, P., Kushwaha, K.P.S. and Singh, R.P. 2007. Evaluation of different substrates and casing mixtures for production of *Calocybe indica*. *Indian Phytopath.* **60**: 128-130.

Bonatti, M., Karnopp, P., Soares, H.M. and Furlan, S.A. 2004. Evaluation of *Pleurotus ostreatus* and *Pleurotus sajor-caju* nutritional characteristics when cultivated in different lignocellulosic wastes. *Food Chem.* **88**:425–428.

Chang, S.T. and Miles, P.G. 1992. Mushroom biology-a new discipline. *The Mycologist* **6**:2.

Chang, S.T., Buswell, J.A., and Miles, P.G. 1999. *Genetics and breeding of edible mushrooms*. Gordon and Breach Science Publishers, The Netherlands-324pp.

Das, T.K., Sharma, R. and Singh, B. 1987. Utilization of weeds and other waste products for spawn and fruiting body production of Oyster mushroom. In: Sharma, R. Ed., *Proceedings of the 8th International Symposium* 3–5 August 1987, US Department of Agriculture Tech., USA, pp. 84.1–60.

Das, T.K., Sharma, R. and Singh, B. 1991. Some Principles in Mushroom Growing and Spawn Mocking. US Department of Agriculture Tech., USA, Bull 85, pp. 1–7.

Dubey, S.C. 2003. Cultivation of *Pleurotus* species during different months an influence of temperature and relative humidity on yield in Jharkhand. *Pl. Dis. Res.*, **18**:147-151.

Dundar, A., Acay, H. and Yildiz, A. 2009. Effect of using different lignocellulusic wastes for cultivation of *Pleurotus ostreatus* Jacq P. Kumm. on mushroom yield, chemical composition and nutritional value. *Afr. J. Biotechnol.* **8**:662–666.

Kalita, M.K., Rathaiah, Y. and Bhagabati, K.N. 2000. Evaluation of yield performance of seven species of *Pleurotus* oyster mushroom under Assam conditions. *Adv. Plant Sci.* **13**: 457-459.

Kochuthresiamma, J., Kothandarmam, R., Mathew, J. and Joseph, K. 1998. Rubber wood saw dust- a ideal substrate for summer mushroom cultivation. *Planter* **74**: 527-529.

Krishnamoorthy, A.S. 1995. *Studies on the cultivation of milky mushroom Calocybe indica* P&C. Ph.D. thesis, TNAU, Coimbatore, India, pp.222.

Krishnamoorthy, A.S. and Muthusamy, M. 1997. Yield performance of *Calocybe indica* P&C on different substrates. *Mush. Res.* **6**:29-32.

Krishnamoorthy, A.S., Muthusamy, M. and Nakkeeran, S. 2000. Techniques for commercial production of milky mushroom *Calocybe indica*. *Indian J. Mush.* **18**:19-23.

Krishnamoorthy, A.S., Muthusamy, M., Marimuthu, T., Narasimhan, V., and Muthusankaranarayanan, A. 1998. APK2 milky mushroom-Extn.Bulletin, RRS, TNAU, Aruppukottai.

Kumar, A., Ratan, V., Shukla, H.P. and Singh, P.N. 2006. Evaluation of locally available substrates for cultivation of milky mushroom *Calocybe indica*. *Indian J. Pl. Pathol.* **24**:116.

Kurtzman, R.H. 1979. A vertical tray system for the cultivation of edible fungi. *Mush. Sci.* **10**: 429-436.

Kushwaha, K.P.S., Mishra, S.K. and Singh, R.P. 2000. Effect of agroclimate on the yield of different species of *Pleurotus*. *J. Mycol. Pl. Pathol.* **30**:288.

Mane, V.P., Patil, S.S., Syed, A.A. and Baig, M.M.V. 2007. Bioconversion of low quality lignocellulosic agricultural waste into edible protein by *Pleurotus sajor-caju* Fr. Singer. *J. Zhejiang Univ. Sci.* **8**: 745-751.

Oei, P. 2005. *Small-scale mushroom cultivation: oyster, shiitake and wood ear mushrooms*. Digigrafi, Wageningen, The Netherlands-86pp.

Pandey, A., Soccol, C.R., Nigam, P. and Soccol, V.T. 2000. Biotechnological potential of agro-industrial residues. I: Sugarcane Bagasse. *Bioresource Technol.* **74**:69–80.

Philippoussis, A., Zervakis, G. and Diamantopoulou, P. 2001. Bioconversion of agricultural lignocellulosic wastes through the cultivation of edible mushrooms *Agrocybe aegerita*, *Volvariella volvacea* and *Pleurotus* spp. *World J. Microbiol. Biotechnol.* **17**:191–200.

Purkayastha, R.P. and Chandra, A. 1976. A new technique for in vitro production of Calocybe indica—an edible mushroom of India. *Mush J.* **40**:112–113

Ragunathan, R., Guruswamy, R., Palaniswamy, M. and Swaminathan, K. 1996. Cultivation of *Pleurotus* on various agroresidues. *Food Chem.* **55**:134-144.

Rawat, S., Chaudhary, A. and Verma, R.C. 2007. Yield performance of *Calocybe indica* on different districts of Uttarakhand Abstract. *International Conference on Mushroom Biology and Biotechnology*, held at NRCM, solan, India. Feb.10-11, pp.151.

Salam, S.A., Geetha, D., Suharban, M. and Nair, K.H. 2004. Coir pith-a non-conventional substrate for *Calocybe indica* milky mushroom production. *Mush. Res.* **13**: 60-64.

Shah, Z.A., Ashraf, M. and Ishtiaq, C.M. 2004. Comperative study on cultivation and yield performance of oyster mushroom *Pleurotus ostreatus* on different substrate wheat straw, leaves, saw dust. *Pakistan J. Nutri.* **3**:158-160.

Sharma, J.P. and Kumar, S. 2007. Evaluation of strains of milky mushroom *Calocybe indica* for cultivation in Jharkhand Abstract. *International Conference on Mushroom Biology and Biotechnology*, held at NRCM, solan, India. Feb.10-11, 2007.pp.135-136.

Singh, M., Singh, A.K. and Gautam, R.K. 2009. Screening of substrates for growth and yield of *Calocybe indica*. *Indian Phytopath.* **62**:109-111.

Singh, R.P. and Dwivedi, R.R. 1991. Standardization of substrate for production of *P. sajor caju* Fr Singer. *Proceeding of the National Symposium on mushroom*, pp.102-103.

Tandon, G. and Sharma, V.P. 2006. Yield performance of *Calocybe indica* on various substrates and supplements. *Mush. Res.* **15**:33-35.

Tandon, G., Sharma, V.P. and Guleria, D.S. 2004. Studies on spawn production of *Calocybe indica* P&C. *Indian J. Mush.* **22**:64-67.

Varshney, A. 2007. *Variability among the strains* of *Calocybe indica* P&C. M.Sc. thesis, GBPUA&T, Pantnagar, pp.94.

Yadav, R.S., Patil, A.B. and Prabhu, H.V. 2006. Effect of different substrates on yield and composition of milky mushroom *Calocybe indica* Abstract. In: *National symposium on biodiversity and biotechnology: research and development needs in edible mushroom and crop disease management* held at GBPUA&T, Pantnagar, Nov. 09-11, 2006, pp. 3.

Zadrazil, F. 1978. Cultivation of *Pleurotus*. In: *The biology and cultivation of edible mushroom* Eds. Chang, S.T. and Hayes, W.A., pp. 521-556, Academic Press, New York, USA.

Zadrazil, F., Kamra, D.N., Isikhuemhen, O.S., Schuchardt, F. and Flachowsky, G. 1996. Bioconversion of lignocellulose into ruminant feed with white rot fungi- review of work done at the FAL Braunschweig. *J. Appl. Anim. Res.* **10**:105–124.