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Physical parameters of casing materials on yield parameter of white button mushroom [*Agaricus bisporus* (longe. Imboch)]

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Abstract

Combinations of different casing mixture showed significant variation in water holding capacity with the maximum (95.95 per cent) in T₇ treatment (FYM + Soil + Sand (2:1:1)). Similarly, different casing mixture showed significant variation on bulk density varies from 37.75 – 65.40 per cent. The casing materials have ability to increase yield and yield parameters like length and diameter of stalk, thickness of pileus etc. of white button mushroom. The maximum length and diameter of stalk was found in T₇ - FYM + Soil + Sand (2:1:1), representing 3.04 cm and 2.84 cm., respectively. The significant variation on diameter and thickness of pileus (cm) was also found maximum in T₇ - FYM + Soil + Sand (2:1:1), representing 5.49 cm and 1.89 cm. against 4.01 and 1.14 cm. in case of control. The casing materials have ability to increase the fresh and dry matter on fruiting body of mushroom with maximum in T₇ - FYM + Soil + Sand (2:1:1), representing 1192.41 and 173.42 g, against 763.89 g and 82.8(g) in case of control.

Keywords: Physical, casing materials, yield parameter, white button mushroom, *Agaricus bisporus*

Introduction

Commercial production of edible mushrooms represents unique exploitation of the microbial technology for bioconversion of the agricultural, industrial, forestry and house- hold wastes into nutritious food. Indoor cultivation of mushrooms and utilizing the vertical space is regarded as the highest protein producer per unit area and time, almost hundred times more than the conventional agriculture and animal husbandry. Protein contents vary between 24 to 44% in *Agaricus* sp. The protein value of mushrooms is twice as that of asparagus and potato, four times as that of tomato and carrots, and six times as that of oranges. Their energy value also varies according to species, which is about equal to that of an apple (Adejumo and Awosanya, 2005) ^[1]. This hi-tech horticulture venture has a promising scope to meet the food shortages. It is gaining importance in recent years due to increasing global demand for protein. These are considered as source of protein, vitamins, fat, carbohydrates, amino acids and minerals. All essential amino acids are present as well as water-soluble vitamins. These are good sources of vitamins like riboflavin, biotin and thiamine, indicated that mushroom is about 16.5% dry matter out of which 7.4% is crude fiber, 14.6% is crude protein and 4.48% is fat and oil. The mushroom cultivation uses agro-waste efficiently and converts it into quality food, imparts environmental sustainability and helps in socio-economic upliftment of the common people. It is prepared from a mixture of organic materials subjected to a composting process for making it selective for growth of *A. bisporus*. Casing soil plays an important role in the cultivation of *A. bisporus*. Although many different materials may adequately function as a casing layer, peat is generally used and recommended as a good casing medium. This is because of its unique water holding and structural properties makes it widely accepted as ideal for the purposes of casing (Colak *et al.*, 2007) ^[6]. In the commercial cultivation of mushrooms, compost colonized with mushroom mycelium is covered with a 3-5 cm thick casing layer to initiate the development of sporophores. The main function of casing layer is the production of mushrooms in quantity. Casing layer, which is nutritionally deficient medium brings about important morphological changes from transition of vegetative growth to fruiting stage. Casing is generally done to make a surface where uniform fruitification can take place and to provide anchorage and essential reserves for developing sporophores of mushrooms (Shandilya,

2002). The aim of this study was to evaluate the effect of different casing materials on physical, growth parameters and yield of white button mushroom.

Material and Method

Collection of materials

Wheat straw was used of the studies as the base material. They were procured from the Kanpur market from the respective current year's harvest wheat straw used was 5-8 cm in length was used for compost preparation. Wheat grains were procured from local market. FYM manure was procured from the Dairy Farm at CSAUA&T Kanpur. Similarly, chemicals and other fertilizers were procured from a local dealer of Kanpur

Procedure for compost preparation

Compost by this method was prepared on a cemented platform which was thoroughly washed 24h before composting operation began. Other ingredients viz; wheat bran, urea DAP MoP, gypsum etc. were added to straw etc. were made into a heap and little quantity of water added so that these materials become moist. Later on this heap was covered with a gunny bag. On the following day wheat/paddy straw was thoroughly mixed with the ingredients and a pile measuring 5'x5'x length was made. More water was added to the pile if required. It was kept as such for 5 days. Temperature of the pile was constantly monitored with the help of stem thermometers. On 6th day first turning was given to the pile. Turning was given in such a manner that each and every portion got equal opportunity for aeration. Similarly, other turnings were given on 10th, 13th (gypsum added), 16th, 19th, 22nd, and 25th day. On 28th day compost was break opened, if no ammonia smell persisted then it was spawned and filled in polythene bags or in trays. If ammonia smell persisted, additional turning was given to the pile.

Cultivation

Fresh polythene bags were taken for conducting experiment in bags. Each polybag was filled with 4 Kg of compost. The bag was through spawning with freshly prepared spawn @ 2.5% through surface method system. The bags were then covered with newspaper sheets pre-sterilized with 0.5% formaldehyde solution and were later kept wet by sprinkling water regularly. The bags were kept for spawn running at 24±1C for 12-15 days or at lower temperature for more duration.

Casing

It was steam sterilized at 65°C for 4th. pH of the casing material was kept between 7.2-7.4. It was applied over fully spawn-run compost uniformly (4cm thick). Care was taken to keep the casing layer moist by spraying water regularly. Two-three years old farm yard manure and garden soil (1:1) was used as the casing mixture. Four test casing materials viz., farm yard manure (2-3 year old farm yard manure) (FYM), burnt rice husk (Ash), garden soil and sand were used to prepare casing mixture as describe below on below.

Experimental Details

- Number of treatments- 10
- Genotypes of *Agaricus* spp.
- Number of replication – 3
- Substrate- Wheat straw compost
- Quantity of compost per bag – 4 kg per bag
- Rate of spawning – 1-2 kg per quintal/ compost.
- Design – CRD.

Treatment Details

- T₁- FYM + Soil (2:1)
- T₂- FYM + Soil (1:1)
- T₃- FYM + Sand (2:1)
- T₄- FYM + Sand (1:1)
- T₅- FYM +Soil + Ash (2:1:1)
- T₆- FYM + Sand +Ash (2:1:1)
- T₇- FYM + Soil + Sand (2:1:1)
- T₈- FYM + Ash (3:1)
- T₉- FYM +Sand+ Ash (3:1:1/2)
- T₁₀- FYM (Control)

Cropping room

It was effective in well ventilated rooms which were fumigated with 2% formaldehyde before use. Desired humidity in the rooms was maintained by humidifier or by sprinkling water on floors or walls. Temperature of the growing room ranged between 12-18C during cropping. During December and January months artificial heating was done by heaters/hot air blowers to maintain the temperature at the optimum range. The observation were taken on the following parameters.

Observations recorded

- Length of stalk
- Diameter of stalk
- Diameter of pileus
- Thickness of pileus
- Dry weight and fresh weight

Determination of physical parameters

The physical parameters included particle density, bulk density, porosity and water holding capacity of different casing materials were determine as per following methods.

Bulk density

Bulk density was studied by core method (Singh, 1980). A large weighing bottle of about 50 ml capacity was weighed without stopper. It was filled with casing material and flushed up to the brim by tapping the bottle about 20 times and weighed again. Then the casing material was removed and bottle was filled with water by means of graduated pipette in order to note the exact volume of water needed to fill the bottle. Thereafter, the bulk was calculated by the following formula:

$$\text{Bulk density} = \frac{W_1 - W_2}{V} \text{ g/cm}^3$$

Where,

W₁ = Weight of empty bottle

W₂ = Weight of bottle and casing mixture

V = Volume of soil

Results and Discussion

Effect of different combination of materials on physical parameters of casing.

Water holding capacity (%)

Combinations of different casing mixture under the present study showed significant variation in water holding capacity. The, data presented in Table-1, showed that the water holding capacity was increased in all the treatments. The maximum water holding capacity was found in T₇ - FYM + Soil + Sand (2:1:1), representing 95.95 per cent, followed by T₅ - FYM +

Soil + Ash (2:1:1), representing 92.45 per cent and T₉ - FYM + Sand + Ash (3:1:1/2), representing 90.25 per cent. The minimum water holding capacity was recorded in T₁₀ - Control FYM, representing, 60.10 per cent. It is also cleared that all the casing mixture were statistically significant with respect to water holding capacity. Gierszynski (1974) [8] working with polish peat, sand and clay and concluded that water holding capacity was important character of a good casing medium. Peyvast *et al.* (2011) [16] reported that the required physical and chemical properties of a good casing should be high porosity and water holding capacity (WHC), 7.2-8.2 pH, low content of soluble inorganic and organic nutrients and free of disease and pests. Singh *et al.*, (2000) [20] used spent compost with 91.7% water holding capacity and farm yard manure with 191% water holding capacity but when used in combination of 1:1, 2:1, 1:3 of FYM and spent compost, the WHC was 141%, 109%, 121% respectively. Kalberer (1990) [10] also found the relation between decrease in moisture content of casing soil and increase in fruit body weight.

Bulk density (%)

Similarly, different casing mixture showed significant variation on bulk density. The data presented in Table-1, showed that the bulk density was increased in all the treatments. The maximum bulk density was found in T₇ - FYM + Soil + Sand (2:1:1), representing 65.40 per cent, followed by T₅ - FYM + Soil + Ash (2:1:1), representing 61.25 per cent and T₉ - FYM + Sand + Ash (3:1:1/2), presented 58.85 per cent. In case of control bulk density was recorded as 33.15 per cent. It is also cleared that all the casing mixture were statistically significant with respect to bulk density. Singh *et al.*, (2000) [20] various casing mixtures with 0.60-0.88 g cm³ were used to determine of the bulk density, physico-chemical properties of casing materials (Singh, *et al.*, 2000; Choudhary *et al.*, 2009; Polat *et al.*, 2008.) [20, 5, 17] According to them, casing sample as farmyard manure (FYM) + spent mushroom substrate (SMS) had minimum bulk density while the casing sample FYM + vermiculite (VC) showed relatively higher bulk density. Bels koning (1950) emphasized the importance of porosity so that proper gaseous exchange could take place. Kurtzman (1995) considered porosity as one of the most important characters of casing medium to get maximum crop yield.

Table 1: Effect of different of casing materials on water holding capacity and Bulk density of casing mixture

Treatment	Water holding Capacity %	Bulk density Capacity %
T ₁ =FYM + Soil (2:1)	84.50	54.70
T ₂ =FYM + Soil (1:1)	82.90	51.45
T ₃ =FYM + Sand (2:1)	73.75	42.30
T ₄ =FYM + Sand (1:1)	68.30	37.75
T ₅ =FYM +Soil+Ash (2:1:1)	92.45	61.25
T ₆ =FYM + Sand +Ash (2:1:1)	87.60	55.25
T ₇ = FYM + Soil + Sand (2:1:1)	95.95	65.40
T ₈ =FYM + Ash (3:1)	80.95	48.60
T ₉ = FYM +Sand+ Ash (3:1:1/2)	90.25	58.85
T ₁₀ = Control (FYM only)	60.10	33.15
SEm±	1.400	0.739
CD at 5 %	4.158	2.195

Effect of different casing mixture on yield parameters of White button mushroom

Length of stalk (cm)

The casing materials have ability to increase yield and yield parameters like length and diameter of stalk, thickness of pileus etc. of white button mushroom. The data presented in Table-3, showed that the length of stalk (cm) was increased in all the treatments. The maximum length of stalk (cm) was found in T₇ - FYM + Soil + Sand (2:1:1), representing 3.04 cm, followed by T₅ - FYM + Soil + Ash (2:1:1), as 2.97 cm and T₉ - FYM + Sand + Ash (3:1:1/2), represented 2.94 cm. against 1.69 cm in case of Control (FYM)T₁₀. From the Table it is also cleared that all the treatments increase length of stalk (cm) over control.

The casing layer influences yield, quality and uniformity of cropping of the button mushroom. Thus, mushroom productivity, size and mass are directly affected by the casing layer. The casing soil is reported to possess certain physical, chemical and microbiological properties having stimulatory role in *Agaricus* fruiting (Ahlawat 2002) [2]. Athar (1986) stated that *Pleurotus ostreatus* completed spawn running in 17-20 days on different substrates and time for pinheads formation was noted as 23-27 days with variable length of stipe.

Diameter of stalk (cm)

Different casing mixture showed significant variation on diameter of stalk (cm). The data on the diameter of stalk (cm)

presented in Table- 2, showed that the diameter of stalk (cm) was increased in all the treatments as compare to control. The maximum diameter of stalk (cm) was found in T₇ - FYM + Soil + Sand (2:1:1), representing 2.84 cm, followed by T₅ - FYM +Soil + Ash (2:1:1), representing 2.69 cm and T₉ - FYM + Sand + Ash (3:1:1/2), as 2.59 cm. Among the treatments, the minimum diameter of stalk (cm) was recorded in T₁₀ treatment representing, 2.09 cm. It is also cleared from the table that all the casing mixture was statistically significant with respect to diameter of stalk (cm). Casing material is used in mushroom to cover a nutritional rich composted substrate colonized with mycelium, and has an essential function in stimulating and promoting the development of sporophores (Noble and Pennington 2005) [13]. Onokpise *et al.* (2007) [14] established that palm kernel cake improves the thickness of fruiting bodies of mushroom species. This increase in thickness of the stipe was recorded at maturity in mushrooms grown in variable substrates.

Diameter of Pileus (cm)

The different casing mixture showed significant variation on diameter of pileus (cm). The data presented in Table-3, showed that the diameter of pileus (cm) was increased in all the treatments. The maximum diameter of pileus (cm) was recorded in T₇ - FYM + Soil + Sand (2:1:1), representing 5.49 cm, against 4.01 cm in case of control. The T₅ treatment- FYM +Soil + Ash (2:1:1), representing the value 5.34 cm which is second highest among the treatments. From the table, it is

cleared that all the treatments, increase the diameter of pileus (cm) over control. It is also cleared that all the casing mixture were statistically significant with respect to diameter of pileus (cm). Similar finding was reported by Ram and Kumar (2010) [18]. Pardo 2004 and Singh *et al.*, (2000) [20] evaluated different casing materials for the cultivation of button mushroom. Jarial and Shandilya (2005) [9] also proved that municipal waste based vermi compost (HWBV) in combination with other casing materials was evaluated as a casing substrate for *A. bisporus*. Zerihun Tsegaye (2015) found that mixture of cotton waste and coffee pulp yielded the highest total weight and number of fruit bodies and also had a wider pileus diameter.

Thickness of pileus (cm)

The pileus of mushroom was cut with Sharpe knife and thickness of pileus was measure. The data presented in Table-3, showed that the thickness of pileus (cm) with 2.04cm was increased in all the treatments. The maximum thickness of pileus (cm) was found in T₇ - FYM + Soil + Sand (2:1:1), followed by T₅ - FYM +Soil + Ash (2:1:1), treatments 1.89

cm. Among the treatment the minimum Thickness of pileus (cm) was recorded in representing, 1.14 cm. It is also cleared from the table that all the casing mixture were statistically significant with respect to thickness of pileus (cm). The initiation and growth of mushroom sporophores depend not only on the genetic capacity of the mycelium to yield fruit, but also on physical, environmental, chemical, nutritive and microbiological factors (Pardo *et al.*, 2002a, b). Similar result was reported by Dhar *et al.*, (2006) were used eight commonly available casing materials in India *viz*, FYM, SMC, CCP, MG, VC, Terracare-A, Terracare-B and FYM+ SMC to identify the suitable casing materials for use in button mushroom cultivation and coir pith result as early pinning and significantly higher number of fruit bodies and total yield. This result also conforms with the findings of Pardo 2004 and Singh *et al.*, (2000) [20] evaluated different casing materials for the cultivation of button mushroom. Jarial and Shandilya (2005) [9] also proved that municipal waste based vermi compost (HWBV) in combination with other casing materials was evaluated as a casing substrate for *A. bisporus*. Similar finding was reported by Ram and Kumar (2010) [18].

Table 2: Effect of different casing mixture on yield parameters of White Button mushroom

Treatments	Length of stalk (cm)	Increase in stalk length over control (%)	Diameter of stalk (cm)	Increase in Diameter of stalk over control (%)	Diameter of Pileus (cm)	Increase in Diameter of Pileus over control (%)	Thickness of pileus (cm)	Increase in Thickness of pileus over control (%)
T ₁	2.44	44.37	2.44	16.74	4.95	15.11	1.64	43.85
T ₂	2.44	44.38	2.40	14.83	4.84	12.55	1.54	35.08
T ₃	2.24	32.54	2.34	11.96	4.59	6.74	1.29	13.15
T ₄	2.19	29.58	2.24	7.17	4.49	4.41	1.24	8.77
T ₅	2.97	75.73	2.69	28.70	5.34	24.18	1.89	65.78
T ₆	2.64	56.21	2.54	21.53	5.09	18.37	1.72	50.87
T ₇	3.04	79.88	2.84	35.88	5.49	27.67	2.04	78.94
T ₈	2.34	38.46	2.34	11.96	4.74	10.23	1.44	26.31
T ₉	2.94	65.08	2.59	23.92	5.24	21.86	1.79	57.01
T ₁₀	1.69	-	2.09	-	4.01	-	1.14	-
SEM±	0.037	-	0.029	-	0.090	-	0.024	-
CD at 5%	0.109	-	0.087	-	0.267	-	0.072	-

T₁ - FYM + Soil (2:1), T₂ - FYM + Soil (1:1), T₃ - FYM + Sand (2:1) T₄ - FYM + Sand (1:1), T₅ - FYM +Soil+Ash (2:1:1), T₆ - FYM + Sand +Ash (2:1:1) T₇ - FYM + Soil + Sand (2:1:1), T₈ - FYM + Ash (3:1) T₉ - FYM +Sand+ Ash (3:1:1/2) and T₁₀ - Control FYM

Effect of different type of casing mixture on fresh and dry weight of mushroom White button mushroom

Fresh weight (g)

The casing materials have ability to increase the fresh and dry matter on fruiting body of mushroom. The data presented in Table-5, showed that the fresh weight (g) was increased in all the treatments. The maximum fresh weight (g) was recorded in T₇ - FYM + Soil + Sand (2:1:1), representing 1192.41 against 763.89 g in case of control which is increased by 56.6 per over control. The treatment T₅ - FYM + Soil + Ash (2:1:1), representing 1144.02 g indicating second highest among the treatments. From the table, it is cleared that different casing mixture showed significant variation of fresh weight of mushroom. It is also cleared that all the casing mixture were statistically significant with respect to fresh weight (g) of mushroom. Sarker and Chowdhury (2013) reported that the concentration level 10 ppm and 20 ppm produced the highest number of effective fruiting body. This similar finding has also been reported by Day *et al.*, (2007). Nirdesh and S. K. Biswas (2019) found that *Pleurotus sajor caju* was harvested in 5 flushes, the maximum yield was obtained in the first flush, than the second and third flushes in all the treatments. They also found that the maximum yield with 1483 gm per bag was obtained from combination of

substrates as 3/4 wheat straw+1/4 mustard straw+100gm wheat bran. Kaur and Atri, (2016) [11] found that the maximum yield was obtained with GA₃ when sprayed at pin head formation as comparison to IBA and IAA.

Dry weight (g)

Similarly different casing mixture showed significant variation on dry weight (g) of mushroom. The data presented in Table-5, showed that the dry weight (g) was increased in all the treatments. The maximum dry weight (g) was found in T₇ - FYM + Soil + Sand (2:1:1), representing 173.42 g, followed by T₅ - FYM + Soil + Ash (2:1:1), representing 154.3 g and T₉ - FYM + Sand + Ash (3:1:1/2), presented 147.2 g. The minimum dry weight (g) was recorded in T₁₀ - Control FYM, representing, 82.8(g). Ahlawat and Vijay (2000) [4] reported yield stimulatory effect of different micro-nutrients and growth hormones on *A. bisporus* button mushroom. The spray of 0.1 per cent verdex (commercial formulation of Indole butyric acid) resulted in significantly higher mushroom yield at the pinhead initiation state of the first three flushes of the cropping. Xavier and Kumuthakalavalli (2001) reported that application of indole acitic acid (IAA), Gibberallic acid (GA₃) and kenetin (50 ppm and 100 ppm) were increased the yield up to 46.8 and 37.8 percentage respectively over the control.

Table 3: Effect of different type of casing mixture on fresh and dry weight of White button mushroom

Treatment	Fresh weight (g)	Percentage increase in fresh weight over control	Dry weight (g)	Percentage increase in dry weight over control	
T ₁	1089.15	42.56	132.5	29.69	
T ₂	1063.46	39.19	125.75	22.51	
T ₃	988.25	29.35	108.6	7.73	
T ₄	871.68	14.05	96.75	4.84	
T ₅	1144.02	48.30	154.3	14.13	
T ₆	1122.36	46.90	141.15	6.70	
T ₇	1192.41	56.6	173.42	8.553	133.38
T ₈	1118.77	46.43	119.4	10.00	130.82
T ₉	1135.48	49.93	147.2	11.81	130.55
T ₁₀	763.89	-	82.8	-	-
SEm±	19.370		2.000		
CD at 5%	57.544		5.943		

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