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Effect of different substrates on the growth and yield of milky mushroom (*Calocybe indica* P & C)

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Abstract
Milky mushroom (*Calocybe indica*) is one of the most potential species of mushroom, being cultivated in tropical and subtropical parts of India. It's high productivity, beautiful shape and colour, pleasant flavour and good shelf life are the major characters responsible to establish it among the mushroom growers and consumer. At present it is mostly being cultivated on wheat straw, however, like other mushroom, it can also be grown on other substrates. Keeping in view the economic of production different substrates were tested along and in combination with spent straw (SWS). Observation on time of taken for spawn run indicated that there was not much difference among the substrates; it look 20-30 days. Extent of spawn run varied greatly among the substances and it was highest in wheat straw (WS, 98.38) followed by sugarcane bagasse (Scb, 97.75), Scb + SWS 96.75, paddy straw (Pds, 95.5), PdS + SWS 94.5, WS + SWS 92.5, mustard straw + SWS (MS + SWS 73.75, MS 15.5, pigeonpea straw + SWS (PgS + SWS 10.0), and PgS 4.8 respectively. No difference was observed in time taken for pinhead initiation after casing. Effect of different substrates on length, average weight and number of fruiting bodies was mostly observed significantly. Highest yield of fruiting bodies was recorded in wheat straw followed by Scb, Scb + SWS, PdS, PdS + SWS, WS + SWS, MS + SWS, MS, PgS, SWS and PgS respectively. All the substrates were found productive upto varying degree of extent except pigeonpea straw. Usefulness of SWS was also proving in combination with different substrates.

Keywords: Substrates, *Calocybe indica*, pigeonpea, Milky mushroom

1. Introduction
Milky mushroom is commonly known as dudhiya mushroom. It is recommended as most suitable diet for diabetic patients. It is a important and used as vegetable in Indian food. Mushroom having various shape, size and colours. All quite different in character, appearance, edibility. Commonly a consist is cap or piles and stalk or stipe but other may have additional structures like annules and valva performing various functions in the life cycle of the fungus. This mushroom naturally grown on the humas rich soil under trees and in agriculture field in local language it is called "Kundu" or more popularly Dhudhi "Chhata". During rainy wind form of *C. indica* were observed near Calcutta and their edibility was confirmed. Natural occurrence of plains of Tamil Nadu, Rajasthan and U.P. The nutritive value of milky mushroom in comparable with other mushroom. Due to its alkaline and higher fibre content, it is highly suitable for people with hyper acidity and constipation protein content in *C. indica* has been documented to range between 17.7-28.5 per cent, fat 4.1 per cent, crude fibre 2.3-3.4 per cent and carbohydrate 50.0-64.0 per cent.
According to an estimate (Chang, 2002), total world production of mushroom was 12 million tones and it is being increased annually more than 12 per cent during 1981 to 1997. Highest production is done in China while U.S. is the biggest consumer of mushrooms. World production of cultivated mushroom in 1981 was 1257.2 thousand mt, in 1986, 2176.0 thousand mt, in 1990, 3794 thousand mt, in 1994, 4909.3 thousand mt, in 1997, 6158.4 thousand mt (Singh and Mishra, 2006) [16].
First attempt on the induction of fruiting bodies of *Calocybe indica* P & C in culture by (Purkayastha, 1979) [11] was made almost three decades ago. However, only limited success was achieved on its cultivation and exploitation till 1990 (Chakraverty *et al.*, 1981; Doshi *et al.*, 1989; Purkayastha and Nayak, 1981) [2, 6, 12]. Later, owing to efforts made under all India Coordinated Mushroom Improvement Project (AICMIP), it is now being cultivated on commercial scale during summer throughout the country.
Cultivation of *C. indica* is mainly done on substrates like wheat, paddy straw, sugarcane wastes, etc. Spawning is done with spawn @ of 4% of wet weight of straw containing about

60-65% moisture (Anon., 2004; Shukla, 2006) [1, 15]. After the completion of spawn run, casing is very important point in its cultivation. Quality and quantity of easing material determines the pinhead initiation as well as ultimate yield (Shukla, 2006) [15]. A casing thickness of 10-15 mm has been reported best (Shukla, 2006) [15]. Ten to fifteen days after casing, fruiting bodies are formed, which continues to grow for next 45-60 days.

Materials and Methods

Preparation of substrate

For the production of sporophore locally available agro wastes like wheat straw, mustard straw, pigeonpea straw, paddy straw, sugarcane, bagasse, wheat straw + 50% spent wheat straw, mustard straw + 50% spent wheat straw, pigeonpea straw + 50% spent wheat straw, paddy straw + 50% spent wheat straw, sugarcane bagasse + 50% spent wheat straw was steeped in formaldehyde and bavistin solution for 16-18 h and then express of solution was drained from straw before spawning.

Fruiting

Fruiting depends on proper environment management in the cropping rooms i.e. humidity, temperature, light and CO_2 concentration. Any one of the factors, if increase or decrease may adversely affect the fruiting. After pin initiation and further increase size fruiting body can be seen. After maturity stage the mature sporophore were harvested by anti-clock wise twisting the mushroom The observations were made on growth and yield of mushroom.

Cultivation of *Calocybe indica*

The experiment was conducted to investigate the effect of different substrates on physical and biochemical parameters of milky mushroom. The experiment was laid out I polythene bags filled with 3 kg (wet weight) wheat straw as basal substrates upto sugarcane bagasse + 50% spent wheat straw were seeded.

To find out the best method of spawning an experiment was conducted by using fixed amount of straw (3 kg wet weight) and spawning with fixed amount of spawn late 75g. The extent of spawn run recoded through visual observation of colonization of substances by the fungus of 10^{th} day 15 day and 20day after spawning. Time taken for pinhead initation was calculated form the date of casing

Lenth of all fruting bodies harvested form each replicate was measured and recorded separately. Number of fruiting bodies were counted and time of each picking form all the replicates separately.

The yield of furling bodies harvested form each replicate of different treatments was receded separately during each picking. The average weight of fruiting bodies was calculated by using the following formula.

$$\text{Average weight} = \frac{\text{Total weight of fruiting bodies}}{\text{Total number of fruiting bodies harvested}}$$

Result and Discussion

The average weight of harvested fruiting bodies of milky mushroom (g/bag) were noticed in T_2 (wheat straw (51.58 and 51.11 g/bag) followed by T1 (1.58 and 51.11 g/bag), T7 (50.45 and 54.42), T4 (48.22 and 51.51 g/bag), T6 (46.97 and 47.0 g/bag) and T3 (50.65 g/bag) during 2007-08, whereas minimum in T8 (28.46 and 38.11 g/bag) both the years of experiment. The average weight of fruiting bodies was significant in all treatments during both the years of steady. It may be due to vary in temperature, humidity and environmental condition.

Time taken for spawn run after spawning (DAS)

Data displayed in Table-1, the DAS ranged from 7.88-38.13% DAS and 13.13-46.88% DAS at 10 DAS during 2006-07 and 2007-08 respectively. The maximum spawn-run was observed in T_1 (33.13; 40.63%) and T_9 (28.13; 36.88). The spawn-run of all treatments/ substances of milky mushroom showed significant variation in all the treatments. This variation in spawn-run during two summer seasons might be due to variation in ecological condition, humidity, climatic/environment condition prevailed during both the years of studies. Similar results of spawn-run have been also reported by Shah *et al.* (2004) and Vyas *et al.* (2003) [13, 18] in regards to spawn-run in milky mushroom. The spawn-run was ranged in milky mushroom at 15 DAS from (25.63-70.63%) and (38.38-46.88%) during 2006-07 and 2007-08 respectively. The maximum spawn-run was achieved in T_1 (70.63; 81.25%) DAS followed by T_{10} (72.50; 80.0%), T_9 (71.25; 74.75%) and T_5 (68.13; 74.38%) at 15 DAS. The spawn-run of all treatment/ substrates of milky mushroom showed significantly result in all the treatments. This variation in spawn-run during two summer seasons might be due to variation ecological, humidity, climatic condition prevailed during both the years of studies. Similar results of spawn-run have been also reported by Vyas *et al.* (2003) and Patra *et al.* (1995) [18, 9], in regards of spawn-run at 15 DAS in milky mushroom. 20 DAS at spawn-run was ranged in (45.0-96.25%) and (46.25-98.75% at 20 DAS during 2006-07 and 2007-08 respectively. Maximum spawn-run was observed in T_1 (96.88; 98.75%) followed by T_{10} (96.88; 98.75%) T_9 (95.0:95.63%) and T_4 (92.0; 94.38%) at 20 DAS. The spawn-run of all treatments of milky mushroom showed significant variation in all the treatment. This variation in spawn-run during two summer season might be due to variation in environment condition, humidity and temperature during both the years of experiments. Similar result of spawn-run have been also reported by Vyas *et al.* (2003) [18] in regards of spawn-run at 20 DAS.

Total number of pinheads initiated at 20 DAC (Days after casing)

The total number of pinheads at 20 DAC presented in Table 2, showed the total number of pinhead initiation varied from 45.13-280.50% and 48.75-283.0 at 20 DAC, during both the years respectively. The maximum number of pinheads initiated at 20 DAC was noted in T_1 (280.5; 283.0) and T_4 (279.88 13%) at 20 DAC. The total number of pinheads initiated of all the treatments of milky mushroom showed significantly variation in all the treatment of milky mushroom. It may be due to the humidity temperature, climatic condition. The variation in the pin heads initiation at 20 DAC may be due to the straw used in various treatments contains cellulose, fibre and lignin and the pH of substrate have been maintained by addition of calcium sulphate, while calcium carbonates helps to reduce the stickyness property of spawn. The digestibility of straw have been improved by the treatment with alkali which breaks the ester bonds because the lignin and cell was polysaccharide making the carbohydrate

more available. This may be a possible reason for increase in heads initiation in T_1 and T_5 as compared to other treatments (Chesworth *et al.*, 2000). Similar results have been reported by Shanmughavel and Velliangiri (1994), Patra and Pani (1995), Shah *et al.* (2004) and Kumar *et al.* (2006) [5, 14, 9, 13, 7] in mushroom.

Table 1: Total number of pinheads initiation in Milky mushroom at 20 days after easing (DAC)

Treatments	Pinheads initiation at 20 DAC	
	2006-07	2007-08
T_1	280.50	283.00*
T_2	267.50*	270.75*
T_3	45.13*	48.75*
T_4	269.00	271.50
T_5	271.75*	276.88*
T_6	279.88*	281.13*
T_7	269.50*	274.63*
T_8	64.25*	67.25*
T_9	274.00	276.88
T_{10}	278.00*	281.75*
C.D. at 5% level	7.175	5.826

	2006-07	2007-08
T_1	280.5	283
T_2	267.5	270.75
T_3	45.13	48.75
T_4	269	271.5
T_5	271.75	276.88
T_6	279.88	281.13
T_7	269.5	274.63
T_8	64.25	67.25
T_9	274	276.88
T_{10}	278	281.75

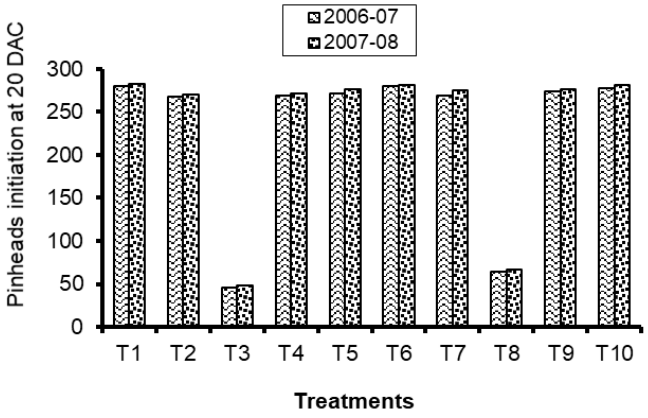

Fig 1: Total number of pinheads initiation in Milky mushroom at 20 days after easing (DAC)

Length of harvested fruiting bodies per bag

Data recorded to length of harvested fruiting bodies per bag was presented in Table 3, showed the average length of fruiting bodies from (11.60-13.16 cm) and (11.72-13.25) during 2006-07 and 2007-08 respectively. The maximum length of fruiting bodies was observed in T_4 (13.16; 12.71 cm) followed by T_{10} (12.81; 12.93) and T_9 (12.38; 10.9 cm). The length of fruiting bodies was non-significant during 2006-07 and significantly in 2007-08. It may be due to the temperature, humidity and environment conditions. The variation in the length of harvesting fruiting bodies may be due to the straw used in various treatments contains cellulose, fibre and lignin and the pH of substrate have been maintained by addition of calcium sulphate, while calcium carbonates helps to reduce the stickyness property of spawn. The digestibility of straw have been improved by the treatment with alkali which breaks the ester bonds because the lignin and cell was polysaccharide making the carbohydrate more available. This may be a possible reason for increase in the length of harvested fruiting bodies in T_1 and T4 as compared to other treatments (Chesworth *et al.*, 2000) [5].

Table 2: Length of harvested fruiting bodies per bag in Milky mushroom (cm)

Treatments	Length of harvested fruiting bodies in Milky mushroom (cm)	
	2006-07	2007-08
T_1	13.16	13.25
T_2	11.85	11.96
T_3	11.60	11.72
T_4	12.35	12.48
T_5	13.00	13.22
T_6	12.70	12.85
T_7	12.78	12.91
T_8	11.93	12.15
T_9	12.38	12.52
T_{10}	12.85	12.93
C.D. at 5% level	1.99	2.03

	2006-07	2007-08
T_1	13.16	13.25
T_2	11.85	11.96
T_3	11.6	11.72
T_4	12.35	12.48
T_5	13	13.22
T_6	12.7	12.85
T_7	12.78	12.91
T_8	11.93	12.15
T_9	12.38	12.52
T_{10}	12.85	12.93

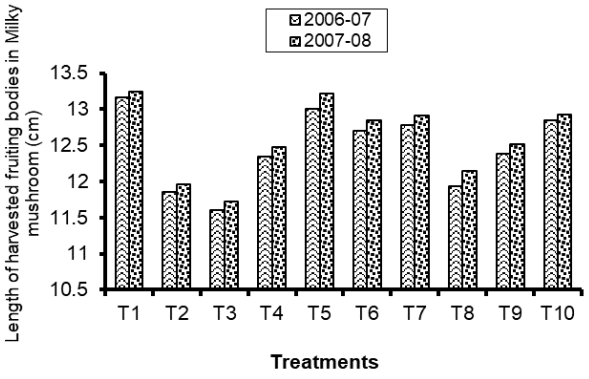

Fig 2: Length of harvested fruiting bodies per bag in Milky mushroom (cm)

Number of harvested fruiting bodies (f.b./bag)

The number of harvested fruiting bodies per bag was ranged from (2.50-12.88 f.b./bag) and (3.0-13.0 f.b./bag) during 2006-07 and 2007-08 respectively. The maximum number of harvested fruiting per bag was recorded in T_1 (12.88; 13.0 fb/bag) followed by T_6 (12.25; 12.5), T_{10} (12.0; 12.13) and T_9 (11.13; 11.5 fb/bag), the number of harvested fruiting bodies per bag was significantly in all the treatments. It may be due to the temperature humidity, environmental conditions. The variation in the number of harvested fruiting bodies may be

due to the straw used in various treatments contains cellulose, fibre and lignin and the pH of substrate have been maintained by addition of calcium sulphate, while calcium carbonates helps to reduce the stickyness property of spawn. The digestibility of straw have been improved by the treatment with alkali which breaks the ester bonds because the lignin and cell was polysaccharide making the carbohydrate more available. This may be a possible reason for increase in number of harvested fruiting bodies in T_1 and T_4 as compared to other treatments (Chesworth *et al.,* 2000) [5]. The similar results have been also reported by Tondon and Sharma (2006).

Table 3: Number of harvested fruiting bodies in Milky mushroom

Treatments	Number of harvested fruiting bodies in Milky mushroom (F.b./bag)	
	2006-07	2007-08
T_1	12.88	13.00
T_2	8.75	10.00
T_3	2.50	3.00
T_4	1.75	11.38
T_5	11.75	12.00
T_6	12.25	12.50
T_7	10.25	11.00
T_8	2.63	3.38
T_9	11.13	11.50
T_{10}	12.00	12.13
C.D. at 5% level	1.619	2.045

	2006-07	2007-08
T_1	12.88	13
T_2	8.75	10
T_3	2.5	3
T_4	1.75	11.38
T_5	11.75	12
T_6	12.25	12.5
T_7	10.25	11
T_8	2.63	3.38
T_9	11.13	11.5
T_{10}	12	12.13

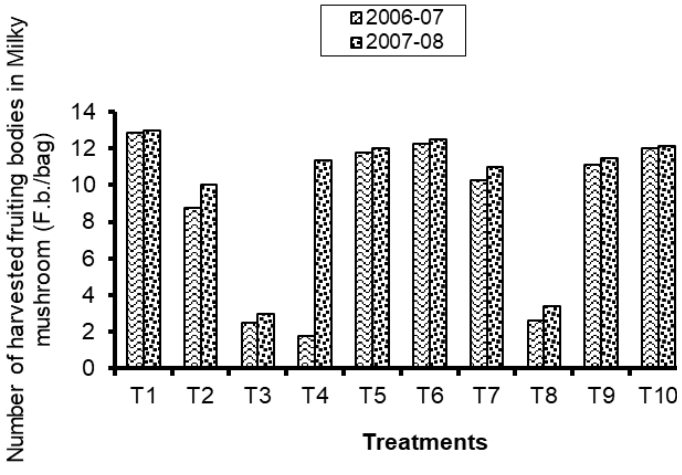

Fig 3: Number of harvested fruiting bodies in Milky mushroom

Yield of fruiting bodies (g/bag)

Data displayed in Table 5 the yield of fruiting bodies ranged from 100.25-679.0 g/bag and 105.75-664.38 g/bag during 2006-07 and 2007-08 respectively. The maximum yield of fruiting bodies (g/bag) was noticed in T_1 (679.0; 664.38 g/bag) followed by T_6 (564.5; 575.88% g/bag. The yield of all treatments of milky mushroom shoed significant results in all the treatments. This significant variation in yield of f.b. during two summer season might be due to the variation in ecological, climatic condition, temperature and humidity during both the years of studies. The variation in the yield of fruiting bodies may be due to the straw used in various treatments contains cellulose, fibre and lignin and the pH of substrate have been maintained by addition of calcium sulphate, while, calcium carbonates helps to reduce the stickyness property of spawn. The digestibility of straw have been improved by treatment with alkali which breaks the ester bonds because the lignin and cell wasll polysaccharide making the carbohydrate more available. This may be a possible reason for increase in yield of fruiting bodies in T_1 and T_4 as compared to other treatments (Chesworth *et al.*, 2000) [5]. Similar results of yield of fruiting bodies have been also reported by Prasuna (2002), Vyas *et al.* (2003), Pathak (1997), Chavan *et al.* (2003).

Table 4: Yield of fruiting bodies of Milky mushroom (g/bag).

Treatments	Yield of fruiting bodies of Milky mushroom (g/bag)	
	2006-07	2007-08
T_1	679.00	664.38
T_2	540.63	552.50
T_3	126.63	134.75
T_4	553.75	549.38
T_5	569.25	553.63
T_6	564.50	575.88
T_7	555.00	557.88
T_8	100.25	106.75
T_9	508.25	509.50
T_{10}	512.50	514.00
C.D. at 5% level	26.320	12.735

	2006-07	2007-08
T_1	679	664.38
T_2	540.63	552.5
T_3	126.63	134.75
T_4	553.75	549.38
T_5	569.25	553.63
T_6	564.5	575.88
T_7	555	557.88
T_8	100.25	106.75
T_9	508.25	509.5
T_{10}	512.5	514

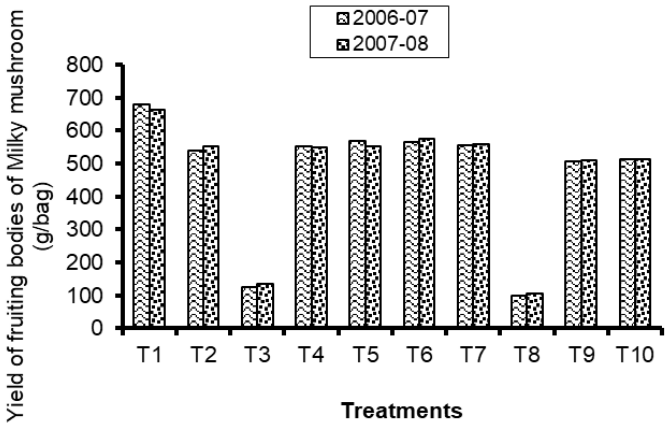

Fig 4: Yield of fruiting bodies of Milky mushroom (g/bag)

Average weight of fruiting bodies (g/bag)

Data recorded to average weight of fruiting bodies varied from 26.46-52.25 and 38.11-61.78 g/bag during 2006-07 and 2007-08, respectively. The maximum average weight of fruiting bodies were obtained in T_2 (52.25; 61.78 g/bag). The

average weight of fruiting bodies were significant in all treatments. The variation in the average weight of fruiting bodies may be due to the straw used in various treatments contains cellulose, fibre and lignin and the pH of substrate have been maintained by addition of calcium sulphate, while calcium carbonates helps to reduce the sticyness property of spawn. The digestibility of straw have been improved by the treatment with alkali which breaks the ester bonds because the lignin and cell wall polysaccharide making the carbohydrate more available. This may be a possible reason for increase in average weight of fruiting bodies in T_1 and T_4 as compared to other treatments (Chesworth *et al.*, 2000) [5]. It may be due to the temperature, humidity, environmental conditions.

Table 5: Average weight of fruiting bodies of Milky mushroom (g/bag).

Treatments	Average weight of fruiting bodies (g/bag)	
	2006-07	2007-08
T_1	51.58	51.11
T_2	52.25	61.78
T_3	44.90	50.65
T_4	48.22	51.51
T_5	46.04	48.46
T_6	46.97	47.01
T_7	50.45	54.42
T_8	28.46	38.11
T_9	44.39	45.70
T_{10}	42.37	45.10
C.D. at 5% level	3.017	1.445

	2006-07	2007-08
T_1	51.58	51.11
T_2	52.25	61.78
T_3	44.9	50.65
T_4	48.22	51.51
T_5	46.04	48.46
T_6	46.97	47.01
T_7	50.45	54.42
T_8	28.46	38.11
T_9	44.39	45.7
T_{10}	42.37	45.1

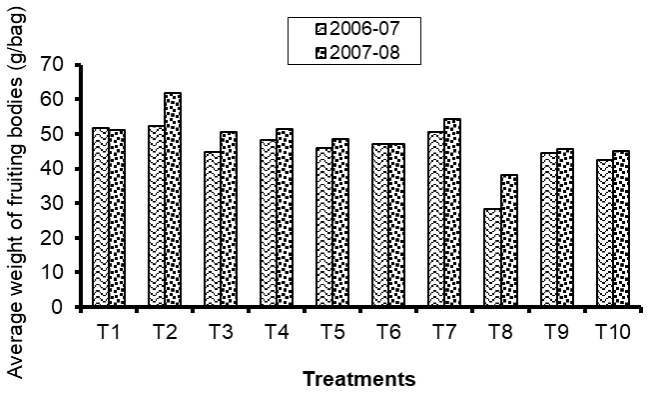

Fig 5: Average weight of fruiting bodies of Milky mushroom (g/bag).

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