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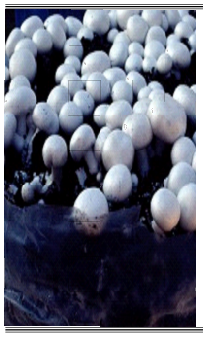

Button mushroom (*Agaricus bisporus*): composting and cultivation technology

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In plain India, the favourable season for cultivation of button mushroom is October to March. The temperature and humidity required for cultivation of this mushroom is 14-22^{0}C and 80-85 per cent, respectively. The substrate for cultivation of this mushroom is specially prepared compost. In general, four steps *viz.,* preparation of compost, spawning of compost, casing and cropping/ crop management involves in cultivation of button mushroom. The details of major steps involved in production of button mushroom are given under.

Preparation of compost: The substrate for mushroom called compost and it is prepared from agro wastes like straw, stem, shoot, apices etc. with organic manure. Mushroom substrate may be simply defined as a lingo-cellulosic material that supports the growth, development and fruiting of mushroom mycelium. This compost is pasteurized by various micro-organisms and at appropriate temperature range. Essential supplements are also added/ supplemented to the compost. The whole process is termed as composting. Generally composting refers to the piling of substrates for a certain period of time and the changes due to the activities of various micro-organisms, which result in a composted substrate that is chemically and physically different from the starting material. The compost provides nutrients, minerals, vitamins and ions required for proper growth of mushroom. This compost supports the growth of only the mycelium of button mushroom and prevents that of other competitive moulds.

Methodology for compost preparation: Compost is an artificially prepared growth medium from which mushroom is able to derive important nutrients required for growth and fructification. Cemented floors are required for making good quality compost. There are two main methods for compost preparation:

Long method of composting: This is an outdoor process and takes around 28 days in its completion with a total of seven turnings. This method is particularly suitable for both small scale and medium scale growers. The following materials are required for long method of compost:

Before making compost, wheat straw is spread on cemented floor and is turned many times with water being spread at regular intervals, with the help of pitchforks.

Table 1: Ingredients for preparation of compost for button mushroom

Sr. No.	Ingredients	Quantity
1.	Wheat straw	300 kg
2.	Wheat bran	15 kg
3.	Calcium ammonium nitrate	9 kg
4.	Super phosphate	3 kg
5.	Muriate of potash	3 kg
6.	Urea	3 kg
7.	Gypsum	30 kg
8.	Furadan	150 g

Day 0: At the stage, there should be around 75 per cent humidity content in the wheat straw, to which wheat bran, calcium ammonium nitrate, urea, muriate of potash and super phosphate are mixed thoroughly and evenly. Thereafter, a stack (pile) of 1.5x 1.5x 1.5m (LXWXD) is prepared with the help of 4 wooden boards. Keeping the width and height of the stack unchanged, the length can be increased depending on the quantity of straw taken. The boards should be removed from the sides of stack as

Fig. 1: Compost stack

soon as it is ready. Water is sprayed twice or thrice to keep the substrate moist. The loss of nutrients due to leaching must be avoided and the run-off water, if any, should be mixed in the straw. The temperature of stack (pile) rises to 68-75ºC in the inner layers within 48 hrs after stacking. The microbial (thermophiles) activity during decomposition is more in these hot layers as long as a fresh air (O_2) is available. To achieve this, turning of the stack should be carried out, which means an outer portion of the stack is exchanged with inner portions. The purpose of turning is that every portion of the pile should get equal amount of aeration and water.

There are 7 turnings required to get final grade compost.

1st turning Day 6: On the sixth day first turning is given to the stack.

2nd turning (*Day 10*): On the tenth day, again the top most part and the inner part of the compost is separated, water is sprayed on the top part. Again the two parts are piled up together in such a way that now the top part is inside and the inner part is on the top of the stack.

3rd turning (*day 13*): Same way as described earlier. Gypsum is mixed at this stage.

4th turning (*day 16*): The same process of turning is followed.

5th turning (*day 19*): The compost is turned in the same manner and Furadan is added dry.

6th turning (*day 22*): The same process of turning is followed.

7th turning (*day 25*): if no ammonia persists in the compost, spawning is done.

Short method of composting: The method is particularly suitable for commercial mushroom growing. It needs insulated pasteurization chambers with a provision of steam heating and air circulation. The compost prepared by this method is superior to that of the long method firstly because it gives higher productivity of mushroom crop and secondly the risk of mushroom diseases, competitors and nematodes is greatly reduced.

Table 2 : Ingredients for preparation of compost for button mushroom

Sr. No.	Ingredients	Quantity
1.	Wheat straw	1000 kg
2.	Chicken manure	600 kg
3.	Urea	15 kg
4.	Wheat bran	60 kg
5.	Gypsum	50 kg

This method is accomplished in two phases:

Phase I- Outdoor composting: It involves 3-4 turnings of straw-fertilizers mixture spread over 9-12 days. Wheat straw mixed with chicken manure is sprayed with water and a 45cm high pile is made on the fourth day and first turning is made. On 7th day, wheat bran, gypsum and urea is mixed thoroughly and piled upto 1.25-1.50 m height with a width ranging from 1.25 -1.5 m. The internal temperature of the compost should be maintained at 70-75^{0}C within 24hr. Second turning is done on this day whereas third turning is done on 8th day with subsequent mixing of gypsum. On the 10th day, the compost is transferred to the pasteurization tunnel. Compost is filled in the pasteurization tunnel to a height of 7 feet. Filling height depends upon the size of the tunnel.

Phase II- Indoor composting: This is the pasteurization procedure which is done in a closed environment. Pasteurization is done for many purposes:

– If the temperature during composting has been low and the compost is heterogeneous, many parasites (nematodes, pathogens, flies and mites etc.) will survive in the compost mass, therefore, pasteurization is the best means with which these parasites can be destroyed.

– To end fermentation and to convert compost into a chemical and biological state favourable to the development of the mycelium and unfavourable to moulds.

– Conversion of ammonia into microbial protein.

Compost is filled in the pasteurization tunnel and as soon as the compost in the tunnel is completely filled the doors and fresh air damper are properly closed and blower is put on for recirculation of air @ 150-250 cubic meter/ 1000 kg compost/ hour. The phase II process is completed in three stages:

Pre-peak heat stage: After about 12-15 hours of compost filling, the temperature of compost starts rising and once 48-50^{0}C is obtained, it should be maintained for 36-40 hours with ventilation system. Normally such temperature is achieved by self-generation of heat by the compost mass without steam injection.

Peak heat stage: Raise the temperature of compost to 57-58 ^{0}C by self-generation of heat from microbial activity if it is not obtained. Injecting the live steam in the bulk chamber and maintain for 8 hours in order to ensure effective pasteurization. Fresh air introduced by opening of the fresh air damper to 1/6 or 1/4 of its capacity and air outlet too is opened to the same extent.

Post- peak heat stage: Lower down the temperature gradually to 48-52^{0}C and maintain till no traces of ammonia are detected in compost. This may take 3-4 days in a

balanced formulation. When the compost is free from ammonia, full fresh air is introduced by opening the damper to its maximum capacity and cool down the compost to around 25^{0}C which is considered as the favourable temperature for spawning. Compost when ready for spawning should possess the following characteristics:

– Compost should be dark brown in colour with profuse fire fangs.

– Compost should have moisture percentage of about 68-70 per cent.

– pH of the compost should be in the range of 7.2-7.8.

– There should not be any smell of ammonia (< 0.006%).

– It should not be sticky or greasy.

– It should be free from insects and nematodes.

– The compost straw should have amorphous texture

– N content should be 1.5-2.5 per cent

Cultivation technology:

Requirements (*facilities and equipment*) : The main facilities in terms of space are the compost making area and the mushroom growing room. Compost making area includes compost Ingredients storage area, mixing area, composting area, compost sterilization area and area for storing sterilized compost. The mushroom growing room is any room where the temperature, humidity and light can be controlled. The house should be free from incoming rain water (leak proof) and with proper drainage in case the room is washed and cleaned. The equipment for the mushroom growing room are: trays/ shelves or beds/ bags, weighing balance, thermometer, humidity meter, buckets, baskets, scissors, knives, forceps for picking mushroom, sprayer for spraying water, formalin, pesticides, plastic bag for storing mushrooms, bag sealer, shelves for storing, spawns, records and accounts.

Cultivation process involves four major steps:

– Preparation of compost/ substratum
– Spawning
– Spawn run
– Casing (Covering the spawned compost)
– Crop management
– Harvesting
– Yield

Fig. 2 : White button mushroom

Preparation of compost/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. 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 per cent, 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 or racks 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 required quantity 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 hole made 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 by mushroom 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 per cent 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 per cent 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 mixture, treatment and application:

Casing mixture: Covering the top of mushroom beds after completion of spawn run with a layer of pasteurized mixture is known as casing. The significance of casing mixture is to maintain the moisture content and exchange of gases within the surface of the compost which helps in the proper growth of the mycelium. The pH of the casing mixture should be 7.5-7.8 and must be free from any infection or disease. In our country casing mixture is prepared from the following ingredients.

Table 3 : Formulae for preparation of casing soil mixture

Ingredients	Ratio
Two years old FYM + garden soil	3:1
Two year old FYM + garden soil	2:1
Two year old FYM + spent compost	2:1
Loam soil + Sand	4:1
Two years old FYM + loam soil	1:1
Two years old spent compost + sand + lime	4:1:1
Two years old spent compost+ loam soil + FYM	2:1:1
Two- three years old spent compost + FYM	1:1

Casing of mushroom beds or spawn run compost is necessary because:

– Casing soil is a nutrient deficient medium, which helps in converting the vegetative phase into fruiting.

– Fruit bodies are formed in abundance and thus, production is economical.

– It helps in conserving the environment in mushroom beds.

– The casing medium harbours some beneficial bacteria and activated charcoal like material which help in initiation of fruiting bodies on the casing surface. Casing mixture also helps in conserving moisture in the beds and gives support to the fruiting bodies.

Characteristics of a good casing:

– Good water holding capacity and more pore space percentage.

– Capable to release harmful gases during cropping.

– Free from harmful microorganisms.

– pH should be slightly alkaline.

– Should be properly decomposed.

– Free from heavy metals and ions.

Treatment of casing mixture: The casing mixture is treated either through chemicals or pasteurized with steam for killing of various pests and disease propagules present in the mixture.

Chemical treatment of casing mixture: Casing can be disinfected with formaldehyde treatment. The formaldehyde solution is prepared by mixing 2 litre of formalin (40% a.i.) in 40 litres of water to obtain 2 per cent solution. Casing mixture, made up into a rectangular pile, is drenched thoroughly with this solution and then covered with a polythene sheet. The treatment should be given at least 2 weeks before casing is to be done. In other words, casing should be prepared and treated immediately after compost has been spawned. In other method, the casing soil is piled on cemented floor and is treated with 4 per cent formalin solution followed by thorough turning of the soil is done and it is covered with polythene sheet for the next 3-4 days. It should be ensured that casing mixture should not have traces of formalin when applied on the beds.

Pasteurization of casing mixture: In farms where facilities for pasteurization of compost with steam are available, casing can also be pasteurized. For pasteurization of casing mixture, casing soil is filled in trays and trays in turn are stacked in the pasteurization room. Steam is introduced to bring the temperature of casing mixture to 65-70°C and which is maintained for 6-8 hours. All the harmful micro-organisms, including mushroom nematodes are killed at this temperature. Useful bacteria like Pseudomonas which play a positive role in introduction of fruit bodies are not killed and survive at this temperature for 7-8 hours. Casing soil pasteurized in this manner gives best result.

Application of casing: When spawn run is completed, the casing is done over spawn run compost after removing newspaper sheet from the trays on racks or after opening mouth of the poly bags. Spawn run compost is slightly pressed and covered on the surface with 4-5 cm thick layer of casing soil. 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 per cent 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 pinnings 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 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

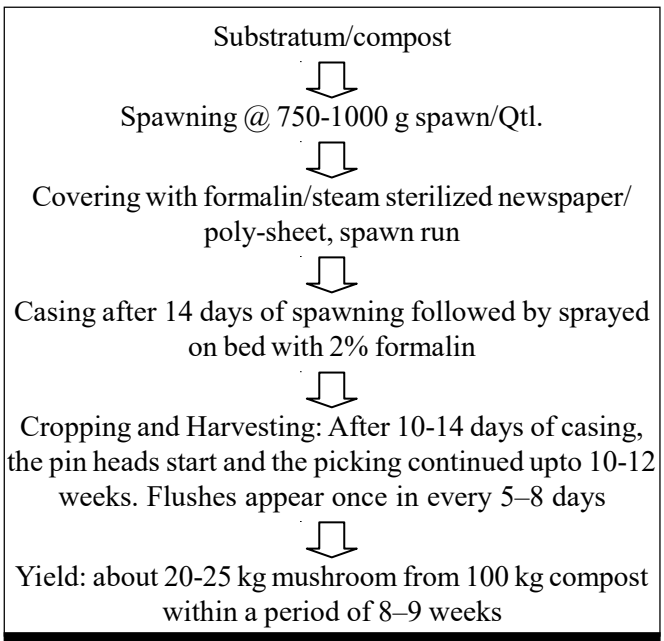

Fig. 3 : Flow chart for cultivation of white button mushroom

Table 4 : Economic analysis of button mushroom (seasonal cropping)

Sr. No.	Particulars	Approx. Cost (Rs.)
Non-recurring expenses		
1.	Crop room (30 x 17 x 9 ft) 3 tier	50000/-
Instruments		
1.	Spray pump (1 No.)	2000/-
2.	Thermo-hygrometer (1 No.)	1000/-
3.	Bucket (1 No.)	400/-
4.	Balance (1 No.)	600/-
Total cost of non-recurring		54000/-
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/-
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/-

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.

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Received : *28.09.2020* ***Revised :*** *13.11.2020* ***Accepted :*** *20.11.2020*