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Evaluation of the different substrates for composting in the cultivation of *Agaricus bisporus* under the agro-ecological conditions of West Bengal

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ABSTRACT

Mushrooms offer a nutrient-dense, low-fat dietary option while serving as an eco-friendly solution for repurposing agricultural waste through cultivation. The study focuses on cultivating *Agaricus bisporus*, or button mushrooms, in the lateritic belt of West Bengal, India, using the Long Method of Composting. Various substrates—paddy straw, maize stalks, and combinations thereof were evaluated. Results show that the 1:1 ratio of paddy straw and maize stalks yielded the best outcomes, with the shortest spawn run period (20.33 days), earliest pinhead formation after casing (15.33 days), and highest number of sporophore (92 per 8 kg compost bag). This substrate also led to the earliest first harvest (9.33 days after flushing), highest yield (1020.00 g/8 kg bag), and biological efficiency (12.75%). Conversely, maize stalk compost had the lowest yield (643.33 g/8 kg bag) and biological efficiency (8.04%), and was susceptible to *Coprinus* infestation. Overall, Paddy straw + Maize stalk (1:1) compost proved superior, offering faster cultivation and higher yields, making it the optimal choice for *A. bisporus* cultivation.

Keywords: Button mushroom, composting, substrates, yield, biological efficiency

Mushrooms have a rich cultural significance around the world, often being associated with festivities and revered as valuable sources of nutrition. The term "mushroom" derives from the French "mousse" or "mousseron," which translates to champignon or fungus, reflecting their historical importance in various cuisines. In Romanian tradition, mushrooms are considered "God's flesh" or "God's Food," while the Chinese view them as the "Elixir of Life." The science of fungi, known as mycology, delves into the intricate world of mushrooms, with *Agaricus bisporus*, commonly known as the white button mushroom, holding particular prominence.

In the cultivation of *A. bisporus*, the substrate or compost plays a crucial role, providing the necessary nutrients for the mushroom mycelium to thrive and eventually produce mushrooms. A considerable amount of agricultural residue, such as straw, leaves, and stems, is left unused and contains abundant lignocellulose, rendering it suitable for growing champignon mushrooms (Zandrazil, 1978). *A. bisporus*, as a heterotrophic organism, depends entirely on its growth substrate to fulfill its carbon, water, nitrogen, and mineral nutritional needs. Compost preparation stands as a crucial aspect of *A. bisporus* cultivation, typically employing three composting methods: the long method, short method, and indoor method. Various composting methods have been developed to prepare the substrate, each with its own advantages and challenges. Compost preparation involves the breakdown of agricultural

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wastes such as paddy straw, wheat straw, or maize stalks, often with the addition of nitrogen sources to enhance microbial activity. The long composting method involves an outdoor process lasting 4-6 weeks (Atkins, 1966). This method entails various steps such as moistening the ingredients and substrates, blending them together, and regularly turning the mixture until completion, which usually takes around 28 days.

Numerous studies have explored different compost formulations and substrates to optimize mushroom cultivation. Studies have explored various compost formulations for the cultivation of *A. bisporus*, with notable findings indicating that a mixture of wheat straw and paddy straw at a 1:2 ratio yields the highest production (Kaur and Khanna, 2002). Additionally, investigations into substrates for milky mushroom (*Calocybe indica*) cultivation have shown that paddy straw substratum produces the maximum yield and biological efficiency, while maize stalks can enhance yield potential when combined with paddy straw (Pani, 2010). Researches also suggest that alternative materials such as grass and maize stalks can yield significantly higher mushroom production compared to conventional horse manure (Kariaga *et al.,* 2012), while Rawal and Doshi (2014) evaluated various combinations of wheat and paddy straw for milky mushroom cultivation. Moreover, experiments with corn stover as a substitute for straw-based compost have shown promising results, indicating its potential in regions with limited straw supplies (Pecchia *et al.,* 2016). Furthermore, investigations into substrate combinations for oyster mushroom cultivation have found that a combination of paddy straw and wheat straw yields the highest production (Sinha, 2018).

In West Bengal, the cultivation of button mushroom is not very popular due to unavailability of wheat straw, while the available paddy straw is reported to be poor yielder. Thus, the present study is aimed to identify the available substrate suitable for composting for button mushroom.

MATERIALS AND METHODS

The research experiments were conducted at the Mushroom Research Laboratory, Department of Plant Pathology at Palli Siksha Bhavana (Institute of Agriculture), located in Sriniketan, Birbhum district, West Bengal. The study employed a Completely Randomized Design, with each treatment being replicated three times for statistical reliability.

Compost preparation

The compost preparation in this study was conducted employing the Long Composting method, as illustrated in Fig 1. The formula used for compost composition included 150 kg of chopped straw (substrate) and 7.5 kg of wheat bran. Additionally, nitrogen sources such as urea (1.5 kg) and single super phosphate (1.5 kg), as well as potassium sources like muriate of potash (1.5 kg) and calcium ammonium nitrate (4.5 kg), were incorporated. To enhance the physical properties of the compost and aid in nutrient availability, gypsum was added at a rate of 10 kg. This meticulously crafted compost mixture provided the necessary organic matter and nutrients essential for the growth and development of *A. bisporus*, contributing to successful mushroom cultivation. The compost was prepared as per the methodology given by Vijay (2011). The whole process took 28 days to complete.

Evaluation of the different substrates for composting in the cultivation of *A. bisporus*

Paddy straw and wheat straw are commonly utilized as compost materials for mushroom cultivation. This study aims to assess the effectiveness of different proportions of composting substrates, specifically paddy straw and maize stalks. Each treatment consists

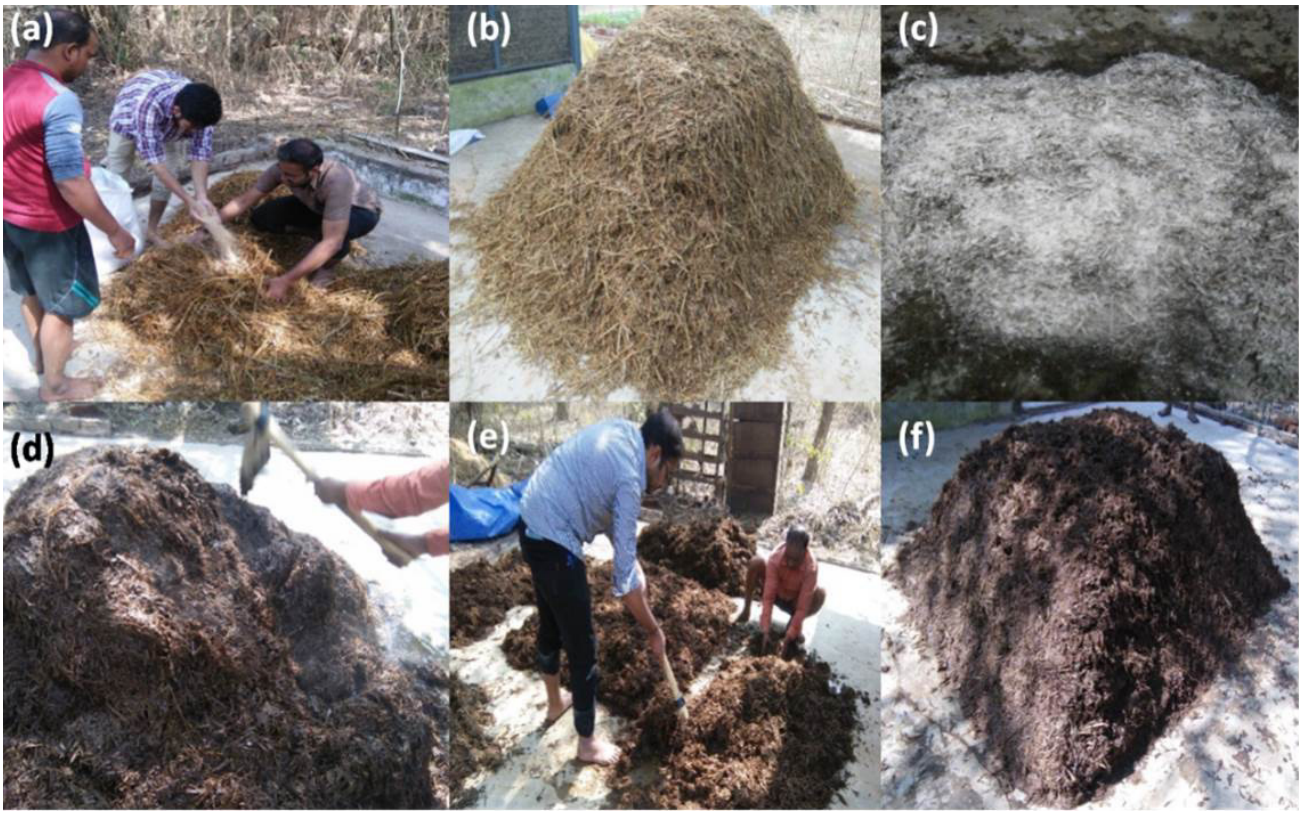

Fig. 1. Steps involved in Compost preparation. (a)Mixing ingredients with substrate, (b) Pile formation, (c) Addition of gypsum, (d) Turning of compost, (e) Re-pile formation, (f) Final compostTop of Form

of three replications, with T1 involving a mixture of paddy straw and maize stalks in a 1:1 ratio, T2 utilizing paddy straw alone, and T3 using maize stalks alone. The composting process for each treatment follows the Long method and takes approximately 28 days to complete and the formalin was used for sterilizing the compost.

Mushroom bed preparation and spawning

After the compost preparation process, it is transferred into polyethylene bags, with a typical spawning rate ranging of 1%. In present study, S-11 strain spawn was utilized through layer spawning method. Subsequently, the bags filled with compost were moved to the cropping room and maintained at a temperature of 24°C with a relative humidity of 90%. Once the spawn run was completed, typically within a span of 15 days, the bags were prepared for casing.

Casing Material

During the spawn run phase, the necessary casing materials were collected. Components such as garden soil are sourced from the Experimental Farm within the Department of Agronomy at Visva-Bharati, Sriniketan. Farmyard manure was obtained from the Model Dairy and Poultry Farm associated with the Department of Animal Science at Visva-Bharati, Sriniketan.

Casing of the Beds

Upon completion of the spawn run, indicated by the uniform white mycelial growth of *A. bisporus*, the sterilized casing materials were evenly spread over

the bed surface to a depth of 4 cm. The beds were maintained at a temperature range of 24-26 °C for 10 days and subsequently at 16-18°C with a relative humidity of 85% for fructification.

Yield and Biological Efficiency

The internationally recognized standard for harvesting button mushrooms is characterized by a closed viel, a stem length not exceeding 2 cm (3/4 inch), and a cap diameter ranging from 2.5 to 6 cm (1-2.5 inches). Harvesting was carried out when the cap diameter is twice the length of the stem. Biological efficiency is calculated using the formula:

$$\text{Biological efficiency (\%)} = \frac{\text{Weight of Fresh Mushroom (g)}}{\text{Weight of Compost (g)}} \times 100$$

RESULTS AND DISCUSSION

To evaluate the most effective composting substrate for button mushroom cultivation in the lateritic belt of West Bengal, different substrates including a mix of paddy straw and maize stalks (in a 1:1 ratio), pure paddy straw, and pure maize stalks were subjected to Long Composting Method. The study aimed to assess their impact on various growth parameters such as spawn run period, duration of pinhead formation, days to first harvest, number of fruiting bodies harvested, average weight of a fruiting body, yield, and biological efficiency (Fig 2). The results of all parameters are summarized in Table 1.

Time for spawn run and primordial initiation

Paddy straw + Maize stalk (1:1) compost showed an early spawn run period (20.33 days), followed by paddy straw compost (22.67 days) and Maize stalk compost (27.0 days). Paddy straw + Maize straw compost (1:1) compost beds initiated early pinhead formation (15.33 days) and gave the first harvest on (9.33 days) followed by paddy straw compost (17.33 and 11.33 days) and maize stalk compost (20.67 and 14.00 days) (Fig. 3).

Production of sporophores

The effect of different composting substrates was measured by the number of sporophores they produced and the maximum number of sporophores (92/8 kg compost bag) was obtained from paddy straw + maize stalks (1:1) compost followed by (74/8 kg compost bag) from paddy straw compost. The average number of sporophores obtained from the maize stalks compost was found to be minimum (51/ 8 kg compost bag) (Fig. 4).

Performance on Yield and Biological efficiency

The key criterion for testing the effect of the various substrates used for composting in the

Table 1. Evaluation of the different substrates for composting in the cultivation of White Button mushroom (*A. bisporus*)

Treatments	SRP	DFPF	DFFH	No. FH	Yield(g)	B.E(%)	Remarks
Paddy straw + Maize stalk (1:1) compost	20.33	15.33	9.33	92	1020.00	12.75	-
Paddy straw compost	22.67	17.33	11.33	74	826.67	10.33	-
Maize stalk compost	27.00	20.67	14.00	51	643.33	8.04	*Coprinus* Sp.
SE(m)(±)	0.72	0.67	0.54	1.29	6.60	0.08	
CD @ 1%	2.49	2.31	1.88	4.47	22.83	0.29	
CV %	5.35	6.50	8.16	3.09	1.38	1.39	

SRP – Spawn Run Period, DFPF – Days for Pinhead Formation, DFFH – Days for First Harvest, No.FH – Number of Fruiting bodies Harvested, B.E – Biological Efficiency

Fig. 2. Steps involved in production of sporophores of *A. bisporus*. (a) Spawning of compost, (b) Bag filling of compost, (c) Incubation, (d) Spawn run initiation, (e) Spawn run completed bag, (f) Casing of beds, (g) pinhead initiation, (h) Developing pinheads, (e) Matured sporophores

cultivation of *A. bisporus* was yield and biological efficiency. The maximum yield and biological efficiency were observed from Paddy straw + Maize stalk (1:1) Compost beds (1020.00 g/8 kg bag and 12.75 %) followed by Paddy straw compost beds (826.67 g/8 kg bag and 10.33 %). Minimum yield and biological efficiency were obtained from Maize stalk compost beds (643.33 g/8 kg bag and 8.04 %) which also invites the weed fungus, *Coprinus* spp. in beds. All the treatments differed significantly from each other (Fig. 5).

The results of the present studies clearly showed that Paddy straw + Maize stalks (1:1) combination is best for making compost which gives lesser days for spawn run, early pinhead formation, and highest

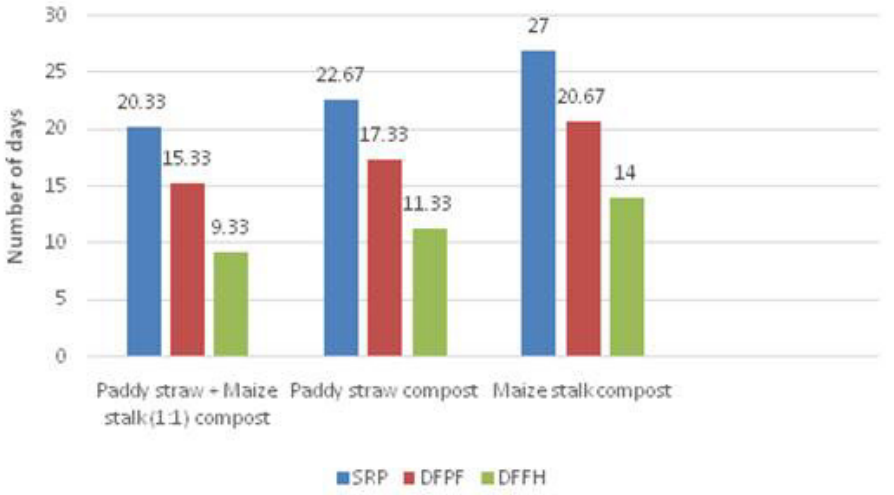

Fig. 3. Effects of different substrates for composting on growth and harvest of *A. bisporus*

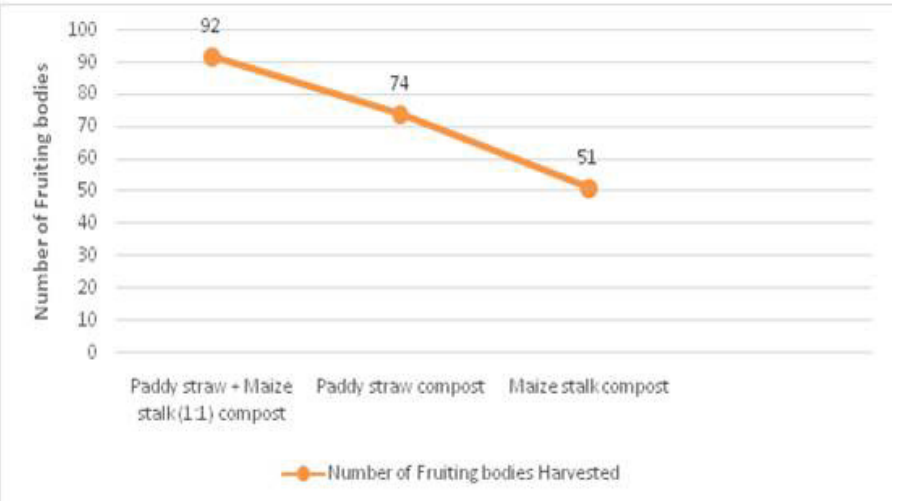

Fig. 4. Effects of different substrates for composting on sporophores production of *A. bisporus*

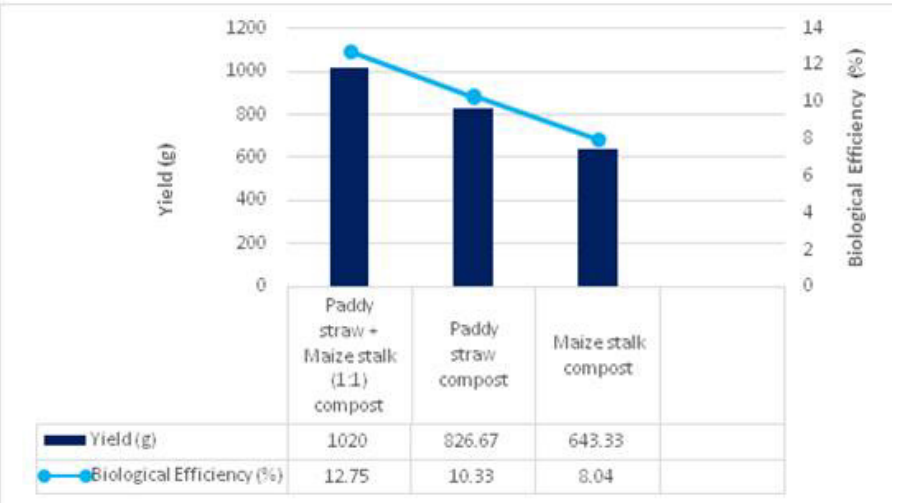

Fig. 5. Effects of different substrates for composting on yield and biological efficiency of *A. bisporus*

number of sporophores production, yield and biological efficiency followed by Paddy straw compost. The present investigation collaborated with the findings of by (Kaur *et al*., 2019). Paddy straw + maize stalk (1:1) substratum for the cultivation of *Calocybe indica* was suggested by few other researchers also (Chakraborty *et al*., 2016). Maize stalks compost is not suitable for the cultivation of button mushroom under the agro-climatic condition of the lateritic belt of West Bengal because they gave less yield and biological efficiency and also invites the various competitor moulds and weed fungus viz. *Coprinus* spp.

CONCLUSION

In summary, the investigation into *A. bisporus* cultivation using the Long Method of Composting with various substrates has demonstrated that the combination of paddy straw and maize stalks in a 1:1 ratio yields the most favorable outcomes. This substrate showcases shorter spawn run periods, earlier pinhead formation, increased sporophores production, higher yield, and biological efficiency compared to alternative substrates. Consequently, Paddy straw + Maize stalk (1:1) compost emerges as the preferred choice, highlighting its potential as an optimal substrate for *A. bisporus* cultivation in the lateritic belt of West Bengal, India.

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