

Effect of compost compactness, compost depth, bag perforation and reversing the compost bags on yield of white button mushroom, *Agaricus bisporus*

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ABSTRACT

Agaricus bisporus is one of the most successfully cultivated edible mushrooms in the world. Studies were conducted on the effect of compost compactness, compost depth, bag perforations and compost bag reversal to observe their influence the yield of *Agaricus bisporus* (Lange) Imbach. Among the treatments used to assess the effect of compost compactness, the treatment with 6'' loose compost required the minimum number of days for spawn run (11.33 days) while highest yield obtained (16.33 kg/100 kg compost) from 12-inch pressed compost. Among the treatments with different compost depths (inches), the maximum yield (21.23 kg/100 kg compost) was achieved with depth of 18''. The effect of bag perforations on spawn run and yield showed that the treatment with five holes per bag required the fewest days for complete spawn run, while the maximum yield (18.98 kg/ 100 kg compost) was obtained from bag with twenty holes. The bag reversed after second flush produced the highest yield of 24.62 kg/100 kg compost. This study demonstrated that minor modifications in the cultivation process including, such as changes in compost compression, compost depth, bag perforations and compost bag reversal can significantly affect the yield of mushrooms.

Keywords: *Agaricus bisporus*, compost compression, compost depth, bag perforations, compost reversal

Mushrooms are unique entity in living world, as they possess a combination of nutritional, medicinal and/or nutraceutical properties. These are considered a non-conventional source of human food and are consumed worldwide as a good source of digestible proteins, carbohydrates, fibres and vitamins (Heleno *et al.*, 2010). The food value of mushroom is increasingly being realized and appreciated by food experts due to its low calories and high nutritive value in terms of vitamins, minerals and protein. In India, the temperate button mushroom has dominated the

mushroom industry, accounting for 70% of the country's total mushroom production (Bijla and Sharma, 2023). A substantial portion of the production comes from commercial units where mushrooms are cultivated under controlled conditions. Mushroom cultivation embodies the principles of microbiology, environmental technology and solid-state fermentation in converting domestic agricultural and industrial organic waste material into food for human consumption (Chang and Miles, 2004). It has been reported that the composition and nutritional quality

of mushrooms vary depending on the strain, substrate, cultivation technology, stage of harvest and post-harvest management (Bano *et al.*, 1981; Rai, 1990). For button mushroom cultivation, appropriate substrates, composting, casing, suitable growing conditions and their associated operations play crucial role to achieve good yields. To remain competitive, it is important to harness scientific knowledge and modern technologies for a profitable mushroom cultivation scenario. Ahlawat and Manikandan (2014) reported that compost compression and perforations influence yield of mushrooms.

MATERIALS AND METHODS

The experiment was conducted at the mushroom unit at Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh using U3 strain of *Agaricus bisporus* following standard protocols.

Preparation of compost

Synthetic compost was prepared using the short method of composting, following the composition formula and method of preparation as described by Munjal and Seth (1980). Compost was prepared in two phases i.e. Phase I (outdoor composting) and Phase II (Indoor composting).

Wheat straw	1000.00 kg
Chicken manure	400.00 kg
Cotton seed meal	20.00kg
Urea	14.50 kg
Gypsum	30.00 kg

Effect of compost compactness on spawn run and yield of mushroom

The pasteurized and conditioned compost was spawned @ 0.7% using the spawn of strain U3 and

filled into polybags of size 21" x 24" with different weight and compressed at different levels (Table 1).

Table 1. Compost compactness treatments used in the study

Treatment No.	Treatments	Wt. of bag (Kg)
T ₁	6'' pressed compost	3.84
T ₂	6'' loose compost	3.03
T ₃	10'' pressed compost	6.29
T ₄	10'' loose compost	5.30
T ₅	12'' pressed compost	8.95
T ₆	12'' loose compost	5.63

Each treatment was replicated thrice, with 4 bags per replication. The compost filled bags were incubated at a compost temperature 22 to 25 °C for next 2 weeks to allow mycelial colonization of compost. The CO₂ level and relative humidity were maintained in the range of 10,000 to 12,000 ppm and 85-90%, respectively. The number of days required for the mycelial colonization of the compost was recorded. The days to first harvest were counted after casing. Mushroom were harvested when the caps were still tightly closed over the stipe. Yield was recorded over a period of five weeks.

Effect of compost depth / height on spawn run and yield of mushroom

The pasteurized and conditioned compost was spawned @ 0.7% with spawn of strain U3 and filled into polybags at variable heights (Table 2).

Table 2. Compost depth / height used in the study

Treatment No.	Treatments (Compost height)	Wt. of bag (Kg)
T ₁	10''	6.29
T ₂	12''	8.95
T ₃	14''	10.60
T ₄	16''	11.76
T ₅	18''	12.78
T ₆	20''	13.85

Each treatment was replicated thrice, with 4 bags per replication. Standard conditions were maintained for cultivation of button mushroom as given above.

Effect of bag perforation on spawn run and yield of mushroom

The pasteurized and conditioned compost was spawned @ 0.7% using spawn of strain U3 and filled @ 10 Kg/bag in polybags. After spawning, the compost-filled polythene bags were perforated with holes of 0.5 cm diameter (Table 3).

Table 3. Number of holes used in the study

Treatment No.	Treatments (Holes per bag)
T ₁	No holes (control)
T ₂	5 holes
T ₃	10 holes
T ₄	15 holes
T ₅	20 holes

Each treatment was replicated 4 times with 4 bags per replication. Standard conditions were maintained for cultivation of button mushroom as given above.

Effect of reversing the bags on yield of mushroom

In this experiment, the compost filled bags were incubated at 22 to 25 °C for the next 12-15 days for spawn run. Standard conditions were maintained for cultivation of button mushroom as given above. The yield was recorded for 5 weeks (up to 3 flushes of mushroom) after pinning and the bags were randomly divided into 3 sets (I, II and III). One set (I) was kept in the cropping room as a control and its yield was recorded. In the second set (II), after the first flush of mushrooms, the old casing was removed, the polythene bags were closed at the top, and then each bag was inverted and re-cased after cutting open the

bags from the lower side. In third (III) set, the bags reversed and re-cased after second flush of mushroom. In set II and III 0.2% of formalin was sprayed after re-casing the bags with 3.5 cm of casing soil and set II and III were kept for case run at 21-25°C for 10 days and subsequently placed in the cropping room under controlled conditions (14-18 °C) along with set I. Final yield for all the sets were recorded. There were seven replications were maintained each with four bags.

RESULTS AND DISCUSSION

Effect of compost compactness on spawn run and yield of mushroom

The cultivation trial was conducted using standard cultivation practices for crop management, as described by Dhar *et al.* (2003). Table 4 shows that the treatment with 6" loose compost required the fewest days (11.33 days) for the spawn run, followed by the treatment with 6" pressed compost (12.33 days). On the other hand, the treatments with 12" loose compost took the longest (17.33 days) to complete the spawn run, followed by the treatments with 12" pressed compost (16.66 days).

Regarding the time to first harvest after casing, the shortest duration was observed in the 6" pressed compost treatment (15.33 days), followed by the 6" loose compost (16.33 days). The longest duration to first harvest after casing was recorded in the 12" loose compost treatment (19.67 days), followed by the 12" pressed compost (19.33 days). Statistical parity was observed among the treatments with 10" pressed, 10" loose, 12" pressed, and 12" loose compost. Additionally, treatments with 6" pressed, 10" pressed, and 10" loose compost were statistically similar to the 6" loose compost treatment. The maximum yield (16.33 Kg/100 Kg compost) was obtained from the 12" pressed compost, followed by the 12" loose compost (16.00 kg/100 kg compost). In contrast, the

Table 4. Effect of compost compactness on spawn run and yield of mushroom

Treatments	Mean no. of days taken for spawn run*	Mean no. of days taken for first harvest post casing*	Yield (kg/100 kg compost)*
6'' pressed	12.33	15.33	10.08
6'' loose	11.33	16.33	9.50
10'' pressed	14.00	18.00	14.20
10'' loose	15.00	18.33	13.00
12'' pressed	16.66	19.33	16.33
12'' loose	17.33	19.67	16.00
C.D _{0.05}	1.64	2.02	2.55

*- Average of three replications

minimum yield (9.50 kg/100 kg compost) was recorded from 6'' loose compost, followed by the 6'' pressed compost (10.08 kg/100 kg compost).

Compost bags with 12'' of compost produced higher yields in the present study, regardless of the compression level. This result can be attributed to the greater availability of air space and moisture per unit area of compost, which are critical factors for optimal mushroom growth. Achieving the optimum ratio of air space to water availability per unit area of compost through the highest level of compression in the compost-filled plastic bags may have facilitated enhanced growth of mushrooms. On the other hand, lower yields may have resulted from the disruption of one or more of these critical factors due to variations in compression levels.

In a study by Ahlawat and Manikandan (2014) on compost compression for white button mushroom cultivation, the shortest time to first harvest (17.66 days post-casing) and higher yield were observed in treatments where compost compressed to depths of 5'' and 3'' depth with perforated compost bags. Researchers worldwide have sought to enhance button mushroom yields by introducing modifications at various stages of button mushroom cultivation, including compost preparation (Sinden and Hauser,

1950, 1953; Straatsma *et al.*, 1994), cultivation system (Staunton, 1989), and so forth.

Effect of compost depth / height on spawn run and yield of mushroom

As per the results presented in Table 5, the treatment with a 10'' compost depth required the fewest days (15 days) for the spawn run while 19 days in the treatment with a 20'' compost depth. The treatments with 12'' and 14'' compost depth were statistically similar to the 10'' compost depth treatment while the 14'', 16'', and 18'' compost depth treatments were statistically comparable to the 20'' compost depth treatment. The shortest time to first harvest post-casing was observed with the 10'' and 12'' compost depth treatment (15 and 16.33 days). The longest time to first harvest was recorded in the 20'' compost depth treatment (20 days).

The highest yield (21.23 kg) was obtained from the 18'' compost depth treatment, followed by the 20'' compost depth treatment (19.50 kg). The lowest yield (13.41 kg) was recorded in the 10'' compost depth, followed by the 12'' compost depth treatment (15.51 kg). This increase in yield with deeper compost layers may be attributed to the prolonged availability of nutrition and vegetative mycelium. Additionally,

Table 5. Effect of compost depth/height on spawn run and yield of mushroom

Compost depth (inch)	Mean no. of days taken for spawn run (days)*	Mean no. of days taken for first harvest post casing*	Yield (kg/100 kg compost)*
10"	15.00	15.00	13.41
12"	16.67	16.33	15.51
14"	17.00	17.33	16.27
16"	17.33	18.00	17.95
18"	18.00	19.00	21.23
20"	19.00	20.00	19.50
C.D. _{0.05}	2.02	1.70	2.89

*- Average of three replications

compost bags with depths of 18" or 20" required less casing material due to the reduced surface area per unit of compost. This suggests a more efficient and economical use of resources as the required compost quantity occupies a smaller area.

In a previous study by Wu (1967), the effect of compost thickness on fruit body yield was examined across three different cropping room types. The highest fruit body yield was obtained with compost filled to a thickness of 9.53 with 49.50 kg compost/m² produced. In another study, polythene bags filled to a depth of compost up to 25 cm depth yielded a maximum of 13.8 kg of cut mushrooms per 100 kg of compost, followed by 12.9 kg at a 30 cm depth (Gupta *et al.*, 2004). Earlier studies did not examine

compost depths beyond 12", however in this study, results at 12" compost depth were comparable to those reported by Gupta *et al.* (2004). However, by increasing the compost depth to 18" resulted in higher yields.

Effect of bag perforation on spawn run and yield of mushroom

The data presented in Table 6 indicated that perforations in the compost bags had no significant effect on the duration of spawn run or the time to first harvest after casing. Furthermore, all compost bags remained disease-free across all treatment combinations studied. The treatment with 20 holes per bag produced a significantly higher yield (18.98 kg per

Table 6. Effect of bag perforation on spawn run and yield of mushroom

Number of Holes per bag	Mean no. of days taken for spawn run (days)*	Mean no. of days taken for first harvest post casing*	Disease Prevalence*	Yield (kg/100 kg compost) *
5 holes	15.75	18.00	Nil	16.25
10 holes	16.75	17.00	Nil	17.25
15 holes	17.75	17.75	Nil	18.39
20 holes	16.50	17.25	Nil	18.98
No holes (Control)	16.00	18.75	Nil	15.90
C.D. _{0.05}	N/S	N/S	-	1.998

*- Average of four replications

100 kg of compost) along with at par results in the treatment with 15 and 20 holes per bag (18.39 kg per 100 kg of compost). In contrast, the control treatment, with no holes in the compost bags, resulted in the lowest yield (15.90 kg per 100 kg of compost). These findings are consistent with a study by Ahlawat and Manikandan (2014), which demonstrated that compost bags with perforation produced higher fruit body yields. This can be attributed to the importance of air space and water availability per unit area of compost, which supports the observations made in the current study.

Effect of reversing the bags on yield of mushroom

Mushroom yield varied significantly among the un-reversed bags (control), bags reversed after the first flush, and bags reversed after the second flush as shown in Table 7. The yields for bags reversed after the second and first flushes were 24.62 kg and 20.93 kg per 100 kg of compost, respectively, while in control treatment yield was 15.21 kg per 100 kg of compost. The increased yields observed in the reversed bags compared to the control may be attributed to the presence of unutilized food reserves at the lower region of the bags, particularly in the bags filled to greater depths. Another possible reason for the lower yields in the control bags could be the presence of

diseases, pests, or a rapid decline in the pH of the casing soil after one or two flushes.

The shortest time to first harvest after casing (15.86 days) was observed in bags reversed after the first flush, followed closely by those reversed after the second flush (16.14 days). In contrast, the control treatment with no bag reversal required the longest time to first harvest after casing at 17.53 days. In the normal bags (control), the sporophores observed after the first two flushes, were often brownish in colour and infested with fly larvae. However, in the reversed bags, a robust flush comprising of white, healthier sporophores was observed. These findings are consistent with those of Bhandal and Mehta (1987), who also reported higher yields when re-casing was performed after reversing the compost bags.

CONCLUSION

This study demonstrated that modifications in the practices of cultivation of white button mushroom can actually change the spawn run and yield dynamics of the button mushroom. As the compost was more firmly pressed, the yield per bag increased. Similarly, when the compost depth was more the yield obtained was also comparatively higher than the others. It was also observed that perforation in the compost bag had no effect on the duration of the spawn run or the time to first harvest after casing. However, bags with more perforations produced a higher number of fruiting bodies compared to those with fewer or no perforations. Reversal of compost bags resulted in higher mushroom yields compared to non-reversed bags. Thus, this study demonstrates to establish cultivation techniques can significantly enhance button mushroom production.

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Table 7. Effect of reversing the bags on yield of mushroom

Treatments	Yield (kg/100 kg compost)*	Mean no. of days taken for pinning after reversal of bag*
Reversing of bags after first flush	20.93	15.86
Reversing of bags after second flush	24.62	16.14
No reversing (Control)	15.21	17.57
C.D_{0.05}	3.16	0.89

*- Average of three replications

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