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Compost Preparation method for White Button Mushroom (*Agaricus bisporus*)

Agaricus bisporus, the white button mushroom is the most popular mushroom in the world and contributes around thirty per cent of world production of mushrooms. It is cultivated on a specially prepared substrate known as compost, which is a product of fermentation by a number of thermophilic organisms that decompose plant residues and other organic and inorganic matters. The main purpose of composting is to release the nutrients in the straw and supplements and to transform them in such a way that they are suitable for the nutrition of mushroom. During composting various chemical and biological processes help in achieving this. The nitrogen available in the ingredients is converted into proteins of the microorganisms and further a lignin humus complex is also formed during composting both of which later on are utilized by the mushroom mycelium as food. Compost if properly prepared is very selective in nature and only *A. bisporus* mycelium can grow successfully on it at the practical exclusion of other competing organisms. Cultivation of this mushroom first originated in France around 1650, where melon growers observed spontaneous appearance of *A. bisporus* on used melon crop compost. Since then, tremendous advancement has taken place in the cultivation technology of this mushroom particularly in the composting field. Today in our country white button mushroom is cultivated on the compost prepared by a traditional method known as long method of composting, on short method of compost or on compost prepared by an accelerated method also known as rapid composting method (Indoor compost).

A. Long Method of Composting (LMC)

Preparation of compost by such method is very old concept and has been abandoned in most parts of the world excepting in few countries in Asia. Compost prepared by such method besides taking

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more time (around one month) gives low yield, as it is prone to attack by many pests and diseases. Yields obtained using such compost range between 10-15 kg of mushrooms per 100 kg of compost. However, higher yields to the tune of 18-22 kg have also been reported by some seasonal growers who take single crop in the entire season.

Compost by this method is prepared on clean cemented platform. If such facility is not available then a simple brick platform can be used. Most of the growers who of compost at start of composting occupies around one square meter of space. Besides composting yard, provision should also be there to store the base materials. In general, around 4000 litres of water are required per ton of raw material for its proper wetting. The ingredients of compost are straw, wheat bran, urea, etc. Any of the region-specific synthetic formulation without chicken manure can be tried for compost production. Details of the formulation are given in the chapter 6 of this book. It is further mentioned that compost production should not be attempted with less than 300 kg of base materials, as required temperature may not be attained in piles made with lesser quantities. Composting yard are cultivating this mushroom seasonally do not have any of the above two facilities and are producing the compost in open fields. Composting yard should preferably be covered by G.I. or asbestos roofing. If such facilities do not exist then provision should be there to cover the heap during rains. For a medium size farm producing around 20 tons of compost in one operation, a platform of size 60’x40' (18 m x 12 m) is sufficient enough. As a thumb rule 1.5 tons of compost at start of composting occupies around one square meter of space. Besides composting yard, provision should also be there to store the base materials. In general, around 4000 litres of water is required per ton of raw material for its proper wetting. The ingredients of compost are straw, wheat bran, urea, etc. Any of the region-specific synthetic formulation without chicken manure can be tried for compost production. Details of the formulation are given in the chapter 6 of this book. It is further mentioned that compost production should not be attempted with less than 300 kg of base materials, as required temperature may not be attained in piles made with lesser quantities.

Requirement of base materials should also be judiciously worked out. In general, one ton of raw material would yield around 1.75 to 2 tons of finally prepared compost having the required moisture level. When the compost is prepared with manual labours, use of a set of 3 wooden or iron boards (2 sides boards-180 x 150 cm; 1 end board-140 cm x 180 cm) is still in use.

1. Method

First important step in the production of compost is to thoroughly clean the area, spray 2% formaldehyde solution so that unwanted organisms are killed. On the following day, wheat straw or any other recommended base material is spread on the platform. Wheat straw is very hard material

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and does not absorb water quickly, since it is coated with wax. This wax layer however, gets removed by the heat produced during composting or due to the physical actions like shredding, trampling, etc. and then, water is able to reach the inner portion of the straw easily. Water is sprinkled over the straw with a pipeline and straw is frequently turned till it absorbs sufficient moisture. Excess water escaping during wetting is collected in a goody pit and is recycled and used again for wetting the straw. Wetting of the straw may continue upto 24-48 hours till it attains 75% moisture. There should not be excessive wetting of the straw, as excess water fills the pores during composting resulting in anaerobic conditions in the pile, which is not a desirable trait of composting. On the contrary, if the moisture is too less in the compost pile plenty of oxygen is available to the microorganisms but desired high temperature is not attained in the pile, which is again not a desirable trait for their growth. When the straw is fully wetted it is collected as a low heap on one side of the yard. Other composting ingredients viz., chicken manure, wheat bran and other fertilizers excepting gypsum and insecticides are mixed, sprinkled with water and covered with a polythene sheet or wet gunny bags. Both wetted straw and these ingredients are kept as such for 24 hours. The day when wetting of these materials is completed is counted as -1 day and the day when the two are mixed is treated as 0 day.

a. Day-0

On this day two lots of the ingredients (straw + other additives) are properly mixed. The main aim of mixing the ingredients is to obtain a homogeneous product. The mixed ingredients are then made into a high aerobic pile with the help of boards (mould). Turning the pile described earlier. While making the pile, materials are slightly pressed from the sides and kept loose in the centre. When the mould is completely filled, the sideboards are moved, lengthwise and again the space is filled with the ingredients. This process is repeated till a compost pile is formed with all the materials. Else the compost piles can also be made without these boards. Dimensions of the pile are important and depend upon the prevailing outside temperature. In the hills, where temperature may range between 7-20°C width of the stack should be kept between 130-150 cm and height of about 150cm, otherwise due to greater difference in temperature of compost and atmosphere proper temperature may not be attained inside the heap which may result in unproductive compost. In plains where the temperature is higher, slightly smaller heaps (100-120 cm width and around same height) are recommended since there is not much difference in temperature outside and inside the compost and hence less natural aeration.

b. Day 1-5

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Pile is kept as such for 5 days. Temperature of heap starts rising and may go upto 700 C in 24-48 hours. Maintaining a proper temperature inside the stack is an important parameter of compost preparation. High temperature besides favouring the growth of thermophilic microorganisms, also removes wax from the straw, which makes it more prone to the attack of microorganisms. Higher temperature attainment is directly related with the activity of microorganisms and is the result of their biological activities. However, role of higher temperature obtained during composting for the productive compost is still a matter of debate. Temperature above 800C is also not desirable in the central core of the pile as it may result in anaerobic conditions and loss of friendly thermophilic flora.

c. Day-6 (1st turning)

Temperature is not homogeneous throughout the pile nor is the oxygen availability. To give compounding mixture an equal opportunity towards fermentation, compost pile is turned at different intervals. In LMC, 7-8, turnings are given to the compost pile. The correct method of turning is as follows. Remove about one feet of the compost from top and sides of the pile, shake it vigorously so that excess of free ammonia is released in the atmosphere and the mass is properly exposed to air, keep this portion on one side (lot A). Now central and bottom portion of the pile are removed, shaken properly and kept separately (lot B). A new pile is then made out of these portions keeping lot A in centre and lot B on the top and sides. During reconstruction of the pile water is added whenever required. In practice however, compost pile is turned inside out.

During the 1st turning itself the compounding mixture turns from golden yellow to dark yellow/light brown in colour and there is a slight shrinkage in its volume. This is accompained by production of ammonia and sometimes foul smell due to anaerobic fermentation within the central core of the pile. Ammonia is produced under aerobic conditions by the breakdown of carbohydrates and proteins while other obnoxious gases due to anaerobiosis. Besides ammonia, large quantities of CO_2 is also produced. After the 1st turning, temperature again starts rising and anaerobic conditions may still prevail, due to limited availability of oxygen in the central core of the pile. Oxygen penetration inside the compost mass depends upon several factors. It is less with more width of the pile, higher bulk density with higher outside temperature, low porosity and high moisture content than the recommended parameters. However, at any stage under LMC, 30-35% volume of the heap after eight hours of turning may be under semi-anaerobic or anaerobic conditions. Since this zone of the pile gets less than 5% oxygen, it becomes imperative to turn the compost again for maintaining proper aerobic conditions.

d. Day 10 (2nd turning)

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Break open the pile and turn as described earlier. Pile will show further shrinkage and will exhibit higher temperature while colour of the ingredients will further darken. Ammonia production will be higher. Further, white flacks/powdery mass, which are known as fire fangs (Actinomycetes), will also be visible in the compost (indicator of a good compost).

e. Day 13 (3rd turning)

Again the pile is turned and the required quantity of gypsum is added. Role of gypsum in mushroom nutrition has already been narrated in chapter 6.

f. Day 16 (4th turning),

Day 19 (5th turning), Day 22 (6th turning), Day 25 (7th turning) The required quantity of recommended insecticide is added during last turning. One may spray Melathion or Decis @ 0.01% for killing insects and pests.

g. Day 28 (filling day)

Break open the pile, check for the smell of ammonia. If no ammonia smell is there in the compost and instead a sweet smell is felt, the compost is ready for spawning. If ammonia smell persists then additional turnings are required to be given after 2-3 days. Normally ammonia concentration at spawning should not be more than 8-10 ppm. Correct amount of ammonia present in the compost can be measured with the help of dragger tubes available in the market. Simply smelling compost is fairly good enough, as generally we cannot smell ammonia concentration below 10 ppm. Steps of long method composting have been shown in the flow chart. 2. Improvements in long method of composting a. Chemical pasteurization Compost prepared by LMC harbours a large number of organisms at spawning, many of which are strong competitors of *A.bisporus*. Such compost is invariably attacked by yellow moulds (*Myceliophthora lutea* and *Sepedonium chrysospermum*), green mould (*Trichoderma viride*) and brown plaster mould (*Papulospora bysinna*). Out of these, yellow moulds are the most dreaded competitors of white button mushroom mycelium and in severe cases complete crop failure has been reported. Best way to eliminate these organisms is to use compost prepared by short method (pasteurized compost). However, procurement/production of such compost is beyond the reach of many growers in India especially for those who are seasonal growers. To control yellow moulds and other diseases mentioned above, this Directorate came out with a novel chemical pasteurization technique of long method compost. The developed technique is as follows: Prepare the long method compost as per schedule and on last day (turning) (27th day), break open the pile on a clean area. Now take 1.5 litres of formalin (formaldehyde 40%) and 50 g of Bavistin (50% Carbendazim), dissolve these chemicals in 40 litres of water for one ton compost. Spray this solution thoroughly in the entire compost mass so that each and every portion of the compost

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gets the dose of this solution. Now make a heap out of this compost and cover it by a polythene sheet for two days. Remove the cover after 2 days and vigorously shake the compost before spawning. It may be noted that above chemical solution is for one ton of finally prepared compost only and growers should prepare the chemical solution as per the quantity of compost available with them. Quantity of water can be adjusted as per the moisture of the compost but it should be sufficient enough to treat the entire compost. Growers are advised to procure standard make of chemicals only otherwise they may not get desired results. This technique works very well against the yellow moulds and also controls other competitors as well thereby increasing the yield (Table 7.2). Such chemical treatment of the compost is safe as there is no translocation of carbendazim or formalin in the fruit bodies when used for the treatment of compost at spawning.

3. Attributes of a good compost

A good compost should be dark brown in colour, should not be greasy or sticky, should have distinct sweet inoffensive smell, free from ammonia smell, should have 68- 72% moisture and pH 7.2- 7.8. There should not be visible growth of other undesirable organisms except for the fire fangs (Actinomycetes) and it should be free from insects and nematodes. As indicated earlier composting is essentially a fermentation process brought about by the activity of various organisms. Their activity and growth determines the quality of the compost produced since these organisms convert ammonical nitrogen to microbial proteins, which are ultimately utilized by A.bisporus mycelium for its nutrition. Beside above, quality and composition of base materials, aeration and moisture also determine the quality of compost. Various factors, which govern the quality of compost, are as follows:

a. Nitrogen content

Nitrogen content of the compounding mixture is very important. It should be 1.5 - 1.75% in the beginning (on dry matter basis). If the N content is kept below 1.5%, compost is not properly fermented and the temperature of the heap may not go beyond 55-600C due to lesser microbial activity. The compost so produced will be yellowish in colour and light in texture and will not be selective to mushroom mycelium. Moulds like Stachybotrys atra, S.alternans, Stilbum nanum and Doratomyces stemonites may inhabit such compost resulting in poor yields. On the other hand if N content is kept above 1.75% level, C: N ratio will not be optimum and more of nitrogen will disappear from the pile in the form of ammonia resulting in the wastage of the nutrients. Such compost is invariably infested by Sepedonium spp. (yellow moulds), which may drastically reduce the yield. Coprinus spp. (Ink caps) and Chaetomium olivaceum (olive green mould) are also indicators of high

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nitrogen in the compost pile. N content of compost at the end of 28 days in long method compost is in the range of 1.75 to 2.0 %

b. Carbohydrate content

During initial stage of composting free carbohydrates and nitrogen are utilized by the mesophilic flora and heat is generated in the process. Later on thermophilic flora takes over the mesophilic population. When the compost is cooled down, thermophilic flora can no longer grow due to low temperature while mesophilic flora also cannot grow since these organisms have already utilized most of the free carbohydrates. Normally there should not be any free or soluble carbohydrates present in the compost. Their presence is the indication of under composting and such composts are easily attacked by green mould (T. viride) or blackwishker mould (D.stemonits).

c. pH

This is an important parameter of A.bisporus compost. A.bisporus mycelium grows best at 7.2 - 7.8 otherwise growth of A.bisporus will be slow and white plaster mould (Scopulariopsis fimicola, S.brevicaulis) may invade such compost.

d. Moisture content

Optimum moisture content for the natural compost (i.e. compost made using horse manure) is about 65-67% while for synthetic compost it is 68-72%. If it is more than 72% at spawning there may not be proper aeration, as free space will be occupied by water. Under such circumstances anaerobic condition may prevail resulting in killing of A.bisporus mycelium. Further, moulds like brown plaster (P. byssina), white plaster (S. fimicola) may appear in the compost.

e. Quality of raw materials

If raw materials especially wheat or paddy straw used in compost making are of poor quality (old and exposed to rains) it may result in improper compost. On such compost Sepedonium spp., Alternaria alternata and Coprinus spp. may appear resulting in low yield of mushroom.

4. Shortcomings of LMC Compost production by LMC is a very old concept and has been done away by advanced countries many decades back. It is presently in vogue only in few countries like India, China and Indonesia. LMC has the under mentioned shortcomings.

● Since compost is prepared over a period of 28-30 days dry matter loss of ingredients is more. We normally get 1.75 to 2.0 tons of final compost from one ton of dry straw.

● Compost is produced under out door conditions and hence invaded by many pests/competitors/diseases and hence not perfectly selective.

● Frequent sprays of insecticides and fungicides are required.

● Most of the ammonia is lost in the atmosphere resulting in low final N content of compost.

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● Low yields

● Not environment friendly

B. Short Method of Composting (SMC)

Long method of composting has many shortcomings as already mentioned. Growers in the United States around 1915 found that if compost prepared for A.bisprous is kept in shelves in growing rooms and subjected to high temperature (around 60°C) for sometimes gives higher and consistent yield. This process was later termed as "sweating out" and it laid down the foundation of pasteurization of compost. Based on the above principles/ findings, American Scientist, Sinden and Hauser in the year 1950, 1953 proposed a new method of composting, where pasteurization became its integral part, which was termed as the short method of composting (SMC). This method of composting is being followed by most of the growers who are cultivating mushrooms round the year and has since revolutionized the mushroom industry. Short method of composting primarily consists of two phases:

Phase-I: Outdoor composting for 10-12 days

Phase-II: Pasteurization and conditioning of the compost inside an insulated room by free circulation of air under definite set of conditions. This phase lasts for around seven days

1. Purpose of pasteurization and conditioning

a. It reduces the time of composting

b. It converts ammonia into microbial protein, most of which otherwise goes waste in the atmosphere in LMC

c. It conditions or sweetens the compost under definite set of temperature and aeration uniformly making compost more selective for the growth of A.bisporus

d. It kills or inactivates insects/pests/diseases and competitors of A.bisporus, which if present hamper the growth of A.bisporus thereby reducing the yield

e. Conditioning increases the biomass of thermophilic organisms especially that of Scytalidium thermophilum, which later on is utilized by the mushroom mycelium as food

f. Through conditioning more compost per unit weight of ingredients is produced

g. Conditioning and pasteurization increases the yield of mushrooms

During Phase-II steam pasteurization is done in a well insulated room constructed for the purpose. Boiler is required for the production of steam for proper maintenance of temperature inside the compost mass. Blower is required for the supply of fresh air and recirculation of ammonia and other gases for their conversion into microbial proteins.

2. Machinery required

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Small farms would not require much mechanization owing to availability of cheap labour in the country. Also they have to handle little quantity of compost at a time, which otherwise can easily be handled manually. However, for a large export oriented unit (around 2000-3000 TPA), which handles the compost in bulk (around 30-40 tons of straw/day), mechanization of the operations viz., prewetting, turning, filling, emptying, spawning and bagging becomes necessary to hasten the process and to get a quality compost. Such farms also employ computers, which monitor and control the process of pasteurization and conditioning inside the tunnels. Following machines will be required for an export oriented unit.

a. Prewetting machine or pre-wet heap turner

This machine is used to blend loose or baled material with other compost ingredients such as chicken manure and horse manure as well as wetting of the mixed ingredients. The primary function of this machine is to turn and restack prewetted materials into long and wide heaps by tractor and front loaders.

b. Compost turner

The compost turner comes in varying capacities from 30-70 tons of compost handling per hour. It is fitted with a round stainless steel pick up drum, one spinner and one forming bore. The turner is generally mounted on 4 wheels, two of which are castoring wheels and rest two are powered, large diameter pneumatic wheels. Turner is usually fitted with a full width water spray pipe mounted at the front of the machine with water outlets over the full input width. Prewetting machine. Compost turner. Bob cat

c. Pile forming case

This machine is used when the pile is formed for the first time. This is usually supported on four castoring wheels and is attached to the front of the compost turner which is pushed by the turner during pile formation.

d. Front end loaders

Bucket type loaders are employed for various composting operations viz, prewetting, and transportation of the compost during pile formation in combination of compost turner and forming case. They are generally attached with a tractor. Else, Bob Cat can be employed for the purpose.

e. Oscillating head filling machine

This is made up of two conveyer units mounted upon a self propelled chasis. The two conveyers are so designed that one feeds directly into the other from above. Conveyer which is positioned above accepts the compost from the feed conveyers and transfer this compost to the conveyer positioned

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below. This is an oscillating type which fills the compost loosely in the tunnel over the entire width. The head filling machine comes in varying sizes suiting to the size of the tunnel.

f. Compost feed conveyers (2-3 units)

These are ordinary conveyer systems slightly elevated and can be coupled together to form a single conveyer system feeding one to the other during tunnel filling. The length and width of each conveyer is generally 7.5- 9 m and 0.6 m.

g. Hopper regulator

This machine is required to feed the compost to the feed conveyers. It accepts the compost from the bucket of the front end loader and provides regulated output of the compost to the feed conveyer

h. Tunnel emptying winch with combination of spawn dosing machine

This unit is employed for emptying the tunnel filled with pasteurized compost by means of a polyethylene glide and pulling nets. The winch is equipped with one net reel for pulling, the nets, two spinners and a chain conveyer for the discharge of the compost. Spawn discharging unit consists of twin spawn dispensers mounted over the full width of the compost flow on the discharge elevator.

i. Bag filling machine

This machine is required to feed the compost to the feed conveyers. It accepts the compost from the bucket of the front-end loader and provides regulated output of the compost to the feed conveyer. This machine is used for filling the bags with spawned compost. The machine is equipped with a conveyer with two filling stations. One or more of the above machines may be needed depending upon scale of operation, labour availability, type of raw materials used, etc Front-end loaders, hopper, conveyers and oscillating head filling machines are useful for any commercial unit.

Besides the above machines, small instruments like multiprobes digital thermometers, oxygen meters, ammonia measuring equipments and computers are also required for a mushroom farm to maintain quality and high productivity of mushrooms.

3. Methodology

Compost by short method can be prepared by any formulation given in the text earlier. However, a formulation based on wheat straw and chicken manure is widely used in the country. (Wheat straw 1000 kg, chicken manure 500 kg, urea 15 kg, wheat bran 75 kg, gypsum 30 kg).

a. Phase-I or outdoor composting

Under stack aeration ducts Like LMC, this phase of SMC also starts with the wetting of the ingredients. Wheat straw and chicken manure are wetted thoroughly till they absorb sufficient water (around 75%). Leached water collected in a goody pit constructed for the purpose is regularly sprayed over the raw materials. After thorough wetting of the substrates an aerobic stack of the

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composting yard is provided with under stack aeration ducts connected with the required capacity small blowers installed at one end of the yard. These blowers blow small quantities of air regularly or at fixed intervals through G.I. or plastic pipes, which have small holes running length wise of the yard. Stack is made on these pipes. Prewetting and mixing of ingredients is a must before starting actual composting procedure on zero day and the stack made during this process are wide with low height of 3-4 feet.

0 Day

On this day the stack is again broken and the entire quantities of other raw materials like urea and wheat bran are added, water is also added if required and a high aerobic stack is made. Dimensions of the stack will be the same as mentioned for LMC. Turnings can be done manually or by compost turners built for the purpose. Similarly the compost is again turned after every 2 days and gypsum is added at third turning. In all three to four turnings are given. On 8th – 10th day the compost is ready for pasteurization to be affected in bulk chamber. This marks the end of Phase -I.

Characteristics of the compost after phase-I and before Phase-II

● Brownish throughout. Pieces of straw gleaming and wet

● Straw rather long but can be broken with some force

● Properly hydrated, around 72-75% moisture; when squeezed drops of water appears between the fingers

Methods of Compost Preparation

● Very heavy smell of ammonia. pH approximately around 8.2 - 8.5

● Still sticky and slimy, hands get dirty and wet

● Actinomycetes (fire fangs) not so apparent

● Nitrogen content between 1.5 - 2.0%; ammonia concentration around 800-1000 ppm

b. Phase-II

This phase of composting is generally performed in pasteurization tunnel in bulk. Phase-II process can be divided into two stages namely conditioning and pasteurization.

i. Conditioning

It can be divided into pre-pasteurization conditioning (PPC) and post pasteurization conditioning (POPC). During this phase of composting, whole of the compost mass is brought to a temperature range optimum for the growth of thermophilic flora (45-52°C). During this phase major part of NH_3 gets fixed in lignin-humus complex or as microbial biomass and excess of ammonia is released into the atmosphere. POPC again regenerates the lost thermophilic organisms during pasteurization. It has also been found that maximum ammonia generation takes place at 45-50°C, which corresponds

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well with optimum temperature range of majority of thermophilic flora. Compost should not be conditioned below 40°C, as some mesophilic fungi may set in at this temperature rendering compost unsuitable for mushroom growth specially A.bitorquis. Besides keeping compost at a particular range of temperatures (45-52°C), during this phase enough of oxygen is supplied (O2 concentration above 10%) to the compost mass to maintain fully aerobic conditions. Both pasteurization and conditioning make the compost most selective for the growth of white button mushroom at the expense of other harmful competing organisms.

ii. Pasteurization

Main purpose of pasteurization is to kill or inactivate harmful organisms. They are eliminated when the compost is subjected to a temperature above 55°C for certain period when humidity in the compost and surroundings is high. Therefore, use of live steam to heatup the room and compost sometimes becomes essential. It has been found that compost is pasteurized properly if it is kept at 59°C for 4-6 hours. Temperature above 60C is harmful as this temperature may kill all kinds of organisms including thermophilic fungi very essential for governing the phase-II of composting. Activity status of the compost is also very important to achieve pasteurization temperature. If it is an active compost, its temperature starts rising immediately after filling and may rise by 1°C per hour and the required temperature of pasteurization can be achieved in few hours only by self-generation of heat. Pasteurization of the compost can either be done soon after room/tunnel filling or after few days.

iii. Phase-II in tunnel (Bulk pasteurization)

In this process the compost is treated in bulk inside a specially built chamber known as the tunnel. The compost is filled in the bulk chamber upto the height of 2- 2.2 meters in such a way that one square meter of space occupies approximately 900-1000 kg of compost. Several temperature sensors are placed at different points of the tunnel to measure the temperature. One sensor is placed below the plenum in the ventilation duct below the grated floor, one to three are placed inside the compost mass and one or two above the compost for air temperature. Immediately after filling, all the doors are closed and the blower is switched on to bring the air in plenum, compost and air above the compost at a uniform temperature (around 45-48°C). There will be a little difference in temperature at all the three places and this difference may be 1-3°C. Levelling off may take 4-5 hours and at this stage no fresh air is generally introduced in the tunnel and air introduced through the leakage of the dampers and ducting would suffice the purpose. After levelling that is to say after 4-5 hours (more in case of bigger tunnels >15 tons) of filling the tunnel, we will start Pre Pasteurization Conditioning (PPC). This is to increase the population of thermophilic fungi at this stage, which will demand more

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oxygen for their growth and multiplication and this may reach above 15% of the total gaseous volume inside the tunnel. Fresh air is therefore introduced in the tunnel through the dampers (10% opening). Now the compost is kept between 45-52°C for two days. Two days after conditioning, the compost is now ready for pasteurization. Now opening of the damper is narrowed down, which will gradually increase the temperature of the compost by approximately 1°C/h. Required temperature (58-59°C) of compost needed for pasteurization may reach in 10-12 h by self-generation of heat. The difference in the temperature above the compost (air temperature), inside the compost and plenum (below the compost) should be as less as possible and may not exceed 3°C. Some quantity of steam can also be used if temperature is not rising. This process is called pasteurization or killing. Duration of the pasteurization is normally 4-6 hours. It will eliminate harmful insects, nematodes and competitor moulds from the compost and at the same time will preserve the nutrients in the compost, which can effectively be utilized by A.bisporus mycelium. Temperature can be monitored or regulated through automatic computerised systems available in the international market. A low cost alternative has been developed at the Directorate wherein one can set the minimum and maximum temperature and as soon as the temperature goes above or below the set temperature range, there is siren and corrections in tunnel parameters thereafter can be made manually. After killing, fresh air is again introduced/increased in the tunnel and temperature of the compost is brought down @ 1.5°C/hour and finally maintained between 45-48°C till there is no detectable smell of ammonia (less than 10 ppm) in the compost. This phase is known as post pasteurization conditioning (POPC) of the compost, which is normally accomplished in 3-4 days. Temperature of the compost is gradually brought down to 25- 30°C after conditioning by introduction of fresh air in the tunnel and when this temperature reaches, the compost is ready for spawning.

Above method of pasteurization is recommended for the commercial tunnels having more than 15 tons output of the compost. Smaller tunnels while adopting above procedure may require frequent injection of steam during PPC and especially when pasteurization is affected, this increases the cost of production of compost. Such tunnels may resort to traditional pasteurization wherein levelling is done at higher temperature (around 50°C) and after that opening of the damper is so adjusted that compost temperature starts rising and it attains pasteurization temperature mentioned as above. Usual conditioning is done afterwards for 4-5 days or till the period when compost is free from ammonia and spawning done as usual. At the end of conditioning (at spawning) compost should be dark brown in colour with a full coating of white powdery mass due to abundant growth of actinomycetes. This is a sign that Phase-II was performed in a perfect manner with abundant supply of fresh air.

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Phase-II process is almost a biological oxidation (90%) and hence here O2 and temperature play very important role. It is advisable to connect temperature probes with a computer or data logger for round the clock changes/monitoring of the temperature. Further, gadgets are available in the market to monitor ammonia concentration and oxygen level inside the tunnels. These can also be installed in the tunnel to monitor above gases round the clock. The fresh air inlets are fitted with 2 micron washable HDPE filters. As the composting proceeds there is loss in biomass. In phase–I there is about 30% loss in weight and in phase –II, 20-25 % loss in weight takes place. As a result from the standard formula of one ton wheat straw and 0.5 ton chicken manure, we can get about 2.5 tons of final compost.

Characteristics of the compost after Phase-II

● Dark brown in colour, full of thermophilic fungi and actinomycetes.

● It is soft, straw breaks rather easily.

● Moisture around 64-66%. No liquid oozes when squeezed firmly

● Pleasant sweet smell

● No stickiness. Hands stay clean and dry

● N content > 2%

● Ammonia below 10 ppm

Advantages of bulk pasteurization

● More compost per unit size of the room can be treated at a time.

● The cost of pasteurization in tunnel is less.

● Same tunnel can be utilized for spawn run in bulk, which gives effective use of the space.

● Yield per unit weight of compost is generally higher.

C. Indoor Composting Compost prepared either by LMC or SMC involves traditional outdoor composting, which causes environmental pollution. Large amount of malodourous gases viz., ammonia, methane, hydrogen sulfide and other methylated sulphur compounds are emitted in the atmosphere creating nuisance. This foul smell is more when the compost is fermented at high temperature under anaerobic conditions. Laws governing pollution are becoming stringent day by day in India and many mushroom units producing compost by LMC or by SMC are threatened to close down their operation or to shift their operations away from the municipal limits. Need is, therefore, felt to control the composting process in such a manner that there is least possibility of environmental pollution and at the same time to produce high yielding compost in shortest possible time. Work on such composting procedure started in France way back in the year 1967 but only recently put to use by commercial units abroad. In this case whole composting process is carried out

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indoors in specially built tunnels and hence the name indoor composting. Since such compost is produced under total environmental controlled conditions. Sometimes it is also called environmentally controlled composting (ECC) or rapid indoor composting (REC), or aerated rapid composting (ARC). In India work on this line was started at our Directorate few year back and technology to produce such compost in 12 days time perfected. Facilities required and methodology for the production of such compost is presented below:

Most important aspect of indoor composting is that besides being environment friendly, it takes less time and gives more compost biomass (around 25-30% more) per unit weight of the ingredients taken and hence over all yield of mushrooms in such compost is higher.

1. Facilities required

a. Composting Yard

In indoor composting Phase-I is performed indoors and hence requirement of composting yard is greatly reduced. A small composting platform is required for prewetting and mixing of the ingredients, which is mainly performed either by front-end loaders or by preheap turners by big commercial units. A platform of the size 60x60x14 ft (h) would suffice the purpose for a medium size farm (250 TPA).

b. Phase-I tunnels or bunkers

These are specially built non-insulated tunnels having full width opening at the front. Dimension of the bunkers would depend upon the output of the compost required. Generally the bunkers are 1.5 times more the size of the phase-II tunnels. It has a plenum (ventilation duct). A perforated concrete floor is constructed above the plenum, which is serviced by a centrifugal fan having ¼ the capacity of phase -II blower, which means that a ventilator having air displacement of 50 m3 /hour/ton of compost at 50mm WG water pressure would suffice the purpose. Alternatively, the bunkers have no plenum and several pipes are buried in the floor along the full length of the bunkers having small holes (5-8 mm dia). These pipes are converged into a manifold, which in turn is connected to a high-speed blower fan (around 1000 pascals). A timer is usually attached to the blower, which pulsates the air in the bunker periodically as per the setting of the timer. A minimum of 2 such phase-I tunnels (bunkers) are required.

c. Phase-II tunnels

Two methods, INRA method (double phase high temperature process) and Anglo Dutch method (single phase, low temperature process) are prevalent in most parts of the world giving almost equal yields. This Directorate has developed a method combining the two methods as mentioned above. Methodology developed is presented below: For preparing compost by this improved method of

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composting, ingredients say – wheat straw 1000 kg, poultry manure 500 kg, wheat bran 70 kg, cotton seed cake 20 kg, and gypsum 40 kg are first thoroughly mixed in dry form. They are then thoroughly wetted so as to achieve around 75% moisture percentage. Run off water should regularly be collected and sprinkled over the wetted straw. On the following day these wetted ingredients are then spread over the composting yard (around 8-10" height) and trampled hard by running Bobcat several times over the wetted ingredients or by other means so as to increase the bulk density of the ingredients and also to shred the straw. Wetted straw together with other ingredients is then made up into heap and left as such for 48 hours. Temperature in the heap may rise up to 55-600 C. On the following day, material is again flipped to bring the uniformity and proper mixing and transferred to phase-I bunker, for phase-I operation. This material will weigh around 4 tons and height of the compost in the bunker is kept up to 1.8-2 meters. Temperature sensors are installed on the top and in the Centre of the pile in the bunker and blower fan switched on @ 5 min/h with the help of a timer installed for the purpose. Temperature will rise to 60-650 C after 24 hours in the centre and 48-520C at the bottom, sides and on top of the compost. After 24 hours air flow inside the tunnel is increased to 10 min/hour. This will further increase the temperature in the centre of the compost between 72-75°C while it will remain same in other parts of the compost mentioned as above. No foul smell will be noticed while performing phase-I operation in the bunker, however little bit ammonia smell will be there. After 3 days of partial fermentation in phase-I tunnel, entire compost mass is taken out and a complementary turning is given, more water can be added if required and is transferred to another bunker or to the same bunker at the same sets of conditions mentioned as above for 3-4 days. Total period of phase-I operation in the bunker should normally last for 6-8 days. Afterwards compost is transferred to phase-II tunnel for usual phase-II operations to be completed in 6-7 days.

a. Composting Schedule -4 day:

Mixing and wetting and of the ingredients out doors -3 day: Turning, trampling by Bobcat and thorough mixing of the ingredients, addition of water. -2 day: High aerobic heap 0 day: Filling in the phase-I bunker.

+ 3 day: Emptying the bunker, turning and mixing of the compounding mixture and re-filling the compost in another phase-I bunker +6 day: Phase-I operation over and compost transferred to phase-II tunnel + 12 day: Phase-II operation over The phase-II operation is same as described for SMC. As temperature inside bunkers sometimes rises above 750 C, it may be desirable to add some inoculumin the form of readymade compost to the ingredients at the time of filling the tunnels or pahse-II.

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b. Advantages of indoor composting

● Requirement of composting yard is reduced to 1/3

● No emission of foul smell

● Number of labourers and cost of production reduced

● Duration of composting greatly reduced

● Reduced effects of weather and seasonal variations

● More compost per unit weight of the ingredients

● Higher yields

● Compost turner is not required

c. Disadvantages of indoor composting

● Low bulk density of compost

● Aesthetic look of the compost is not good (brown in colour)

● Since turnings are less, initial superior blend of raw materials and homogeneity at the time of filling phase-II tunnel is critical

Further Reading

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