Mushroom Biology and Mushroom Products, Royse (ed.) © 1996 Penn State Univ. ISBN 1-883956-01-3

Composting for *Agaricus* — Recent Developments and Present Position in India

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ABSTRACT: Compost for cultivation of the white button mushroom *Agaricus bisporus* is prepared in several ways in India for making it selective for growth of mushroom mycelium. The seasonal/small growers prepare compost from cereal straws in a single prolonged phase without pasteurization and obtain mushroom yields of 80 to 100 kg per ton of compost in 6 to 8 weeks of cropping. The growers in the organised sector for commerce prepare their compost by the traditional short method of composting in two phases, Phase I devoted to pre-wetting/outdoor composting and Phase II for pasteurization/conditioning. Most of the growers prepare compost in bulk chambers but some do it in peak heating chambers. They obtain a yield of 160 to 180 kg of mushrooms per ton of compost in 6 weeks of cropping. Some units have discarded the use of bulk chambers/turning machines and have successfully shifted to innovated indoor composting where Phase I is done in open door bulk chambers and peak heating in cropping rooms. This has resulted in revolutionary increase in mushroom yields to 200 to 220 kg of mushrooms per ton of compost.

1 INTRODUCTION

The white button mushroom, *Agaricus bisporus*, is the most widely grown mushroom for commerce in India. The bulk of production (about 70%) comes from commercial units and the rest from seasonal growers. India produced 30 thousand tons of mushrooms in the year 1995 (estimate based on production of the big units, seasonal growers and spawn consumption). Compost is mostly prepared from the base materials wheat/paddy straw supplemented with animal manures (mostly poultry manure). The science of mushroom cultivation is still new to the common farmer in India and tremendous effort by the Indian Council of Agricultural Research and Agricultural Universities has helped to popularize the art of mushroom cultivation throughout India. Presently, the mushroom research and development effort is conducted in almost all states of the Indian Union with great enthusiasm, resulting in an increase in mushroom production by 4 to 5 times in the last 5 years. Today India is exporting a large quantity of processed cultivated mushrooms and has replaced Taiwan in export of processed mushrooms to the USA (Aclin 1995).

The art of compost making for mushroom cultivation is as old as mushroom growing itself. Earlier efforts to prepare mushroom compost in 30 to 40 days of time were, more or less, based on empirical observations and growers would obtain a crop of mushrooms but with poor yields. It is only during the middle of 20th century that a breakthrough was achieved in compost making by Sinden and Hauser (1950, 1953). They demonstrated the role of aerobic fermentation of the cereal straws/animal manures in a sequential manner done in Phase I and Phase II (controlled fermentation) which resulted in the preparation of selective compost for mushroom growth. This was termed the short method of composting, wherein the period of composting was shortened from 30 days to 18 to 20 days. Presently, this method of compost making is used by majority of growers all over the world for mushroom compost making with mushroom yields varying from 160 to 220 kg per ton of compost in 4 to 6 weeks of cropping. With improvement in crop management, crop agronomy and use of tailored germplasm (mushroom strains), growers are able to harvest very high yields of mushrooms over a shorter period of time in 3 to 4 flushes.

Since composting is not considered environmentally friendly because the process emits gases which cause damage to the environment and the earth's ozone layer, efforts were focused on developing indoor composting systems wherein the gases could be released into the environment after being rendered harmless. Research in this direction was initiated in Italy, France, Netherlands and Australia (Laborde *et al.* 1994) in a big way and indoor composting by now has become an established way of compost preparation for mushroom cultivation. This method of composting, besides being environmentally friendly, also results in higher mushroom yields because of reduced shrinkage of the bulk during composting. The requirement of reduced space for outdoor composting is another big advantage of indoor composting, with elimination of turning machines used for Phase I in the short method of composting. These innovations have become the need of the hour in the present day world and work is still in progress in various countries to adopt this system of composting with minor modifications suiting local conditions. In India, some commercial units have started preparing mushroom compost by this system with greater profits, though it is not very popular with majority of commercial growers in India.

2 COMPOSTING METHODS

Mushroom compost is prepared in 3 different ways by the growers in India. These are: (1) long method of composting without pasteurization, (2) short method of composting done in Phase I and Phase II, and (3) indoor composting where both Phase I and Phase II are done indoors.

2.1 *Long method of composting without pasteurization*

Even though this method of compost preparation for mushroom growing is the oldest method in India, it still is in use with most of the seasonal growers throughout the country. The chief reason for its popularity is that this method does not require heavy capital investment and the composting materials are subjected by aerobic fermentation outdoors with periodic turnings till the compost is selective enough for mushroom mycelium. The compost thus prepared is not enriched/free from harmful microbes and will contain lower nitrogen content (1.5 to 1.6%), resulting in poor mushroom yields (Dhar 1993).

This method of composting is simple and can be accomplished by a grower with minimum facilities. The composting ingredients are watered on an open platform overnight with stacking done the next day. The stack is allowed to stay undisturbed for 3 to 4 days till the temperature inside the stack reaches 75 to 80 C. At this stage the first turn is made and subsequent turns are made after every 2 to 3 days depending upon heating of the stack. Gypsum is added on 3rd turn and the compost is ready for spawning in 28 to 30 days. It is the experience of the grower that determines the quality of the compost prepared. Compost prepared by the above method has a reduced bulk as compared to other methods of composting. From a ton of dry base material, we obtain 1.5 to 1.6 tons of compost after 28 to 30 days of composting. It was a practice earlier to use horse dung and poultry manure for composting by this method, but due to increased problems of competitor moulds, pathogenic fungi and insect pests/nematode during cropping, the use of animal manures is declining. The areas around Delhi (North Western plains of India) are the concentrated pockets where intensive mushroom growing is done in the winter season and the majority of growers prepare compost by this method. With more and more villages adopting mushroom growing in winter months, molds (especially yellow mold caused by species of *Sepedonium* and *Myceliophthora*) have caused a problem in obtaining a healthy crop of mushrooms. In certain areas, mushroom growing has been threatened to an extent that scores of farmers have stopped growing mushrooms in winter months. Many of the seasonal growers in these areas are now building low cost bulk chambers for pasteurization of the compost to overcome the problem of yellow molds. The growers are able to harvest 80 to 100 kg of mushrooms on average from a ton of compost in 6 to 8 weeks of cropping and some seasonal growers harvest as high as 15 to 16 kg from a ton of compost in 10 to 12 weeks of cropping. The quality of mushrooms produced are not as good as obtained from environmentally controlled cropping rooms. About 15 to 20% of our production comes from seasonal growers and almost the entire product is sold fresh locally in the Delhi market.

2.2 *Short method of composting*

This method of composting was introduced in India in the late 70's at Solan. The compost is prepared in two phases, Phase I and Phase II. Phase I is principally done outdoors in 2 parts, pre-wetting and outdoor composting. The pre-wetting takes 6 to 7 days where the ingredients are wetted, mixed and well blended. During pre-wetting, enough water is added to soak the base materials, enabling the individual straw cells to imbibe enough moisture for the microbes to later degrade the cell contents.

The materials are turned 2 to 3 times during pre-wetting and small heaps of 4' high are prepared during pre-wet. The leached materials run-off into the guddy pit, and are pumped back onto the compost ingredients during the pre-wet turnings.

Compost ingredients are brought to 75% moisture content during pre-wetting with production of some heat (45 to 50C). The stack is prepared on completion of pre-wet and the composting ingredients are made into a rectangular stack of 6' height and 6' width, using stacking boards. The stack is erected on a perforated pipe provided for aeration of the stack during Phase I composting. Air is blown into the stack periodically to replenish oxygen in the compost pile. The stack is turned after every 2 days when the stack temperature reaches 75 to 80C in the middle. Gypsum is added on the 3rd turn when ammonia is at its maximum. The turns are either completed by machines or manually. Both systems have given satisfactory results. Filling lines are useful as filling is done quickly and loosely inside the chamber. The composting ingredients are filled for Phase II on day 7 or day 8 (one or two days after 3rd turning). The material is filled inside the bulk chamber to a height of 2 m (6 to 7 feet) with a filling machine or manually. The chamber door is closed and the blower fan switched on. The temperature inside the chamber is stabilized (air/compost temperature brought to uniformity) by use of a blower for 8 to 12 hours, depending upon the quality of compost filled and condition of the Phase I compost. During stabilization, the vents are kept open. On stabilizing the air/compost temperature to 45 to 50C inside the chamber

(plenum air, compost and air above), steam is introduced into the chamber and the vents closed. The temperature starts rising steadily and on reaching an air temperature of 57 to 58C, the steam is cut off with the blower running round the clock. The temperature in air/compost is recorded every 30 minutes. The compost material is maintained at this temperature for 6 to 8 hours for pasteurization. After pasteurization, ventilation is increased by 20% of the air circulating capacity through filtered air entry point to bring in oxygen, which is vitally required by the thermophilic microflora inside the compost ingredients. This results in a fall of temperature inside (both air/compost temperature) to around 50C (48 to 53C), which is the temperature required by the thermophiles to multiply in the compost. This conditioning process takes another 4 to 5 days until the ammonia is eliminated. Ammonia is checked by smelling (experience) or by use of a Dragger tube. Ammonia levels higher than 3 ppm is not permissible in the compost.

Phase II of pasteurization/conditioning is also accomplished in peak heating rooms (growing room/peak heating room) by filling the green compost into the shelves in the peak heating room and introducing steam for pasteurization and conditioning. The experience in India shows that a single zone system of pasteurization in peak heating rooms is more suited to conditions in tropical India than in temperate Europe. But bulk chambers are equally efficient if the operations are totally mechanized. The grower pays a heavy price by doing emptying manually for reasons of hygiene.

The compost prepared by this method yields 160 to 180 kg of mushrooms per ton of compost on the average, but yields as high as 200 kg per ton of compost have also been obtained in 4 to 6 weeks of cropping in 4 to 5 flushes. Mushrooms grown from this compost are far superior in quality than that grown under seasonal growing conditions. Most of the commercial growing units established for export produce their compost by the above method very successfully, with effective monitoring of composting done by use of computers or monitoring equipment. Some of the commercial growing units have switched over to use of sugarcane bagasse as a base material in place of wheat straw for composting with success. This has resulted in reduced cost of composting ingredients as sugarcane bagasse sells for less in India as compared to wheat straw.

2.3 *Indoor composting*

This method of composting is done indoors entirely. This enables the growers to monitor and control the entire composting process and prevent the emission of noxious gases into the environment. The pre-wetting, mixing and blending are done with machines/manually for 5 to 6 days as in the traditional short method of composting. The composting ingredients, instead of stacking into a Phase I compost pile, are filled into the specially built Phase I chamber with a perforated floor built over the plenum. The air is forced into the composting material for 2 to 3 minutes every hour to replenish the depleted quantity of oxygen inside the compost. This facilitates development of healthy aerobic fermentation microbial populations inside the compost and the anaerobic zones are more or less eliminated. The composting ingredients are moved out of the chamber after every 2 days and refilled into the chamber. This also helps in wetting the dry areas of the compost and facilitates closer monitoring of composting process. The above process can also be done with machines but labour is employed in India for this work. The compost stays in the chamber for 5 to 6 days for Phase I of composting after which the compost is filled onto shelves in the peak heating room/growing room, where Phase II of composting is accomplished. The temperature during indoor Phase I reaches 75 to 80C, with an abrupt rise near the walls and slowly the whole mass reaches a uniform temperature with rich ammonia production. During Phase II, the air temperature in the peak-heat room is raised to 57 to 58C and maintained at this level for an 8-hour pasteurization of the compost. This is followed by conditioning of the compost at 48 to 53C for 4 to 5 days with opening of ventilation to 20% of the circulation capacity of the room. The compost, thus prepared, is fully enriched and supports an excellent spawn run. Growers using this method are able to harvest 200 to 220 kg of mushrooms in 6 weeks of cropping. This method of composting seems to be superior in the sense that a good quality compost is produced in lesser number of days without the use of an outdoor composting yard.

The Phase I chamber is an ordinary chamber with both ends open. On one end of the chamber, the blower fan is installed which forces the air into the composting materials through perforated floor covering the plenum. The other end of the chamber is open and is used for filling/emptying of compost ingredients. The compost is filed into the Phase I chamber to a height of 4 feet. The moisture content of the compost is maintained at about 75% throughout the composting process, Phase I and Phase II. The total compost N content at spawning is 2.3 to 2.4%. The compost prepared by this method has so far provided excellent mushroom yields.

3 DISCUSSION

The concept of low technology-low output and high technology-high output seem to be maintaining a balance as far as profits are concerned. Low technology means growing mushrooms without any heavy capital investment and preparation of compost by the long method in a single phase. This gives the small grower half the mushroom yield per ton of compost obtained by the other two methods. The lower output matches the lower investment by a grower. The commercial growers get a higher return in the hot season and face tough competition from seasonal growers in winter months. This results in reduced profit margins for the commercial growers, but the increased mushroom yields obtained per ton of compost by the short and indoor composting methods amply compensate for lower returns per kg of mushrooms.

The traditional short method of composting in bulk chambers has yielded consistent results when operations are mechanised. But the results are inconsistent if the filling/emptying is done manually. The reason is that manual filling is not uniform and manual emptying contaminates compost during bag filling and transportation.

Indoor composting results have so far been consistent and this method of composting has resulted in production of superior compost which yields increased mushroom yields, besides being environmentally friendly. The gases on emission can be rendered harmless if bio/chemical filters are used at exit points in Phase I chambers. This is not being done in India, nor did I observe the use of these filters in UK on commercial farms.

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