ISSN–0974–0759 | ●●● Popular Article ●●● |Visit us : *www.researchjournal.co.in*|

Cultivation technology of staple edible mushrooms in Northern plain India

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In India, majority of the farmers are cultivating mushrooms only during particular seasons. Farmers in the plains of North India cultivate white button mushrooms during winter only and stop the mushroom cultivation during summer and dismantle their temporary growing houses. It is also paradoxical to note that India is largely a tropical country and we mainly cultivate temperate mushroom. The tropical and sub-tropical mushrooms like oyster (*Pleurotus* spp.), paddy straw (*Volvariella* sp.), milky (*Calocybe* sp.), reishi (*Ganoderma* sp.), wood ear (*Auricularia* spp.), etc. are not cultivated on a larger scale. To cultivate different types of mushrooms based on different seasons and prevailing climate one should know the requirement of specific temperature and humidity of different edible mushrooms. Since mushrooms contain about 90% water, it is desirable to grow them under a relative humidity of above 85-90%. In north plain region, white button mushroom can be cultivated during winter months of October to February. High temperature tolerant button mushroom can be cultivated from September to April except during peak winter. Black ear mushroom during February to April, oyster from September to May, paddy straw mushroom from July to September and milky mushroom can be cultivated from February to April and July to September. Due to following the round the year cultivation of different edible mushrooms depending on the season, the growers can achieve round the year economic returns, employment opportunities, resource utilization in the farm, continuous nutrition to family members and it can break the chain of epidemic of pests and diseases.The cultivation technology of staple edible mushrooms grown in Northern Plain region of India are given under.

Cultivation of white button mushroom (*Agaricus bisporus*) : In North-East India, white button mushroom can be cultivated from mid-November to mid-March. The optimum temperature for mycelial growth/spawn run/ vegetative growth is 22-25°C and that for fruit body formation/reproductive growth/fructification is 14-18°C. This mushroom also needs a high percentage (80-85%) of relative humidity. The substrate for cultivation of this mushroom is specially prepared compost. Following steps involved in cultivation of white button mushroom.

Preparation of compost/ substratum: Substratum/ compost can be prepared through long or short methods as described in previous exercise. Once the compost and spawns are ready, the containers/poly-bags are to be filled up with the compost leaving about two inches' space from above. After the containers are filled spawning is done.

Spawning: The process of mixing of the spawn in the compost is known as spawning. Spawn is thoroughly mixed in the compost at the rate of 600-750 g per 100 kg of compost (0.6 - 0.75%). The spawned compost is filled in tray or polypropylene bags @ 10-12 kg/ bag and covered with formalin treated newspapers for 12-14 days. In case of bags, they should be folded at the top and covered up. After spawning, temperature and humidity of crop room should be maintained at 18-22^0 C and 85-90%, respectively. Water should be sprayed over the covered newspapers, walls and floors of the crop room.

There are different methods of spawning which are as follows:

Surface spawning: Grain spawn is scattered all over the surface of the compost in trays orracks which is then covered with 2 cm thin layer of compost.

Double layer spawning: Usually done under unfavorable environmental conditions at low temperature. The trays are half filled with compost, spawn is scattered over it, then trays are filled completely with compost and again spawned in the same manner. Finally, a thin layer of compost is spread on the spawn covering it completely.

Through spawning: The desired quantity of spawn is mixed thoroughly in the requiredquantity of compost which is then filled in racks, trays or bags. This type of spawning is done mainly in bag cultivation.

Spot spawning: Trays are filled with compost. Spawning

is done in 1-2 inches' deep holemade in the compost about 4-5 inches apart in rows. A tea spoonful spawn is filled in the holes which are later covered with compost. After spawning, trays or racks are covered with old newspaper sheets and watered lightly with the help of water sprayer. In Polythene bag cultivation, its mouth is tied with the help of thread.

Active spawning: Here in place of grain spawn, fresh compost after complete colonization bymushroom mycelium is used as spawn. In this method spawn run is very quick but care should be taken to avoid use of contaminated compost.

Spawn run : Spawn-run is colonization of compost from the grain Inoculum. The mycelium grows best in the compost at a temperature between 24-25°C and 90-95% RH. The paper over the beds should be sprayed regularly with water to prevent drying out. The floor and walls should also be kept wet to avoid the drying out after evaporation from surface. Carbon dioxide levels upto 0.2% are beneficial and could be achieved by recirculation of air within the crop room. Completion of mycelial run-in compost takes 12-14 days from spawning day. After 12-14 days of spawning, white mycelial growth is seen running the entire length of the tray/bag. This is then covered with casing soil on the surface. The paper or plastic sheeting should be removed from the beds one day before casing.

Casing: Casing helps to retain moisture and help in gaseous exchange. Casing mixture for casing of top of mushroom beds should be prepared as described in previous exercise. After 14 days of spawning, the paper covering the compost surface should be removed and the surface of bed compost is covered with a thin layer (4-5 cm) of soil mixture treated with heat or with 4% formalin. The beds are sprayed with 2% formalin solution just after casing. After casing, the temperature of the mushroom house is maintained at 24-25 °C for another 8-10 days and water is sprayed over casing soil. Within 8-10 days, white mycelium spreads in the casing soil. Thereafter temperature of the mushroom house is lowered down to 18 °C and maintained between 14-18°C during rest of the fruiting period. Whenever required, watering is done with the help of sprayer and RH is maintained at 80-85% throughout the cropping period.

Crop management : As soon as the white cottony growth of the mycelium appears on the casing surface, fresh air should be introduced inside the cropping room and bed temperature lowered to 16-18 °C which is to be maintained throughout the cropping period. The CO_2 level is also lowered to below 1000 ppm. Under such conditions, the initiation of fruiting bodies *i.e.* pinning takes place within 6-7 days of aeration which reaches to the harvesting stage within next 4-5 days. The individual fruit bodies are harvested carefully without disturbing the adjoining pinning and before the cap opens. The cropping period lasts for 40-60 days. Mushrooms appear in flushes provided optimum conditions like bed temperature (16-18º C), relative humidity (80-90 %) by spraying water with misty nozzle, about 4-5 air changes every hour resulting CO_2 level less than 1000 ppm in the cropping room with no light at all, are maintained.The environmental factors like temperature, relative humidity, light, air flow in the cropping room etc.; all play vital roles which together determine the nature of further mushroom development. The mushroom crop grows in cycle called–Flushes or "Breaks". Depending on the species being grown, day intervals with each successive flush bearing fewer mushrooms. These flushes normally appear in 7-10 days.

Harvesting : Timing is the most important factor in button mushroom harvesting. Mushrooms should be picked before the veil breaks and the stem elongates as this may

Table 1: Economic analysis of button mushroom (seasonal cropping)

Sr. No.	Particulars	Approx. cost (Rs.)
A.	Non-recurring expenses	
1.	Crop room (30 x 17 x 9 ft) 3 tier	50000/-
2.	Instruments	
2.1	Spray pump (1 No.)	2000/-
2.2	Thermo-hygrometer (1 No.)	1000/-
2.3	Bucket (1 No.)	400/-
2.4	Balance (1 No.)	600/-
Total cost of non-recurring		54000/-
B.	Recurring expenses (for two crops)	
1.	Compost (10 Ton) @ Rs. 5000/Ton	50000/-
2.	Spawn (100 kg) @ Rs. 90/kg	9000/-
3.	Casing soil (20 Quintal) @ Rs. 50/Q	1000/-
4.	Pesticides insecticides and formalin	2000/-
5.	Disposable polythene sheet/ bags	5000/-
6.	Electricity, fuel, water charges	2000/-
7.	Labor charges (90 days) @ Rs. 200/day	18000/-
8.	Miscellaneous (packaging, marketing etc.)	3000/-
Total cost of non-recurring		90000/-
Grand total (Cost)		144000/-
C.	Return	
1.	Total mushroom production	2000kg
2.	Market rate @ Rs. 180/kg	360000/-
3.	Depreciation @ 33.33% on Rs. 54000/-	17998/-
4.	Interest on Rs. 144000 @10%	14400/-
Net profit: [360000 — (144000+17998+14400)]		183602/-

decrease its quality and market value.Pin head initiation takes place after 10 -12 days of casing and the fruiting bodies of the mushroom can be harvested for around 50-60 days. Damage to pinheads and disturbance of the casing soil must be minimized during picking. The standard harvesting technique consists of grasping the base of the stem, pull it with a twisting motion being careful not to disturb adjacent pinheads. The stem base, with mycelia and casing particles adhered to it, is trimmed with the help of a short-bladed knife. All trimmings should be kept in a plastic bag and removed from the cropping area. Mushrooms growing in clusters should be broken apart and harvested individually. Immature mushrooms should be left attached to the casing for further development.

Yield : Production of 20-25 kg mushroom from 100 kg compost within a period of 8–9 weeks is the best yield. It is depending upon the quality of spawn, compost, casing mixture and prevailing environmental conditions in the mushroom house. The shelf-life of mushrooms is very short and it can be extended to one week by storing at 5°C. When mushrooms stored at high temperature, they become brown in colour and rotten. The harvested mushrooms are cleaned off the compost sticking to them and are packed in perforated polythene bags @ 200 g/ bag. The marketable mushroom must be kept at cool temperature.

Cultivation of oyster/ Dhingri mushroom (*Pleurotus* spp) : Oyster mushroom is popularly known as 'Dhingri' in North India and grows naturally on dead and decaying cellulosic materials. Oyster mushroom can grow at moderate temperature ranging from 20 to 30^{0}C and humidity >80%. In plane regions of North-East India, it can be cultivated from September/October to March/April. Commonly cultivated species of Pleurotus includes *P. sajor-caju*(Fr.) Singer, *P. ostreatus*, *P. florida*, *P. cornucopiae*, *P. eryngii*, *P. flabellatus*, *P. opuntiae*, *P. platypus*, *P. cystidiosus* and *P. columbinus*. Different species are grown under different agro-climatic conditions. Steps involved in cultivation are given under.

Substrate preparation : It is commonly cultivated on wheat or rice straw, due to their easy availability in large quantities. The straw of 4-6cm size is taken and dipped in cold water for 10-12 hours. Straw can be sterilized by various methods as given below:

Hot water treatment: The soaked straw is dipped in hot water at 80°C for 2 hours. Hot water treatment makes hard substrate soft so that growth of the mycelium takes place very easily. This method is not suitable for large scale commercial cultivation.

Steam pasteurization: In this method pre-wetted straw is pasteurized by passing steam through the straw for 2-3 hours. This method is used for commercial cultivation.

Chemical sterilization technique: In this method 7.5g Bavistin and 125 ml formalin are dissolved in 100 liters water and slowly poured on the heap of wheat straw. Soaked straw is covered with a polythene sheet. After about 18 hours the straw is taken out and excess water drained off.

Spawning: The normal rate of spawning in pasteurized substrate is 1.5-2.0 % of the wet substrate, however it is slightly higher (2.0-2.5%) in unpasteurized material. The spawning is usually done in layers or even in thorough spawning care should be taken that the spawn gets uniformly mixed with the substrate, while in layer method the spawn is mixed after each layer of 3-4 cm thickness of straw.

Polythene bags (50X75cm) have been found to be the best and cheap container for Pleurotus cultivation. Before filling the substrate in polythene bags, holes of about 1cm diameter should be made at 10-15 cm distance all over the surface for diffusion of gases and heat generated inside. After filling the substrate in the bags, the mouth of the bag should be tied with thread and kept at 22-26ºC temperature on shelves in a mushroom house for spawn run. R.H. of mushroom house should be maintained between 80-85%.

Cropping and management: Within 15-18 days of filling and spawning, white cottony growth of the mycelium spreads in these bags which can be noticed easily. These bags are cut open and kept in mushroom house on racks, 25-30cm apart from one another or these may also be hanged on nylon ropes keeping some distance between them. Water is sprayed over them in the morning and evening hours to maintain 80-85 % RH in mushroom house and also temperature between 22-26ºC. Pinning starts in next 4-5 days and fruit bodies become fully grown within a week of pinning.

Harvesting: The cropping stage lasts for 30-45 days at 20–25ºC, 85–92 % humidity and less than 600 ppm CO_2. Approximately 4-6 air changes per hour and light 200 Lux/ hour to 12 hours per day are most stimulatory. Regular misting is recommended to prevent cracking of caps and resting primordia. Picking is done by holding the upper portion of the fruiting body and giving it a gentle twist so that it is pulled out without leaving any stub, and also the surrounding fruiting bodies are not disturbed. The lower root portion is removed with the help of a knife.

Yield : The average yield comes around 100-125 kg

Table 2 : Cost and return for oyster mushroom

Sr. No.	Particulars	Approx. cost (Rs.)
Recurring expenses (for two crops)		
1.	Wheat Straw 10 Qtl. @ Rs. 500/Qtl.	5000/-
2.	Spawn 100 Kg @ Rs. 90/kg	9000/-
3.	Chemical treatment (Formalin, Carbendazim etc.)	2000/-
4.	Polythene bags (800) @ Rs. 2/- each	1600/-
5.	Electricity and water	2000/-
6.	Labour charges (40 days) @ Rs. 200/day	8000/-
7.	Miscellaneous (packaging, marketing etc.)	2000/-
Total cost of recurring		**29600/-**
Return		
1.	Total mushroom production	700kg
2.	Market rate @ Rs. 100/kg	70000/-
3.	Interest @ 10% of 29600/-	2960/-
Net profit (for two crops)=70000— (29600+2960)		**37440/-**

mushrooms / 100 kg dry straw or substratum.

Marketing and preservation: The oyster mushrooms are packed in perforated polythene bags in different packings after proper cleaning. These are either sold fresh in the market or stored in a refrigerator (0-5^0 C) / deep freeze for 4-6 days. Canning can also be done for long term storage but it is not recommended as these can easily be dried in the sun or in a mechanical dehydrator and kept for a longer period when packed in air tight packing. For cooking the dried mushrooms, these have to be dipped in lukewarm water for 15-20 minutes. Pickle making is also an easy and economic method of their preservation.

Cultivation of milky mushroom (*Calocybe indica*) :

Calocybe indica is an edible white summer mushroom also known as milky mushroom. It canbe easily grown in the temperature range of 25-35^{0}C. It has moderate protein content and has a good biological efficiency (60 -70%) under optimum conditions. Its sporophores have long shelf life. The major advantage is that it can be best fitted in relay cropping when no other mushroom can be grown at higher temperature. Following steps are required for cultivation of this mushroom.

Substrate preparation: In general, milky mushroom is grown on fresh straw. Fresh straw (paddy / wheat) is chopped and soaked in clean water for 8-16 hours and subsequently soaked in hot water (80-90ºC) for 40 minutes to achieve pasteurization. This method is popular among small growers.Pasteurization/sterilization of substrate can be achieved by any of the following ways.

Hot water treatment: Water is boiled in wide mouth container and chopped wet straw filled in gunny bag is submersed in hot water for 40 minutes at 80-90°C to achieve pasteurization. This is very popular method particularly with small growers.

Steam pasteurization: Wet straw is filled inside insulated room either in perforated shelves or in wooden trays. Steam is released from a boiler and temperature inside substrate is raised to 65°C and maintained for 5-6 hours. Air inside the room should be circulated to have uniform temperature in the substrate.

Steam sterilization: Substrate is filled in polypropylene bags (35x45cm, holding 2-3 kg wet substrate) and sterilized at 15 psi for 1 hour. Once pasteurization/sterilization is over straw is shifted to spawning room for cooling and spawning.

Chemical sterilization technique : As describes in for oyster mushroom can also be used for sterilization of substrate for milky mushroom.

Spawning and spawn running : At the time of spawning moisture content of the substrate should be 62-65 % and a higher spawn dose (4-5%) of wet substrate is used. After spawning, bags are shifted to spawn running room and kept in the dark where temperature of 35ºC and relative humidity above 80 % are maintained. It takes about 15-20 days when the substrate is fully colonized and bags are ready for casing. Bags are shifted to cropping rooms for casing and cropping.

Casing : After spawn run, the top surface of the bags is covered with 2-3 cm thick layer of pasteurized casing mixture. Casing mixture (soil 75% + sand 25%) with its pH adjusted to 7.8-7.9 is pasteurized in an autoclave at 15 p.s.i for one hour or chemically treated with formaldehyde solution (4%) about one week before casing. Casing soil so treated should be covered with polythene sheet for about a week for proper fumigation and to avoid escape of chemical. Casing mixture is spread on the straw surface in uniform layer of 2-3 cm thickness and bed temperature of 30-35ºC and 80-90% relative humidity are maintained.

Cropping : When the temperature of cropping room is maintained at 30-35ºC along with 80-90 % RH and sufficient light during the day time, it results in the initiation of fruit bodies within 3-5 days in the form of needle shape which matures in about a week. Mushrooms with 7-8 cm diameter caps are harvested by twisting which are then cleaned and packed in polythene bags for marketing.

Yield : It is a crop of 40–45 days' cycle and the yield vary from 12-15 Kg per 100 Kg compost. The mushrooms are either sold fresh in the market or canned for long time

Table 3 : Cost and return for milky mushroom

Sr. No.	Particulars	Approx. cost (Rs.)
Recurring expenses (for two crops)		
1.	Wheat straw 10 Qtl. @ Rs. 500/Qtl.	5000/-
2.	Spawn 100 Kg @ Rs. 80/kg	8000/-
3.	Chemical treatment (Formalin, Carbendazim etc.)	2000/-
4.	Polythene bags (1000) @ Rs. 2/- each	2000/-
5.	Electricity and water	2000/-
6.	Labor charges (30 days) @ Rs 200/day	6000/-
7.	Miscellaneous (packaging, marketing etc.)	2000/-
Total cost of recurring		**27000/-**
Return		
1.	Total mushroom production	800kg
2.	Market rate @ Rs. 100/kg	80000/-
	Interest @ 10% of 27000	2700/-
Net profit:[80000 —(27000 + 2700)]		**50300/-**

preservation.

Cultivation of paddy straw mushroom (*Volvariella volvacea*) : The paddy straw mushroom is also known as tropical or warm mushroom. In North-East India, it can be grown from mid-March to mid-September at a wide range of temperature *i.e.* 28-48 °C but the optimum temperature for well growth is 30-35 °C.

Cultivation : Commonly cultivated varieties of paddy straw mushroom are *V. volvacea* (Bull ex Fr.) Singer, *V. diplasia* (Berk and Br.) Singer and *V. esculenta* (Mass) Singer. This mushroom is commonly cultivated on paddy straw in the open as well as inside a mushroom house. Open cultivation method is very common among marginal and small growers

Open air cultivation :

Preparation of beds and spawning : The paddy straw stored after the preceding harvesting season is made into bundles manually. In this method 100X60cm size foundation beds of 15-20 cm height are made with the help of bricks or mud under the shade, to save them from rains or direct sunlight. Paddy straw bundles of 7-8 cm diameter are made by tying them at one end. The length of these bundles is kept between 70-80 cm. These bundles are soaked in water for 16-18 hours in a water tank. For chemical sterilization of the straw, Bavistin 7g and formalin 125 ml can be added in 100 liters of water. After dipping bundles in water, cover the water tank with the polythene sheet. Later, bundles are taken out and excess water allowed to drain off on a cemented floor.

A bamboo frame exactly of the size of the bed on foundation is kept on the floor. Now place four bundles of paddy straw (water soaked) side by side over bamboo frame, keeping tied end in one direction. Place another set of four bundles over it but this time tied end in opposite direction. In this way 8 bundles make the first layer of bundles. Scatter the grain spawn about 8-12cm from the edges of the layer bundles. Spread the spawn along with powdered red gram or gram flour. Wheat bran or rice bran can also be added. Place the second row of the bundles and spawn on it as described earlier. Likewise, third and fourth layer of bundles are also placed and spawned. Finally, the square shaped bed is covered with a transparent polythene sheet and bed temperature of 32 ± 1 °C is maintained. Within 7-8 days' mushroom mycelium permeates the straw completely and at this stage the plastic cover is removed. If the surface of the bed appears to be dry, spray water with the help of water sprayer at least once in a day.

Fruiting and harvesting : Mushroom fruiting occurs nearly 18-20 days after spawning at favorable moisture and temperature conditions. Fruiting continues for another 10-12 days. In paddy straw alone, yield of 12-14 kg /100 kg of wet substrate can be obtained. Harvesting of mushroom is done when volva just breaks and mushroom exposes from inside. In any case mushroom should be harvested before it opens. Paddy straw mushrooms are very delicate in nature and can be stored under refrigerated condition for 2-3 days only. Drying of mushroom can be done under shade or in sunlight.

Indoor cultivation : The principal of indoor cultivation is the same as that of white button mushroom. Therefore, indoor cultivation of paddy straw mushroom is done inside the mushroom house on pasteurized compost.

Substrate : Suitable substrates for paddy straw mushroom cultivation are banana leaves, paddy straw, cotton waste etc. For indoor cultivation, rice straw and cotton wastes in 50:50 ratiosare preferred which gives more consistent yield.

Composting : The composting process involves two phases: Phase-I is an outdoor process while phase-II involves pasteurization and conditioning of the compost.

Phase-I (*Outdoor composting*) : This mushroom requires very little nitrogen for its growth. Paddy straw and cotton wastes when used in 50:50 ratios, will provide 1.4% nitrogen, while some nitrogen is generated by the microorganisms during composting and spawn running processes. The pre-wetted straw and cotton waste are mixed thoroughly and then piled up. Pile raised is narrow with a height of 1.5cm. After 2 days, first turning is given to this pile. During this turning, rice bran @ 50% (w/w

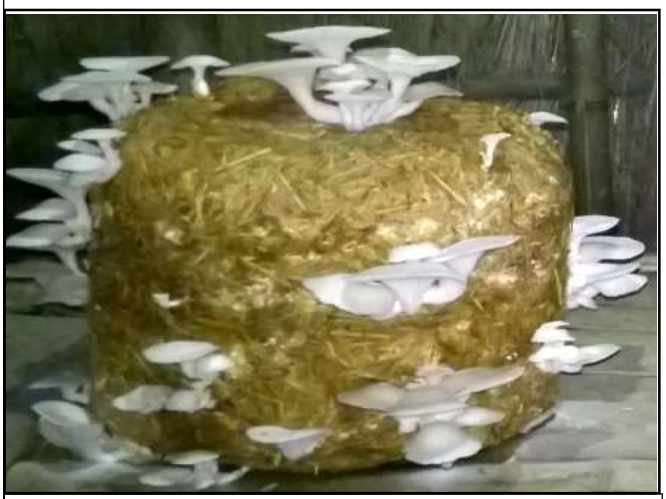
basis) is added. Watering is done if required. Remake the pile and leave it for another 2-3 days and only then the compost becomes ready for phase II.

Phase-II (*Indoor composting*) : After Phase-I, compost is taken inside the mushroom house, placed on the shelves and preheated at 40-45 ºC. Now steam is introduced in the mushroom house for 2-3 hours so as to raise the temperature of the house to 60-65 ºC. This temperature is maintained for another 2-3 hours. The steam supply is then cut off and fresh air given. In next 8 hours' temperature of the mushroom house goes to 50-52 ºC, which is maintained for another 12 hours or till the smell of ammonia persists in the compost. This process is completed in 4-5 days.

Spawning and cropping : When treated beds do not have the smell of ammonia and temperature of the compost cools down to 34-38 ºC, spawning is done @ 2% of the compost (w/w). After spawning, doors of the mushroom house are closed for 3-4 days. Temperature during this period remains between 34-38 ºC (but should not be less than 30 ºC). R.H is to be maintained between 80-85 % by spraying water daily. Little aeration is also provided. Within 4-5 days, mushroom mycelium spreads in the compost. Then temperature of the mushroom house is lowered to 28-30 ºC by opening ventilators. If bed surface appears dry, water is again sprayed. During next 2-3 days, doors are kept open to allow some light. This condition is maintained till sufficient amount of fruit bodies are formed. When primordia formation is completed, air of the room is circulated for at least 5 minutes for 5-6 times a day. Bed temperature is kept below 32 ºC and RH between 85-90%. In next 4-5 days' mushrooms become large

Agaricus bisporus

Calocybe indica



Calocybe indica

Volvariella volvacea

Table 4 : Cost and return for paddy straw mushroom

Sr. No.	Particulars	Approx. cost (Rs.)
A.	**Recurring expenses (for two crops)**	
1.	Paddy straw 10 Qtl. @ Rs. 80/Qtl.	800/-
2.	Spawn 15 Kg @ Rs. 80/kg	1200/-
3.	Chemical treatment (Formalin, Carbendazim etc.)	800/-
5.	Electricity and water	500/-
6.	Labor charges	3000/-
7.	Miscellaneous (packaging, marketing etc.)	800/-
Total cost of recurring		**7100/-**
A.	**Return**	
1.	Total mushroom production (15% on dry weight basis)	150kg
2.	Market rate @ Rs 100/kg	15000/-
	Interest @ 10% of 7100/-	710/-
Net profit	[15000 — (7100 + 710)]	**7190/-**

enough for harvesting.

Harvesting : Fruit bodies are harvested when they become mature and before the cap opens completely, mainly in its egg form. The fruit bodies have got very low keeping quality and hence consumed immediately or they can be canned or dried and packed in sealed polythene bags so that these may be kept for a longer period. Cropping cycle lasts for 7 – 12 days in two flushes

Yield and marketing : Yield varies from 22-28 kg to 25 – 45 kg per 100 kg straw. Due to very low keeping quality, these mushrooms cannot be stored even in the refrigerator for more than 15-24 hours. Generally, mushrooms are sold fresh or in canned form but rarely in dried form in the market.

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Received : *28.03.2022* ***Revised :*** *25.04.2022* ***Accepted :*** *02.05.2022*