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RESEARCH ARTICLE :

Development of suitable techniques for cultivation of paddy straw mushroom (*Volvariella volvacea*) on a commercial scale

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SUMMARY : The cost of production for ill-filled spawn is Rs. 4 as against Rs. 8 in sorghum grain spawn. In the existing system of bed preparation *viz.*, circular compact method, highest yield with 30.46 per cent biological efficiency was recorded in ill-filled paddy spawn with above said treatment, but in new method *viz.*, cylindrical polybag method, the same type of spawn with stripping off polybag on 7th day after bed preparation the biological efficiency was increased to 67.74 per cent. By adopting hanging rope system of bed storage about 50.0 and 52.7 per cent increased yield and income were recorded respectively, compared to rack system.

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KEY WORDS :
Volvariella volvacea, Additives, Pre-treatments, Mother, Bed spawn preparation, Yield, different cultivation method

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BACKGROUND AND OBJECTIVES

The genus *Volvariella* (paddy straw mushroom) comprised a group of several species, which can be found growing on a variety of substrates in tropical and sub-tropical regions. *V. volvacea* (Bull. ex Fr.) Sing., is probably the best known species, as it has been traditionally cultivated in Southeast Asia since the 18th century (Chang, 1977). At present time, *V. volvacea* is the third most important cultivated mushroom reaching total world production of 287 metric tones (Chang and Miles, 1993). In India, Su and Seth (1940) have first cultivated straw mushroom but the scientific cultivation using spawn was successfully demonstrated by Thomas *et al.* (1943). It is commonly known as Chinese mushroom, the most favourite mushroom in South Asian countries because of its excellent delicacy, high protein, aminoacid, vitamins and minerals contents (Thakur and Vijay, 2006). The climatic conditions prevailing in the Indian plains seems to be quite suitable for large scale production of paddy straw mushroom.

The success of paddy straw mushroom cultivation and its yield solely depends to a large extent on the purity and quality of spawn and suitable substrates. At present, spawn on cereal grains are commonly employed for the commercial cultivation of variety of edible mushrooms (Singer, 1961). The use of cereals

for the production of spawn is not very popular since it is pointed that grains often favour the development of saprophytic molds and bacteria. The usual practice is to raise the spawn in bottles on bits of paddy straw mixed with suitable additives, which is laborious and time consuming process.

A variety of substrates including paddy straw, banana leaf waste, water hyacinth and composted cotton waste have been successfully used for growing *V. volvacea*, (Chang, 1974; Saeed *et al.*, 1994 and Krishnamoorthy *et al*., 2005). Practically in India very little improvement in the cultivation technique has been made during the last two decades. Major draw back in the cultivation of *Volvariella* is the very low biological efficiency (BE) compared to other tropical mushrooms. If cultivation technique improves, it can be cultivated widely and cheaply as other common vegetables, which can be consumed regularly by all people.

RESOURCES AND METHODS

Indoor mushroom cultivation :

Effect of various substrates and pre treatments on yield of V. volvacea (*circular compact method*):

The substrates *viz.,* paddy straw and sugarcane trash were, separately made into small twists of 2.5 m long and 5-8 cm dia weighing about 1.25 kg. Totally four twisted bundles were used for the preparation of circular compact method. The treatments included were:

T_1- Paddy straw overnight soaking in water (12 h) + resources and methodssteam sterilization at 15 lbs pressure for 30 min + calcium carbonate (20g/kg)

T_2- Paddy straw overnight soaking in water (12 h)+ calcium carbonate (20g/kg)

T_3- Paddy straw overnight soaking in water (12 h) + steam sterilization at 15 lbs pressure for 30 min + horse gram (20g/kg)

T_4- Paddy straw overnight soaking in water (12 h) + horse gram (20g/kg)

T_5- Sugarcane trash overnight soaking in water (12 h) + steam sterilization at 15 lbs pressure for 30 min + calcium carbonate (20g/kg)

T_6- Sugarcane trash overnight soaking in water (12 h) + calcium carbonate (20g/kg)

T_7- Sugarcane trash overnight soaking in water (12 h) + steam sterilization at 15 lbs pressure for 30 min + horse gram (20g/kg)

T_8- Sugarcane trash overnight soaking in water (12 h) + horse gram (20g/kg)

In the substrates excess water was drained after soaking and steaming/without steaming and shade dried to have 65-75 per cent moisture. Initially, the twists were made clockwise in a circular fashion. Then, horse gram powder/ calcium carbonate (2%) was sprinkled uniformly over the surface of the bed. Then, sprinkled the ill-filled paddy spawn (1/4 of spawn bottle) all along the periphery layer over the additives. Second layer was placed over this in the same manner and sprinkle the additives and spawn as described in first layer. Like wise, third and fourth layers were formed. The completed beds were pressed tightly and kept on the wooden rack in a poly house. The temperature range of 30-35°C and humidity 80-85 per cent were maintained. The beds were regularly sprayed with clean water. Observations on number of basidiocarp per bed, average weight of basidiocarp (egg stage) and total yield were recorded. Each treatment was replicated thrice. Per cent of biological efficiency (BE) was calculated as per the formula :

$$\text{Biological effieciency (\%)} = \frac{\text{Fresh weight of mushrooms harvested/bed}}{\text{Dry weight of the substrate used / bed}}$$

Effect of a new method *viz.*, cylindrical poly bag method on yield of *V.volvacea* :

Well dried un chopped @ 500g/bed, previously soaked in water 12h, followed by stream sterilization (15 lbs pressure for 30 min) was used for the preparation of cylindrical (poly bag 2 X 1') beds similar to that of oyster mushroom bed preparation. At the time of bed preparation the moisture level of the straw was maintained at 50 per cent. First the straw was placed inside the poly bags and pressed tightly upto 10 cm height. Then sprinkled with calcium carbonate / horse gram (20g/kg). Then one segment of ill-filled paddy spawn (out four segment) was sprinkled over the inner periphery (1/2 inch) of the straw. Likewise 4 layers were prepared. Then, it was filled with straw at 10 cm level. The beds were pressed gently and tied the polythene strip. This was compared with existing method *viz.*, circular compact method. For each treatment three replications were maintained. Inside the poly house sufficient temperature and humidity as described earlier were maintained. The polythene bag was stripped off at regular intervals and keep the bed moistened.

The treatment included were :

– *Cylindrical poly bag method* (500g dry straw/ bed; additive calcium carbonate).

Stripping off poly bag
0 day
3 day
5 day
7 day
10 day.

– *Cylindrical poly bag method* (500g dry straw/ bed; additive horse gram).

Stripping off poly bag
0 day
3 day
5 day
7 day
10 day.

– *Circular compact bed* (5.0 kg/bed)

– Paddy straw overnight soaking in water (12 h) + steam sterilization at 15 lbs pressure for 30 min + calcium carbonate (20g/kg)

– Paddy straw overnight soaking in water (12 h) + stream sterilization at 15 lbs pressure for 30 min + horse gram (20g/kg)

Observations on number of basidiocarp formation, weight of individual basidiocarp and total yield were recorded. Per cent of biological efficiency was calculated as described earlier.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Advantages of ill filled paddy spawn over sorghum grain spawn :

The cost involved for the production of ill filled spawn and sorghum grain spawn was worked out and presented in Table 1.

For the production of ill filled paddy spawn (200 nos.), the cost involved was Rs.785/-. But, incase of sorghum grain spawn (200 nos.), the total cost was about Rs.1500/-. Total cost of production was Rs.4/- and Rs.8/- in case of ill filled paddy spawn and sorghum grain spawn, respectively. The net profit from one spawn was about Rs.11/- in ill filled paddy spawn and Rs.7/- in sorghum grain spawn.

Effect of various substrates and pre-treatments on mushroom yield (circular compact method) :

The effect of various substrates *viz.*, paddy straw and sugarcane trash with / without steam sterilization and additives calcium carbonate / horse gram were studied using a common existing method *viz.*, circular compact method. The results were presented in Table 2.

In general paddy straw substrate performed very well compared to sugarcane trash. Among the treatment beds prepared from paddy straw overnight soaking in water + steam sterilization + calcium carbonate recorded the highest yield of 1523.32 (average no. of eggs 65.10/ bed, average wt. per egg 23.40 g) with biological efficiency of 30.46. This was followed by paddy straw overnight soaking in water + steam sterilization + horse gram, where the total yield of 1333.82 g (average no. of eggs 58.16/bed, average wt per egg 22.93g) with

Table 1: Advantages of ill-filled paddy spawn over sorghum grain spawn (economics)

Sr. No.	Particulars	Ill-filled paddy spawn (Rs.)	Sorghum grain spawn (Rs.)
1.	Cost of substrate 1 gunny bag- 200 spawns	100	800
2.	Pre cooking labour and fuel cost,	-	100
3.	Overnight soaking in fungicides (50 g carbendazim/kg)	35	0.00
4.	Additives (calcium carbonate)	50	100
5.	Spawn bottle (200 nos)	200	200
6.	Non-absorbent cotton	200	200
7.	Labour cost	200-	200
8.	Total cost of the production (200 nos.)	785	1600
9.	Cost of production /spawn bottle	4	8
10.	Net profit /spawn bottle	11	7

biological efficiency of 26.67 per cent was recorded. Paddy straw substrate without steam sterilization, very low yield was recorded (850.92 g/ bed) with very low biological efficiency of 17.01 per cent.

Effect of new method *viz.*, cylindrical poly bag method on yield of *V. volvacea* :

A new method of bed preparation *viz.*, cylindrical poly bag method on the yield of mushroom was compared with existing method *viz.*, circular compact method. The result of this experiment was presented in Table 3.

Among the two bed systems, cylindrical poly bag method recorded more yield with biological efficiency of 41.12 to 67.74 per cent. But in existing method *viz.*, circular compact method recorded poor yield with low biological efficiency of 26.67 to 30.46 per cent. In cylindrical poly bag method, stripping of poly bags seven days after bed formation recorded maximum yield of 338.73g/500g substrate (additive calcium carbonate) with high biological efficiency of 67.74 per cent. The same treatment calcium carbonate substituted with horse gram recorded the yield of 298.7g/500g substrate with biological efficiency of 59.75 per cent.

Traditionally *V. volvacea* has been grown on rice straw. That tradition earned it the name of paddy straw mushroom (Chang, 1983). The straw mushroom cultivation in tropical/subtropical areas is still less advanced. The climatic condition prevailing in the Indian plains seems to be quit suitable for large scale production. Practically in India a very little improvement in the cultivation technique has been done during the last two decades. Major draw back in the cultivation of *Volvariella* is the very low biological efficiency (B.E) as compared to other tropical mushrooms. If culture technique improved, it should be cultivated widely and cheaply as other common vegetables which can be consumed regularly by all people. In view of the above facts, the present research was aimed to increase the biological efficiency by utilizing various new cultivation technologies for yield improvement. The results obtained were discussed herein.

Improvement of mushroom yield :

Several technique have been used for cultivation of *V. volvacea* in the tropics with varying temperature 30-35°C and relative humidity of 75-85 per cent. However, the traditional methods followed for cultivation of paddy straw mushroom in different parts of the world vary from

Table 2. Effect of various substrates and pre treatments on the yield of *V.volvacea* (circular compact method)

Sr.No.	Substrates and pre-treatments	Av. No. of eggs harvested /bed	Av.wt / egg (g)	Yield g / 5 kg straw	BE %
1.	Paddy straw overnight soaking in water (12 h) + steam sterilization at 15 lb pressure for 30 min + calcium carbonate (20g/kg)	65.10 [a]	23.40 [a]	1523.32 [a]	30.46 [a] (33.49)
2.	Paddy straw overnight soaking in water (12 h) + calcium carbonate (20g/kg)	37.93 [c]	22.43 [d]	850.92 [c]	17.01 [c] (24.35)
3.	Paddy straw overnight soaking in water (12 h) + steam sterilization at 15 lb pressure for 30 min + horse gram (20g/kg)	58.16 [b]	22.93 [b]	1333.82 [b]	26.67 [b] (31.09)
4.	Paddy straw overnight soaking in water (12 h) + horse gram (20g/kg)	33.06 [e]	22.80 [bc]	753.86 [e]	15.07 [e] (22.84)
5.	Sugarcane trash overnight soaking in water (12 h) + steam sterilization at 15 lb pressure for 30 min + calcium carbonate (20g/kg)	35.63 [d]	22.50 [cd]	801.72 [d]	16.03 [d] (23.60)
6.	Sugarcane trash overnight soaking in water (12 h) + calcium carbonate (20g/kg)	15.73 [h]	21.86 [e]	344.00 [g]	6.87 [h] (15.20)
7.	Sugarcane trash overnight soaking in water (12 h) + steam sterilization at 15 lb pressure for 30 min + horse gram (20g/kg)	31.26 [f]	23.06 [b]	721.25 [e]	14.42 [f] (22.31)
8.	Sugarcane trash overnight soaking in water (12 h) + horse gram (20g/kg)	31.26 [f]	21.30 f	402.48 [f]	8.06 [g] (16.49)

Figures in parentheses are arcsine transformed values
Mean of three replicates
Means followed by a common letter are not significantly different at the 5% level by DMRT

country to country, state to state and region to region. Among the different methods of cultivation of paddy straw, circular compact method is being adopted in various parts of India including Tamil Nadu.

In the present study the cheaply available substrate paddy straw and sugarcane trash with various pre treatments on the yield of mushroom were tried in a existing method *viz.*, circular compact method. In general, paddy straw substrate performed very well compared to sugarcane trash. Among the treatments, beds prepared from paddy straw overnight soaking water + steam sterilization (15 lbs pressure for 30 min) + calcium carbonate (20g/ kg) recorded the highest yield of 1523.32 g with biological efficiency of 30.46 per cent. This was followed by same treatment where calcium carbonate was substituted with horse gram (2g/kg) recorded the yield of 1333.8 g with biological efficiency of 26.67 per cent. Paddy straw without steaming recorded very poor yield with biological efficiency of 15.07 to17.01 per cent, irrespective of the additives (calcium carbonate/horse gram powder) used. To improve the biological efficiency, a new method of bed system *viz.*, cylindrical poly bag method with modified technique was adopted. The results of the experiment showed the biological efficiency was recorded upto 67.74 per cent in this new system, by following above said best treatments after stripping of polybag on in 7 day after bed preparation. In addition, by adopting hanging rope system of bed storage 33.0 per cent more bed could be accommodated compared to rack system. About 50.0 per cent and 52.7 per cent increased yield and income were recorded, respectively in hanging rope system compare to rack system. Similar results were also recorded by Prabhakara (2006) in oyster mushroom *P. euos*, utilizing the same techniques for cultivation.

The results of the present experiment clearly showed that for paddy straw mushroom yield improvement with high biological efficiency (67.74%), the substrates paddy straw overnight soaking in water + steam sterilization (15 lbs pressure for 30 min) + calcium carbonate (20g/ kg), using cylindrical polybag method (hanging rope system) and striping of polybag on 7th day after bed formation could be used for successful cultivation of paddy

Table 3: Effect of cylindrical poly bag method on the yield of *V.volvacea* compared with existing method

Sr.No.	Method	Av. No. of eggs harvested /bed	Av.wt / egg (g)	Yield g / 5 kg straw	BE %
	Cylindrical poly bag method				
1.	**Paddy straw overnight soaking in water (12 h) + Stream sterilization at 15 lb pressure for 30 min + Calcium carbonate (20g/kg)**				
	0 days	10.06 ^{ef}	22.367 ^{a}	225.093 ^{e}	45.01 ^{e} (42.13)
	3 days	11.66 ^{cd}	22.26 ^{ab}	262.74 ^{c}	52.54 ^{c} (46.45)
	5 days	13.06 ^{b}	22.43 ^{a}	291.62 ^{b}	58.32 ^{b} (49.79)
	7 days	15.26 ^{a}	22.33 ^{a}	338.73 ^{a}	67.74 ^{a} (55.39)
	10 days	11.23 ^{cd}	22.33 ^{a}	253.87 ^{cd}	50.77 ^{cd} (45.44)
2.	**Paddy straw overnight soaking in water (12 h) + Stream sterilization at 15 lb pressure for 30 min + Horse gram**				
	0 days	9.23 ^{f}	22.26 ab	205.65 ^{f}	41.12 ^{l} (39.88)
	3 days	10.20 ^{e}	22.26 ^{ab}	227.03 ^{e}	45.40 ^{e} (42.35)
	5 days	12.00 ^{c}	22.43 a	266.94 ^{c}	53.38 ^{c} (46.94)
	7 days	13.20 ^{b}	22.63 a	298.76 ^{b}	59.75 ^{b} (50.62)
	10 days	10.80 ^{de}	21.93 ^{b}	235.79 ^{de}	47.15 ^{de} (43.36)
3.	**Existing method (5 kg dry straw)**				
	Paddy straw overnight soaking in water (12 h) + Stream sterilization at 15 lb pressure for 30 min + Calcium carbonate	65.10	23.40	1523.32	30.46
	Paddy straw overnight soaking in water (12 h) + Stream sterilization at 15 lb pressure for 30 min + Horse gram	58.16	22.93	1333.82	26.67

Figures in parentheses are arcsine transformed values
Mean of three replicates,
Means followed by a common letter are not significantly different at the 5% level by DMRT

straw mushroom.

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