

Cultivation, Seasonal Productivity and Morphological Variation in *Agaricus bisporus*

Poonam Dehariya*¹

¹ Lab of Mushroom Biology, Department of Botany, Dr. Harisingh Gour Vishwavidyalaya, Sagar - 470 003, Madhya Pradesh, India

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Abstract

Agaricus bisporus is one of the most popular and commercial crops of mushroom all over the world. Compost plays a most important role in the growth of *Agaricus bisporus*. The process of composting involves a controlled microbial succession, a suitable chemical condition, a suitable physical condition and controlled environmental conditions in regard to temperature, light and changes in concentration of atmospheric gases in the substrate. Present study deals with the cultivation of *Agaricus bisporus* in different four types of compost. All the test composts are suitable for the growth of *Agaricus bisporus* but Compost 1 and 3 are best for the growth. Apart from this growth in different seasons effect on morphological variation are also studied in *Agaricus bisporus*. It was observed that winter (Nov. to Dec.) and Spring (Jan.) season was best, not only morphological characters i.e. but also higher productivity.

Key words: *Agaricus bisporus*, Cultivation, Spawning, Seasonal productivity

Agaricus bisporus belongs to group basidiomycetes and order agaricales. Button mushrooms derived their name from the shape of young fruit bodies when veil is still closed. This linked is most linked by consumers, hence the name button mushroom. Stipe is long, cylindrical, structure which supports the pileups or 'cap'. It is white, solid when young, annulate and hollow below the annulus when mature, slightly thicker at the base and tapering upwards. Pileus is the spore bearing structure centrally attached to stipe, it is 5-10 cm. broad, white-creamish white, turns brown on bruising, fleshy, convex with fattened surface at the centre. The under surface of pileups is covered with pink colored lamellae which turn brown as fruit body matures, which is called gills or lamellae. Gills are free crowded, narrow, pink when young and turn dark brown with age. In mature fruit bodies, the veil, which is a membranous structure covers the gills. Spores are broadly ellipsoid, heilocystidia broadly clavate, odour pleasant and mushroom like when fresh. On lamellae the spores are born on 'basidia' [1].

The substratum on which the mushroom mycelium grows and fruit body eventually develops is known as compost. It is the product of a fermentation process brought about by a number of mesophilic and thermophilic organisms which decompose plant residues and other organic and inorganic matters. The purpose of composting is to convert a rich mixture of organic materials into satisfactory and stable medium suitable for the growth of *Agaricus bisporus*, but not so for other kinds of organisms. Composting is a biological process in which the activities of numerous types of microorganisms are involved [2].

Spawning is the planting of mushroom spawn in the prepared compost. For spawning, completely colonized and fresh spawn should be used. Spawn is thoroughly mixed in the compost while filling in the compost in containers. After 7 days

of spawning, it should be gives a shake-up of compost that gives a quicker spawn-run by distributing the inoculum and dispersing ammonia in a poor compost. Rate of spawning is between 0.5- 0.75 percent of fresh weight of compost [3].

The process by which the covering material is put on compost surface is named as casing. The main purpose of spraying a casing layer to the surface of the spawn running compost is to stimulate and promote formation of fruiting bodies. Quality casing material should be used for casing mushroom beds. Shandilya and Munjal [4] reported that pasteurization of casing at 65°C for 4 hours gives best results as at this temperature it get rids of bacterial blotch organism. For pasteurization of casing soil, moist casing soil is filled in trays and trays in turn are stacked in the insulated pasteurization of room. Steam is introduced to bring the temperature of casing soil at 65-70°C and this temperature is maintained for 7-8 hours. Casing media pasteurized in this manner give best results.

Mushroom yield in India shows considerable variability, largely due to the predominance of cultivation under natural or semi-controlled conditions. Unlike temperate countries where button mushroom cultivation is carried out in environmentally controlled growing rooms, most Indian growers rely on ambient climatic conditions. Under traditional cultivation practices, when normal cropping methods are adopted using well-prepared, good-quality compost and basic hygienic measures are maintained, fresh mushroom yields of approximately 10–14 kg per 100 kg of fresh compost can be achieved. This yield range reflects the baseline productivity attainable under conventional long-method composting and natural environmental conditions. However, even within this range, yields may fluctuate depending on compost maturity, microbial activity during composting, moisture content, and seasonal suitability.

*Correspondence to: Poonam Dehariya, E-mail: dpoonambot18@gmail.com

Yields in India are highly variable as most of the growers grow this crop natural conditions without any control over environmental factors like temperature, humidity, aeration etc. If normal cropping practices are followed on a properly prepared good quality compost and hygiene is maintained, fresh mushroom yields at or around 10-14 kg per 100 kg fresh compost can be obtained. If compost prepared by short method is used under natural conditions, yield ranging from 15-20 kg or more per 100 kg compost can be obtained.

From an analytical perspective, these observations highlight that while environmental factors play a crucial role in mushroom production, their adverse effects can be partially mitigated through improved substrate preparation and strict hygiene practices. The higher yields associated with short-method composting suggest that optimizing composting techniques is a practical and cost-effective strategy for Indian growers, especially those unable to invest in fully controlled cultivation facilities. Therefore, enhancing compost quality, adopting improved composting methods, and maintaining sanitation standards can substantially narrow the yield gap between natural and controlled cultivation systems, contributing to more stable and profitable button mushroom production in India.

MATERIALS AND METHODS

A healthy closed button mushroom was selected for taking tissue culture, surface sterilized, cut into two halves and later a bit was cut from the junction of pileus and stipe and introduced into a container containing sterilized medium (PDA) under aseptic conditions and incubated at 25°C.

Preparation of spawn- Same as it was described above.

Preparation of compost

The substratum on which the mushroom mycelium grows and fruit body eventually develops was known as compost. It was the product of a fermentation process brought about by a number of mesophilic and thermophilic organisms which decompose plant residues and other organic and inorganic matters.

Long method of composting

Long method of composting was used in present study.

Long method of composting

This method was first introduced in India by Mentel *et al.* [5]. It generally takes 20-28 days. The process of wetting of wheat straw and fertilizers is known as day-1.

Day-0-On this day, the base material (wheat straw) and fertilizers are mixed thoroughly with the help of forks. The mixture is filled in the rectangular mould.

Day 1-5-In these days start monitoring the temperature. It was start rising within 24-48 hours after stacking and may reach up to 65-70°C in the centre. If moisture of the compost mixture is less, then more water added. Watering stopped as soon as leaching starts from the bottom of pile.

Day-6-(1 turning) Turning was done to ensure that every portion of the pile gets equal amount of aeration and water. On this day first turning was given to the stack. Remove about 1 ft of compost from top and side the pile, shake them thoroughly so that excess of ammonia is released and it is exposed to air properly, keep this portion on one side. Central and bottom

portion of the pile was removed and shake with the forks. Top and side portion was placed at the centre while bottom part comes on top and sides.

Day-10-(2nd turning)-Break open the pile and turned as indicated above.

Day-13-(3rd turning)-Turning was given and required quantity of gypsum is added.

Day-16-(4th turning)- To check the nematodes furadan was added.

Day-19- 5th turning was done

Day -22- 6th turning was done

Day 25 -7th turning, required quantity of BHC was added.

Day-28- Filling day.

Pile was broken and check the smell of ammonia. If there is no ammonia then the bags were filled.

Different compost material used

Composition of different compost formulations used for cultivation of *Agaricus bisporus*

Component	Quantity
Compost-(1)	
Wheat straw	: 300 kg
Wheat bran	: 30 kg
Saw dust	: 10–12 kg
Ammonium sulphate	: 9 kg
Super phosphate	: 2.4 kg
Gypsum	: 30 kg
Compost-(2)	
Wheat straw	: 300 kg
Calcium ammonium nitrate	: 9 kg
Urea	: 3 kg
Superphosphate	: 3 kg
Muriate of potash	: 3 kg
Wheat bran	: 15 kg
Molasses	: 5 kg
Gypsum	: 30 kg
Lindane dust	: 250 g
Compost-(3)	
Wheat straw	: 300 kg
Molasses	: 12 kg
Urea	: 4.5 kg
Wheat bran	: 50 kg
Muriate of potash	: 2 kg
Cotton seed meal	: 5 kg
Gypsum	: 15 kg
Compost-(4)	
Wheat straw	: 300 kg
Chicken manure	: 125 kg
Wheat bran	: 15 kg
Gypsum	: 20 kg
Urea	: 5.5 kg
BHC (10%)	: 125 g

Spawning

For spawning, completely colonized and fresh spawn was used. Spawn was thoroughly mixed @ 4% of the wet

weight of the substrate before filling in the composted bags. 7 days later, bags were gently shake up, it gives a quicker spawn-run by distributing the inoculum and dispersing ammonia in the bags.

Care after spawning

After spawning, the beds are pressed gently to have uniform surface. Entire compost surface was covered with newspaper sheets. These sheets are initially sprayed with a very light concentration of formalin (0.5-1%). Afterwards water was sprayed on these sheets regularly 2-3 times a day to keep the sheets and compost surface moist. Sufficient air should be circulated in the spawn running room to obtain uniform temperature throughout the room. Mushroom mycelium requires 23±2°C. Growth of the mycelium in compost can be visualized in the form of circular spread of whitish silky mycelial threads in 4 to 5 days after spawning. Compost was fully impregnated with the mycelium in 12-15 days. During spawn run slightly higher carbon dioxide concentration was required (0.5-2.0%). This mushroom mycelium is able to fix and utilize carbon dioxide as a source of carbon.

Casing

In this process, after the spawn-run the beds are cased with appropriate mixture of soil and organic matter to create conditions which induce fructification. After 10-15 days spawning, casing was done. Three types of casing mixtures were used viz. untreated (control), chemically treated with 4 percent formalin and autoclaved at 15 lb pressure.

Materials for casing soil preparation

Five casing mixtures viz. Farm yard manure (FYM), Garden soil (GS), Spent compost (SC), Sandy soil (SS) and Local soil (LS) were used for casing.

Process of casing

Casing was done by to opening the bags after the mycelium completely colonized the compost. The surface of compost is then leveled by pressing with hand and the casing layer about 3-4 cm thick was applied uniformly over the entire surface of compost A very light spray of formalin (0.5%) was given after the casing.

Care after casing

Temperature of the cropping room was maintained at 23 °C for about a week to allowed the mushroom mycelium to spread into casing layer. The casing layer acts as a blanket and conserves heat generated in the compost. To remove the excess heat produced during this stage especially when the

supplementation was done, ventilation and recirculation of air was needed to maintain the desired temperature.

In about a week's time mycelium spreads in the casing soil. At this stage temperature of cropping rooms and beds was kept to 14-18°C. It goes high and reaches beyond 25°C during cropping. The relative humidity of the cropping room was maintained at 85-90 %.

Harvesting, grading and processing of mushrooms

The right stage of picking is when the mushroom cap is firmly attached and still closed. During picking the mushrooms are taken carefully by the head and pulled upwards with slight twisting as well. After picking all the beds should be examined for dead mushrooms, left over of stalks and detached pin heads and buttons. They must be taken out from the beds very carefully and disposed off. The period between two flushes is called intermediate break or flush. The mushroom comes out during intermediate break may not be as good as in flushes. The spraying of water should be done after filling the holes by preserved casing soils. The temperature should be kept within the range (16-17°C) in case of controlled conditions. The spraying of fungicides or insecticides may be done during intermediate flushes. One should be very careful about the doses and necessity of the chemicals.

RESULTS AND DISCUSSION

Base material of all the composts is wheat straw. However, some difference in other constituents. Compost (1) require less time 16 days for spawn run and 18 days for pin head appearance, stipe length was measured 2.3 cm and cap diameter was measured 2.8 cm, maximum yield obtained in this compost 14.5 Kg/ 100 Kg compost. Compost (3) was proved less suitable for the growth of *Agaricus bisporus* because it required more time 16.7 days for spawn run, 22.7 days for pin head appearance, stipe length measured 2.2 cm, cap diameter was 2.7 cm and minimum yield obtained 11.0 Kg/100 Kg compost. Compost (2) and (4) were good for the growth of test mushroom.

Agaricus bisporus (Button Mushroom) is a terricolous secondary decomposer fungus, which plays an ecologically significant role in the degradation of plant materials. It is grown on a cereal straw based composted substrate. It has long been recognized for its potential to degrade lignin component of compost through its extracellular enzyme system [6-7]. Mushroom mycelium secretes a variety of extracellular enzymes to degrade the various components (lignin, carbohydrate and nitrogen sources) of compost for its vegetative growth and reproduction [8].

Table 1 Effect of different compost material on the growth of *Agaricus bisporus*

Compost	Spawn run (days)	Pin head appearance (days)	Stipe length (cm)	Cap diameter (cm)	Yield kg/ 100 kg compost
Compost (1)	16.0	18.0	2.3	2.8	14.5
Compost (2)	16.4	20.4	2.3	3.1	13.4
Compost (3)	16.7	22.7	2.2	2.7	11.0
Compost (4)	16.4	19.0	2.3	3.3	13.7
CD (0.05%)	2.10	2.83	0.14	0.16	1.88
S Em (±)	0.64	0.92	0.04	0.05	0.61

Values are given in average of three replicates

Compost production is the most important and integral part of button mushroom cultivation. It is essentially a fermentation process brought about by a variety of organisms including bacteria, actinomycetes and fungi. Of these organisms, thermophilic fungi namely *Scytalidium thermophilum*, *Humicola insolens* and *Humicola grisea* play a

greater role towards final selectivity and conditioning of the compost [9]. Compost substrate ingredients accommodate a great number of microorganisms. With the addition of water to the dry ingredients and the building of the pile, these microbes grow and reproduce. The addition of nutrient at this time is directed, therefore, toward the nourishing of a microbial

population in the compost substrate rather than direct nutrient addition for the bulk compost substrate ingredients [10].

Data on cultivation of *Agaricus bisporus* in three different seasons i.e. Rainy (July-September) winter (October-December) and spring (January-March), using wheat straw-based compost formulae (Table 2). It was observed that winter (November to December) and Spring (January) season was best, not only morphological characters i.e. (spawn run, pin

head appearance, required lesser time, longer stipe length and greater cap diameter) but also higher productivity i.e. 14.0 Kg/100Kg compost, 16.7 Kg/100Kg compost and 16.0 Kg/100Kg compost with 1.4%, 1.6%, and 1.6% BE was recorded [11]. This also revealed that late spring (March) condition are unfavorable for cultivation of *Agaricus bisporus* because during this period ambient temperature started rising. Hence mycelium fails to grow.

Table 2 Seasonal productivity and morphological variation in *Agaricus bisporus* cultivation

	Season		Morphological variation				Productivity	
	Month of Spawning	Temp. (°C)	Spawn run (days)	Pin head (days)	Stipe length (cm)	Cap diameter (cm)	Yield kg/100 kg compost	BE (%)
Rainy	July	23.4-31.5	18.0	22.7	2.4	3.0	13.7	1.3
	August	22.0-29.0	18.4	22.4	2.3	2.9	13.0	1.3
	September	22.7-30.0	20.0	24.0	2.3	2.8	11.4	1.1
Winter	October	21.9-30.0	21.0	24.7	2.2	2.8	13.0	1.3
	November	20.0-30.8	17.7	22.0	2.4	3.1	14.0	1.4
	December	16.9-19.8	16.0	20.0	2.5	3.2	16.7	1.6
Spring	January	10.5-16.5	16.0	20.4	2.4	3.1	16.0	1.6
	February	17.2-30.5	18.0	22.4	2.3	2.9	14.7	1.4
	March	29.5-35.7	NG	NG	NG	NG	NG	NG

Values are given in average of three replicates

NG = No growth

The moisture content of the compost and humidity of the atmosphere in the growing house are of critical importance for the growth and development of this mushroom. Thus, all these factors are linked together and provide conducive environment for good yield of *Agaricus bisporus*. Months of December and January provide this conducive environment in excess. Thus, yield of mushroom is higher in these months' comparison to other. Months of July to November and February are also good and provide good environmental conditions but in March to June when temperature increase and humidity decreases an imbalance in these conditions arise like over growth of thermophilic and competing microorganisms, imbalance in CO₂ concentration, decreased humidity cause dryness of compost, increase temperature cause kill of mushroom mycelia and supports other competitive fungal growth like *Penicillium*, *Pseudomonas putidia*, *Cladobotrum dendroides* etc. is inhibit the growth of *Agaricus bisporus* mycelia. Thus result no fruiting body formation.

Several workers have attempted cultivation of *Agaricus bisporus* [12-15]. In the present investigation, effect of different seasons were studied on the growth of *A. bisporus*. Results suggest that mushroom starts growth on different substrates but low temperature and high humidity played important role for higher yield. Role of environmental factors such as temperature, relative humidity, light, carbon dioxide and acidity of substrate, which alter together in their co-dependent relationship [16-17].

CONCLUSION

The present investigation clearly demonstrates that the performance of *Agaricus bisporus* is strongly influenced by compost composition as well as prevailing environmental conditions, particularly season, temperature, and humidity. Although wheat straw served as the base material in all compost formulations, variations in supplementary ingredients significantly affected compost quality, mushroom growth behavior, and yield performance. Among the different compost formulations evaluated, Compost (1) proved to be the most suitable substrate for the cultivation of *Agaricus bisporus*, as it supported faster spawn run (16 days), earlier pin head initiation (18 days), favorable morphological traits such as longer stipe

length (2.3 cm) and larger cap diameter (2.8 cm), and ultimately resulted in the highest yield (14.5 kg per 100 kg compost). In contrast, Compost (3) was comparatively less suitable, as indicated by delayed spawn run and pin head formation, inferior morphological attributes, and the lowest yield (11.0 kg per 100 kg compost). Compost (2) and Compost (4) also supported satisfactory growth and yield, highlighting their potential as viable alternatives for button mushroom cultivation. The study reaffirms the ecological role of *Agaricus bisporus* as a terricolous secondary decomposer capable of efficiently utilizing cereal straw-based compost through its well-developed extracellular enzyme system. The degradation of lignin, carbohydrates, and nitrogenous compounds in compost is facilitated by a complex microbial consortium, including bacteria, actinomycetes, and fungi, with thermophilic fungi playing a decisive role in compost selectivity and conditioning. These microbial interactions during composting are critical in determining substrate suitability and subsequent mushroom productivity. Seasonal variation emerged as a key determinant of successful cultivation. The results clearly indicate that winter (November–December) and early spring (January) seasons provided the most favorable environmental conditions for *Agaricus bisporus* cultivation, resulting in superior morphological development, reduced crop cycle duration, and higher yields with biological efficiency ranging from 1.4% to 1.6%. Conversely, late spring (March) and summer months were found to be unfavorable due to rising ambient temperatures and declining humidity, which adversely affected mycelial growth and fruit body initiation. Moisture content of the compost and atmospheric humidity within the growing environment were identified as critical factors governing successful crop establishment and yield. Optimal conditions during December and January ensured balanced microbial activity, appropriate carbon dioxide levels, and adequate moisture, thereby promoting vigorous mycelial growth and fruiting. In contrast, higher temperatures and reduced humidity during warmer months resulted in compost drying, excessive proliferation of thermophilic and competing microorganisms, and increased incidence of contaminating fungi and bacteria, ultimately inhibiting fruit body formation. Overall, the findings of this study emphasize that successful cultivation of *Agaricus*

bisporus depends on an integrated approach involving appropriate compost formulation, effective microbial conditioning during composting, and strict management of environmental parameters. The results are in agreement with earlier reports and further strengthen the understanding that low

temperature and high relative humidity are essential for maximizing yield and biological efficiency. These insights can serve as a practical guideline for mushroom growers to optimize compost selection and seasonal scheduling for enhanced productivity of button mushroom cultivation.

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