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Influence of different casing material on growth parameters and yield of white button mushroom (*Agaricus bisporus* (Longe. Imboch)

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Abstract
Agricus bisporus are edible mushroom which have excellent nutritional value, and are very popular for their delicacy and medicinal properties. Influence of different casing material on growth parameters and yield of *A.bisporus.* Different casing mixture showed significant variation on average number of days for pin head initiation after casing. The data presented in Table-2, showed that the minimum average number of days for pin head initiation after casing was found in T_7 - FYM + Soil + Sand (2:1:1), representing 17 days which was followed by T_5 - FYM + Soil + Ash (2:1:1), representing 18 days and T_9 - FYM + Sand + Ash (3:1:1/2), presented 19 days.in Table-2, showed that the minimum with 26 days number of days require for first harvesting was found in T_7 - FYM + Soil + Sand (2:1:1), and The maximum number of days require for last harvesting was found in T_7 - FYM + Soil + Sand (2:1:1), representing 35 days. Fruiting ability of *A. bisporus* was significantly affected by different casing mixture combinations. The observations of fruiting ability of *A. bisporus* was taken at 1st, 2nd, 3rd and 4th flush. The data presented in Table- 2, showed that the fruiting ability of *A. bisporus* increased in all the treatments. The maximum fruiting ability of *A. bisporus* was recorded in T_7 - FYM + Soil + Sand (2:1:1),, representing 290.24, 332.39, 317.24 and 252.54 gm against 192.54, 230.26, 210.54 and 110.64gm in case of control at 1, 2, 3, and 4th flushed respectively.

Keywords: Casing material, growth parameters, yield, white button mushroom, *Agaricus bisporus*

Introduction
Mushrooms are edible fruiting bodies of fungi which have excellent nutritional value, and are very popular for their delicacy and medicinal properties. The Greeks believed that mushroom provide strength for warriors in battle and Romans regarded them as "Food of Gods" or "Gods Flesh", which were served only on festive occasion. Mushrooms are also known as "Flower of God". In India, mushrooms are widely known as "*Dharti ka phool*", "*Khumbi*", "*Chhatra*", "*Kukurmutta*", "*Dhengri*", "*Doodhchatta*" etc. Mushroom is in various shape, size, colour and aroma and can be produced in various agro-climatic conditions. Generally cultivated mushrooms are saprophytic and absorb nutrition from organic matter which is produced by plants or animal. In natural, mushroom grow wild in almost all types of decaying organic matter, fallen leaves, animal droppings and stumps of dead woods etc. it can survive a variety of environmental condition from snowy mountains to sandy deserts on all type of soil, pastures, forests, cultivated field, water channels, manure heaps, bunds and grassy grounds. However, growth, growth parameter and yield are influence of substrate and environmental conditions (Nirdesh *et al*. 2019, Saber *et al.*, 2010) [5]. Casing soil plays an important role on production, productivity and quality parameter of *A. bisporus.* Various materials may adequately function as a casing layer like FYM (2-3 years old), combination of garden soil, FYM, peat, sand, ash etc is generally used and recommended as a good casing medium (Colak *et al.*, 2007) [1]. Casing layer is nutritionally deficient medium which brings about important morphological changes from transition of vegetative growth to fruiting stage (Shandilya, 2002) [13]. Keeping the above point on view the study was undertaking Influence of different casing material on growth parameters and yield of white button mushroom (*Agaricus bisporus* (longe. Imboch) in the present investigation.

Materials & Methods
Collection of materials: The prepared spawn was collected from Mushroom Research and Development Center, Department of Plant Pathology, C.S. Azad University of Agriculture & Technology, Kanpur. Wheat straw was used of the studies as the base material were procured from the student research farm CSAUA & T, Kanpur. Similarly, chemicals and other fertilizers

were procured from a local dealer were used for compost preparation.

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
T_1- FYM + Soil (2:1)
T_2- FYM + Soil (1:1)
T_3- FYM + Sand (2:1)
T_4- FYM + Sand (1:1)
T_5- FYM +Soil + Ash (2:1:1)
T_6- FYM + Sand +Ash (2:1:1)
T_7- FYM + Soil + Sand (2:1:1)
T_8- FYM + Ash (3:1)
T_9- FYM +Sand+ Ash (3:1:1/2)
T_{10}- 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
I. Days taken for spawn run.
II. Days taken for pin head formation after casing
III. First harvesting days
IV. Last Harvesting days after first harvest
V. Yield data (Number and weight of fruiting bodies per replication).

Biological efficiency
Biological efficiency of substrate was calculated by using following formula-

$$\text{Biological efficiency} = \frac{\text{Fresh weight of fruit body}}{\text{Dry weight of substrate}} \times 100$$

Results
Effect of different type of casing mixture on growth parameters of White button mushroom
Number of days for spawn running: The data presented in (Table- 1) showed that the spawn running days are almost same in the all the treatments representing 13-14 days.

Average number of days for pin head initiation after casing
Different casing mixture showed significant variation on average number of days for pin head initiation after casing. The data presented in Table-2, showed that the minimum average number of days for pin head initiation after casing was found in T_7 - FYM + Soil + Sand (2:1:1), representing 17 days which was followed by T_5 - FYM + Soil + Ash (2:1:1), representing 18 days and T_9 - FYM + Sand + Ash (3:1:1/2), presented 19 days. Among the treatment the maximum average number of days for pin head initiation after casing was recorded in T_{10} - Control FYM, representing, 24 days. From the table-2 it is clear that all the treatments decrease average number of days for pin head initiation after casing over control. It is also cleared that all the casing mixture were statistically significant with respect to number of days for pin head initiation after casing. Sassine *et al.*, (2005) [11] also found an immense difference between the numbers of pin heads of *A. bisporus* treated with various casing materials. Pal *et al.*, (2014) found that two to three weeks were require for spawn running. Shah *et al.* (2004) [12] found that the fruiting bodies appeared 3 -6 weeks after pinhead formation and took 27 -34 days later after inoculation of spawn.

Number of days require for first harvesting
Similarly the data on number of days require for first harvesting data presented in Table-2, showed that the minimum with 26 days number of days require for first harvesting was found in T_7 - FYM + Soil + Sand (2:1:1), followed by T_5 - FYM + Soil + Ash (2:1:1), representing 27 days and T_9 - FYM + Sand + Ash (3:1:1/2), presented 28

days. The highest number of days require for first harvesting was recorded in T_{10} - control, representing, 32 days. From the table, it is cleared that different casing mixture showed significant variation on number of days for first harvesting. Pardo 2004 and Singh *et. al*., (2000) [14] evaluated different casing materials for the cultivation of button mushroom. Jarial and Shandilya (2005) [3] also proved that municipal waste based vermi compost (HWBV) in combination with other casing materials was evaluated as a casing substrate for *A. bisporus*. They proved that casing material like vermi-compost considerably affected crop period of *A. Bisporus*. Nirdesh *et a*l. (2019) [5] reported that different combinations of substrates gave variable response on spawn running, pin head formation and harvesting days of *Pleurotus sajor caju.*

Duration last harvesting

The casing materials have ability to increase the duration of harvesting days. The data presented in Table-2, showed that the number of days require for last harvesting was increased in all the treatments. The maximum number of days require for last harvesting was found in T_7 - FYM + Soil + Sand (2:1:1), representing 35 days as against 25 days in case of contact the treatments T_5 - FYM + Soil + Ash (2:1:1), representing 32 days duration of last harvesting, indicating second highest among the treatment. It is also cleared from the table that all the casing mixture were statistically significant with respect to number of days require for last harvesting. Quimio (1976, 1978) [8, 9] reported that fruiting bodies appeared 3 -4 weeks after inoculation of spawn. Nirdesh *et al*. (2019) [5] found that the 21 – 36 days was required for ready to harvest the crop in various combinations of substrates. Zerihun Tsegaye (2015) [16] found that the number of fruiting bodies recorded is related to their mycelia colonization. Sarker and Chowdhury (2013) [10] reported that the concentration level 10 ppm and 20 ppm produced the highest number of effective fruiting body.

Table 1: Effect of different type of casing mixture on growth parameters of White button mushroom

Treatment	Average number of days for spawn running	Average number of days for pin head initiation after casing	Number of days require for first harvesting	Number of days require for last harvesting
T_1	14	21	30	30
T_2	14	22	31	29
T_3	14	21	30	28
T_4	14	22	29	26
T_5	13	18	27	32
T_6	14	21	29	28
T_7	13	17	26	35
T_8	14	21	29	29
T_9	14	20	28	32
T_{10}	14	24	32	25
SEm±	0.264	0.966	1.080	1.121
CD at 5%	0.785	3.114	3.209	3.329

T_1 - FYM + Soil (2:1), T_2 - FYM + Soil (1:1), T_3 - FYM + Sand (2:1) T_4 - FYM + Sand (1:1), T_5 - FYM +Soil+Ash (2:1:1), T_6 - FYM + Sand +Ash (2:1:1) T_7 - FYM + Soil + Sand (2:1:1), T_8 - FYM + Ash (3:1) T_9 - FYM +Sand+ Ash (3:1:1/2) and T_{10} - Control FYM

Effect of different type of casing mixture on fruiting ability and harvesting of White button mushroom

Fruiting ability of *Agaricus bisporus* (g)

Fruiting ability of *Agaricus bisporus* was significantly affected by different casing mixture combinations. The observations of fruiting ability of *Agaricus bisporus* was taken at 1st, 2nd, 3rd and 4th flush. The data presented in Table-4, showed that the fruiting ability of *A. bisporus* increased in all the treatments. The maximum fruiting ability of *A. bisporus* was recorded in T_7 - FYM + Soil + Sand (2:1:1),, representing 290.24, 332.39, 317.24 and 252.54 gm against 192.54, 230.26, 210.54 and 110.64gm in case of control at 1, 2, 3, and 4th flushed respectively. The T_5treatment as FYM + Soil + Sand (2:1:1) representing 282.50, 325.39, 300.64 and 224.49gm indicating second highest among the treatments. From the table is clear that the yield of forth flush was reduced as compared to the 1st, 2nd and 3rd flush and there was significant difference among all the casing mixtures. It is also cleared that all the casing mixture were statistically significant with respect to fruiting ability of *A. bisporus*. Chaurasia *et al.* (2019) [2] found that the maximum amount of total fresh weight of *P. florida* was obtained from gibberellic acid treatment at concentration of 10 ppm, representing the values 410, 371, 308 and 235 gm per bag at 1st, 2nd,3rd and 4th harvesting, respectively.

As per concern on the yield, the maximum yield with 1192.41 gm was obtained from T_7treatment which was followed by T_5 treatments as FYM + soil + ash (2 :1:1) with 1133.02 gm. It may be consolidated from the table that casing materials influence the fruiting ability and yield of white button mushroom. 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). Kaur and Atri, (2016) [6, 4] found that the maximum yield was obtained with GA_3 when sprayed at pin head formation as comparison to IBA and IAA. Xavier and Kumuthakalavalli (2001) [15] reported that application of indole acitic acid (IAA), Gibberallic acid (GA_3) and kenetin (50 ppm and 100 ppm) were increased the yield up to 46.8 and 37.8 percentage respectively over the control.

Table 2: Effect of different type of casing mixture on fruiting ability and harvesting of *Agaricus bisporus*

Treatments	Fruiting ability of *Agaricusbisporus* (g)				Total weight of fruiting body production (g)	Yield increase over control (%)
	1th (g)	2th (g)	3th (g)	4th (g)		
T_1	262.78	305.04	295.74	225.59	1089.15	42.56
T_2	261.74	299.79	285.59	216.34	1063.46	39.29
T_3	243.14	283.34	268.43	193.34	988.25	29.25
T_4	226.29	254.94	233.49	156.96	871.68	14.09
T_5	282.50	325.39	300.64	224.49	1133.02	48.30
T_6	270.64	310.24	310.24	231.24	1122.36	46.90
T_7	290.24	332.39	317.24	252.54	1192.41	56.06
T_8	258.09	285.24	271.09	204.35	1118.7	46.47
T_9	276.79	315.64	295.50	236.55	1144.48	49.93
T_{10}	192.54	230.26	210.54	110.64	763.98	-
SEm±	3.464	5.577	3.640	2.797	19.370	-
CD at 5 %	10.290	16.568	10.814	8.310	57.544	-

T_1 - FYM + Soil (2:1), T_2 - FYM + Soil (1:1), T_3 - FYM + Sand (2:1) T_4 - FYM + Sand (1:1), T_5 - FYM +Soil + Ash (2:1:1), T_6 - FYM + Sand +Ash (2:1:1) T_7 - FYM + Soil + Sand (2:1:1), T_8 - FYM + Ash (3:1) T_9 - FYM +Sand+ Ash (3:1:1/2) and T_{10} - Control only FYM

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