12. MUSHROOM CULTIVATION

Agriculture will continue to be the main strength of Indian economy. With the variety of agricultural crops grown today, we have achieved food security by producing about 240 million tonnes of food grains. However, our struggle to achieve nutritional security is still on. In future, the ever increasing population, depleting agricultural land, changes in environment, water shortage and need for quality food products at competitive rates are going to be the vital issues and secondary agricultural vocations are going to occupy a prominent place to fill the void quality food requirements. The demand for quality food and novel products is increasing with the changes in life style and income. To meet these challenges and to provide food and nutritional security to our people, it is important to diversify the agricultural activities in areas like horticulture. Diversification in any farming systems imparts sustainability. Mushrooms are one such component that not only impart diversification but also help in addressing the problems of quality food, health and environmental sustainability. The present century is going to be a century of functional foods from synthetic chemicals and mushroom cultivation fits very well into this category and is going to be an important vocation.

Mushrooms represent microbial technology that recycles agricultural residues into food and manure. It is solid state fermentation system in which crop residues are converted into valuable food rich in microbial protein. These are important source of quality protein, minerals and various novel compounds of medicinal value, do not compare for land and have very high productivity per unit area and time. These are considered to be the highest protein per unit area and time due to utilization of vertical space and short crop cycle. Due to their cultivation under controlled conditions the water requirements is less than any other crop grown in the field and has all the potentials of being a major crop in coming years.

Mushroom farming today is being practiced in more than 100 countries and its production is increasing at an annual rate of 6-7%. In some developed countries of Europe and America, mushroom farming has attained the status of a high-tech industry with very high levels of mechanization and automation. China leads in mushroom production and China alone is reported to grow more than 20 different types of mushroom at commercial scale and mushroom cultivation has become China's sixth largest industry. The USA is the second largest producer of mushroom sharing 16% of the world output. Presently, three geographical regions- Europe, America and East Asia contribute to about 96% of world mushroom production. With the rise in the income level, the demand for mushrooms at very low costs with the help of seasonal growing, state subsidies and capturing the potential markets in the world with processed mushrooms at costs not remunerative to the growers in other mushroom producing countries.

Commercial production of edible mushrooms represents unique exploitation of the microbial technology for the bio conversion of the agricultural, industrial, forestry and household waste into nutritious and proteinaceous food. Our country can emerge as a major play in mushroom production in wake of availability of plenty of agricultural residues and labour.Integrating mushroom cultivation in wake of availability of plenty of agricultural residues and labour. Integrating mushroom cultivation in the existing farming systems will not only supplement the income of the farmers but also will promote proper recycling of agro-residues thereby improving soil health and promoting organic agriculture. In India, mushroom research started in1960s and the cultivation picked up in 1970s and new varieties were evolved in button and oyster mushroom during 1980s and 1990s. Since the year 2000, our country is progressing keeping in pace with global growth by developing technologies for cultivation of medicinal mushrooms.

India has varied agro-climate, abundance of agricultural residues and plenty of manpower making it suitable for cultivating different mushrooms. Our country produces about 600 million tonnes of agricultural waste per annum and a major part of it is let out to decompose naturally or burnt *in situ*. This can effectively be utilized to produce highly nutritive food such as mushrooms and spent mushroom substrate can be converted into organic manure and vermi-compost. Mushrooms are grown seasonally as well as in state-of-art environment controlled cropping rooms all the year round in the commercial units. Mushroom growing is a highly labour oriented venture and labour availability is no constraint in the country and two factors, that is, availabilities of raw materials and labour make mushroom growing economically profitable in India. Moreover, scope for intense diversification by cultivation of other edible mushrooms like oyster, shiitake, milky and other medicinal mushrooms are additional opportunities for Indian growers.

At present, four mushrooms *viz.*, Button mushroom (*Agaricus bisporus*), Oyster Mushroom (*Pleurotus* spp), Paddy straw mushroom (*Volvariella* spp.) and Milky mushroom (*Calocybe indica*) have been recommended for round the year cultivation in India.

India produces about 600 million tonnes of agricultural by products, which can profitably be utilized for the cultivation of mushrooms. Currently, we are using 0.04% of these residues for producing around 1.29 lakh tonnes of mushrooms of which 85% is button mushroom. India contributes about 3% of the total world button mushroom production. Even if we use 1% of the residues for mushroom production, we can produce 3.0 million tonnes of mushrooms, which will be almost equal to current global button mushroom production (current world production 3.4 million tonnes). To remain competitive it will be important to harness science and modern technologies for solving the problems of production and bio–risk management. Mushroom being an indoor crop, utilizing vertical space offers a solution to shrinking land and better water utility.

Mushrooms have been reported to be capable of transforming agro wastes like paddy straw into protein rich food and have been confirmed to be sources of single cell

protein. Mushrooms contain rich source of carbohydrates, proteins, amino acids and dietary fibre. Vitamins such as riboflavin, niacin and pantothenic acid, and the essential minerals selenium, copper and potassium are abundant in mushrooms. The foremost importance is that mushrooms do not have cholesterol, instead contain ergosterol that act as a precursor for vitamin D synthesis in human body. Mushrooms are believed to help fight against cancer, relieves hypertension, imparts protection from heart diseases. Mushroom crop is in fact a boon that can solve several problems like the protein malnutrition, unemployment issues and environmental pollution.

Mushrooms are cultivated indoors and do not require arable land and mushroom is a short duration crop with high yield per unit time. For small farmers and landless workers mushroom cultivation is highly suitable for the economic and social security of this group. This hi-tech horticulture venture relieves the pressure on arable land, because it cultivation is indoors, and is also more suited to the women folk. Mushrooms supplement and complement the nutritional deficiencies and are regarded as the highest producers of protein per unit area and almost 100 times more than the conventional agriculture and animal husbandry.

At present, in Tamil Nadu the annual production of mushroom is around 11,000 tonnes, button mushroom accounts for 7,500 tonnes, Oyster mushroom accounts for 2700 tonnes and milky mushroom contributes for 800 tonnes. During the past two decades, the Mushroom Research and Training Centre of the Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore has made tremendous efforts on transfer of mushroom cultivation technology by imparting trainings. By this way it has contributed for the establishment of about 50 spawn producers and 600 oyster mushroom growers accounting for 7- 8 tonnes / day, 50 button mushroom growers producing 18-20 tonnes / day and 35 milky mushroom growers contributing 1-2 tonnes / day in Tamil Nadu. This account for around 8 per cent of total mushroom production of the country.

Mushroom varieties/strains released from TNAU for commercial cultivation

Scientific Name	Variety/strain name	Place of release
Oyster mushroom		
Pleurotus sajorcaju	M2	Dept. of Plant Pathology, TNAU, Coimbatore
P. citrinopileatus	CO1	Dept. of Plant Pathology, TNAU, Coimbatore
P. djamor	MDU 1	Dept. of Plant Pathology,AC&RI, Madurai
P. eous	APK 1	Regional Research Station, Aruppukottai
P. ostreatus	Ooty 1	Horticultural Research Station,Uthagamandalam
P. florida	Pf	Dept. of Plant Pathology,TNAU, Coimbatore

P.platypus	Pp	Dept. of Plant Pathology, TNAU,Coimbatore
P. flabellatus	MDU 2	Dept. of Plant Pathology, AC&RI Madurai
Hypsizygus ulmarius	CO2	Dept. of Plant Pathology,TNAU, Coimbatore
Milky mushroom		
Calocybe indica	APK 2	Regional Research Station, Aruppukottai
Tricholoma giganteum	CO 3	Dept. of Plant Pathology, TANU, Coimbatore
Button mushroom		
Agaricus bisporus	Ooty 1 Ooty 2	Horticultural Research Station, Vijayanagaram Horticultura Research Station, Vijayanagaram

Mushroom Cultivation techniques for Oyster and Milk mushroom

Base culture/ Nucleus culture

Tissue culture technique is used to bring the edible mushroom to pure culture so that the mushroom fungus can further be used to prepare spawn which is an essential material for mushroom cultivation.

- This nucleus culture is grown on Potato Dextrose Agar medium in test tubes.
- A small tissue from a well-grown mushroom is aseptically transferred to agar medium in a test tube in a culture room.
- The test tubes are incubated under room temperature for 10 days for full white growth of fungal culture. This is called base culture/nucleus culture and further used for preparation of Mother Spawn.

Mother spawn

Mother spawn is nothing but the mushroom fungus grown on a grain based medium. Among the several substrate materials tested by TNAU, Coimbatore, sorghum grains are the best substrate for excellent growth of the fungus. Well-filled, disease-free sorghum grains are used as substrate for growing the spawn materials. The various steps involving in preparation of mother spawn are listed below here under.

- The sorghum grains are washed in water thoroughly to remove chaffy and damaged grains.
- The grains are half cooked in an autoclave / vessel for 30 minutes to soften them.
- The half cooked grains are spread evenly over hessian cloth on a platform to remove the excess water.
- Calcium carbonate is mixed thoroughly with the cooked, dried grains@ 20g/Kg.
- The grains are filled in polypropylene bags up to 3/4th height (approximately 300-330 g/bag).
- A one inch diameter PVP ring is inserted on open end of the bag and plugged with non-absorbent cotton wood.

- The bags are arranged inside an autoclave and sterilized under 20-lbs,pressure for 2 hours.
- The bags after cooling are kept inside the culture room under the UV light for 20 min.
- After 20 minutes the UV light is put off and the fungal culture is transferred in to the sterilized cholam bags.
- The inoculated bags are kept in a clean room under room temperature for 10 days for further preparation of bed spawn.

Bed Spawn

The method of preparation of bed spawn was same as that of mother spawn. The cooking, filling and sterilization were similar to that of mother spawn. After sterilization, the bags are taken and the fully grown mother spawn is used for inoculation to prepare bed spawn. Thirty bed spawn can be prepared from a single mother spawn. The bags are incubated at room temperature (27±2˚C) for 10 days and used as bed spawn.

Cultivation of Oyster mushroom

The oyster mushrooms can be grown indoors in cropping house where a temperature of 25-30^{o} C and relative humidity of 80-85 per cent can be maintained.

- Paddy straw is used as the raw substrate which has to be soaked in water for 4 hours and boiled or steamed in autoclave for 45 minutes and shade dried until 65-70% moisture.
- Cylindrical beds are prepared using 60x30 cm polythene bags with a thickness of 80 gauge.
- Paddy straw and spawn are filled as alternate layers in polythene bags and 10-12 holes are made in the beds.
- The bags are placed in the cropping house/shed in racks or in hanging rope system. After 15-16 days when the paddy straws in the bags are covered with white mycelia growth, pinheads start emerging where water spray is essential to prevent drying of buds.
- First harvest begins from 3-4 days after in head emergence and likewise at 5-7 days internal three harvests can be done.
- Total cropping cycle is around 40-45 days.
- The average bio efficiency ranges (100-150 per cent) depending on the variety.

Cultivation of Milky mushroom

The milky mushroom requires a temperature of 30-35˚C and relative humidity of 85-90 per cent. For cultivation of this mushroom two shed are needed.

- Thatched shed / cropping house (28±2˚C) for Spawn running

- A sunken blue poly house (For Cropping)
- Three feet deep pit is dug out and sides are lined with hollow blocks and semicircular structure is built with GI pipe of Langley and covered with Blue silpaulin sheet.
- Paddy straw is processed as in oyster mushroom cultivation and cylindrical beds are prepared with 90x30 cm polythene bags and stored at 30^{o} C in thatched sheds (spawn running room).
- After 18-20 days when the paddy straws in the bags are covered with white mycelial growth, the beds are cut in to two halves and casing soil (autoclaved garden soil) is layered on to the cut halves for 2 cm height and sprayed with water.
- The cased beds are placed in poly houses and the required temperature is maintained.
- The pinheads emerge from the cut halves over the casing soil on 25-26th day.
- First harvest begins on 28th day and likewise three- five harvests can be done. The total cropping cycle is around 45-50 days. The average bio efficiency ranges from 150-160 per cent.

Economics of Spawn Production (100 spawn bags per day)

Sl. No.	Item	Quantity	Rate (Rs.)	Total (Rs.)
A.	**Capital investment**			
1.	Autoclave	1	70,000	70,000
2.	Boiler (GL drum 100 lit. Capacity)	2	2,500	5,000
3.	Culture room with work table (low cost)	1	20,000	20,000
4.	UV lamp with fittings	1	2,500	2,500
5.	Tube light fittings	1	1000	1000
6.	Advance for LPG gas	2	3,000	6,000
7.	Spawn storage room	1	30,000	30,000
8.	Bunsen burner	1	300	300
9.	Heat efficient chulah	1	1000	1000
10.	Glassware & chemicals			5000
	Total			**1,40,800**
B.	**Fixed cost**			
1.	Interest on capital investment @ 15%			21,120
2.	Depreciation (Item 3&7 @ 5%)			2,500
3.	Depreciation (Item 1 2,4,5,8 & 9, 10-10%)			9,080
	Total			**32,700**
C.	**Recurring cost (100 spawn x300 days)**			
1.	Polypropylene bags	150Kg	140	21,000

2.	Cholam grains	8000Kg	26	2,08,000
3.	Calcium carbonate (commercial grade)	160Kg	25	4000
4.	Non-absorbent cotton (400 g rolls)	600	110/roll	66,000
5.	Electricity & Fuel	--	--	60,000
6.	Labour @ 2 men per day for 300 days	300	360/day	2,16,000
7.	Miscellaneous	--	--	10,000
	Total			**5,85,000**

Total cost of Spawn production / Year (Rs)—

Working expenditure	:	5,85,000
Total fixed cost	:	32,700
Total Cost	:	**6,17,700**
Income (Rs.)		
By sale of 30,000 spawn bags @ Rs. 40 per bag	:	12,00,000
Total cost	:	**6,17,700**
Net income per year	:	**5,82,300**

Economics of Oyster mushroom production (10 Kg/day/300 days)
Low cost Investment

Sl. no.	Item	Quantity	Rate (Rs.)	Total (Rs.)
A.	**Capital Investment**			
1.	Thatched House (15' x 25')	1	30,000	30,000
2.	Chaff cutter (Lever type)	1	2000	2,000
3.	Boiler	1	2,000	2,000
4.	Drum	1	1,000	1,000
5.	Spraying systems	1	1,000	1,000
6.	Biomass stove		1,000	1,000
	Total			**37,000**
B.	**Fixed cost**			
1.	Interest on A @ 15%			5,550
2.	Depreciation (Item 1 @ 30%)			9,000
3.	Depreciation (Item 2,3,4,5,& 6 @ 10%)			700
	Total			**15,250**
C.	**Recurring Cost**			
1.	Paddy straw cost + transport	3.5t	7000	24,500
2.	Spawn @ Rs. 40 / No	2000	40	80,000
3.	Polythene bags for bed & packing	25Kg	135	3,375
4.	Labour @ 1 Per day	300	360/day	1,08,000
5.	Others	--		5,000
	Total			**2,20,875**

Total cost of mushroom production / Year (Rs.)

Working expenditure	:	2,20,875
Total fixed cost	:	15,250
Total Cost	**:**	**2,36,125**

Income (Rs.)

By sale of 10Kg/day @ Rs. 135 for300 days	:	4,05,000
Total cost	:	2,36,125
Net Income per year	:	**1,68,875**

Economics of Milky mushroom production (10 Kg/day/300 days)
Low cost Investment

Sl. No.	Item	Quantity	Rate (Rs.)	Total (Rs.)
A.	**Capital Investment**			
1.	Thatched House (15'x 20') Blue Poly house- 20'x50' area (1000 sq.ft)	1 1	20,000 60,000	80,000
2.	Chaff cutter (Lever type)	1	2000	2,000
3.	Boiler	1	2,000	2,000
4.	Drum	1	1,000	1,000
5.	Spraying systems	1	1,000	1,000
6.	Biomass store		1,000	1,000
	Total			**87,000**
B.	**Fixed cost**			
1.	Interest on A @ 15 %			13,050
2.	Depreciation (Item 1 @ 10 %)			8,000
3.	Depreciation (Item 2,3,4,5, & 6 @ 10%)			700
	Total			**21,750**
C.	**Recurring Cost**			
1.	Paddy straw cost + transport	3.5 t	7000	24,500
2.	Spawn @ 40 / day	1600	40	64,000
3.	Polythene bags for bed & packing	25Kg	135	3,375
4.	Labour @ 1 per day	300	360/day	1,08,000
5.	Others	--		5,000
	Total			**2,04,875**

Total cost of mushroom production / Year (Rs.)

Working expenditure	:	2,04,875
Total fixed cost	:	21,750
Total Cost	**:**	**2,26,625**

Income (Rs.)

By sale of 10Kg/day @ Rs. 145 for 300 days	:	4,35,000
Total cost	:	2,26,625
Net Income per year	:	**2,08,375**