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# Response of different spawn substrates and nutritional supplements on the yield and biological efficiency of paddy straw mushroom (*Volvariella volvacea*) under the agro-ecological condition of West Bengal

**Gopinath V, MK Biswas, Elangovan M and Nisha Thakur**

**Gopinath V**
Research Scholar, Department of Plant Pathology, Post Graduate College of Agriculture, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

**MK Biswas**
Assistant Professor, Department of Plant Pathology, Palli Siksha Bhavana, Visva-Bharati University, Sriniketan, West Bengal, India

**Elangovan M**
Research Scholar, Division of Plant Pathology, Indian Agriculture Research Institute, Pusa, New Delhi, India

**Nisha Thakur**
Research Scholar, Department of Plant Pathology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chattisgarh, India

**Corresponding Author:**
**Gopinath V**
Research Scholar, Department of Plant Pathology, Post Graduate College of Agriculture, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

## Abstract
A study was conducted to determine the impact of different spawn substrates and nutritional supplements on yield and biological efficiency of Paddy straw mushroom. Among the various spawn substrates viz., Wheat grain, Jowar grain, maize grain, rice grain and paddy straw respectively tried on paddy straw substrate, the yield (505.3 g/bed) and increase of biological efficiency (15.9%) was highest when Jowar grain was used as spawn substrate, followed by spawn produced from wheat grain, maize grain and rice grain and paddy straw, respectively. Average number of sporophores (28.25/bed) and total bed yield (2021.5 g) was achieved with Jowar grain spawn. Lesser yields and biological efficiency were recorded with paddy straw spawn substrate. Considering grain cost and performance shown by different spawn substrates Jowar grain was found suitable for cultivation. In the event of nutritional supplementation, yield and biological efficiency of paddy straw mushroom were found to be increased further by incorporation of nutritional supplements to the substrates. Supplementation of nutrients to the substrates has an effect on total spawn run period and average weight of sporophores. Paddy straw supplemented with Gram dhal flour produced high yield (612.6 g/bed) and increase of biological efficiency (17.67%) followed by supplementation of Rice flour, water hyacinth, Oil cake and Urea. Gram dhal flour 2% supplemented beds yielded 28.38% more than control. These studies will aid mushroom cultivators in determining suitable spawn substrate and nutritional supplement.

**Keywords:** Paddy straw mushroom, spawn substrate, nutritional supplement, yield, biological efficiency

## Introduction
The ever increasing populations, shrinking of agricultural land area, environmental issues, water scarcity and quality food materials are the major ongoing problems in our country. To meet these challenges diversification in food portfolio has to be considered. Production of edible mushrooms is one of the major ventures that can contribute towards conservation of natural resources and recycling of agro wastes. Mushrooms are fleshy spore bearing fruiting body of fungi, typically produced above ground on soil or on its food source which are preferred for their taste, flavor and medicinal properties. The world grows millions of tonnes of mushrooms every year. China grows most of the world's cultivated edible mushrooms. Since mushrooms can yield more protein per acre of land than any other food source, their cultivation has gained popularity. Mushrooms are highly prized for their organoleptic qualities, medicinal properties, and economic significance, and are widely recognised as nutraceutical foods due to their high nutritional and functional value. Mushroom cultivation serves as a viable means of augmenting the income of impoverished farmers, thereby enhancing their living conditions. Additionally, it offers a means of incorporating protein of superior quality into their daily dietary intake, thereby addressing issues of malnutrition (Biswas, 2014) [2]. India has a wide range of agroclimates and a lot of farm waste, so all over the country different types of temperate, tropical, and subtropical mushrooms are grown. The Paddy straw mushroom, scientifically known as *Volvariella volvacea*, is a species of edible mushroom that is commonly found in tropical and subtropical regions. Its cultivation can be traced back to China in the year 1822, as documented by Chang (1969) [4]. The taxonomic classification of Paddy straw mushroom (*Volvariella volvacea*) is as follows: it is a member of the family Pluteaceae, order Agaricales, and class Agaricomycetes, as described by Singer in 1961. The Paddy straw mushroom, scientifically referred to as *Volvariella volvacea*, is commonly recognised as the "Warm Mushroom" due to its preference for growth in elevated

temperatures ranging from 20 to 35 degrees Celsius. Under optimal climatic conditions, this particular mushroom species exhibits rapid growth, allowing for the completion of a full crop cycle within a relatively short period of 3-4 weeks. The utilisation of a diverse array of cellulosic materials is a characteristic of this particular mushroom species. Notably, the optimal carbon-to-nitrogen (C:N) ratio for its cultivation falls within the range of 40-60, which is relatively high when compared to other cultivated mushrooms. The Paddy straw mushroom exhibits a rapid growth rate, possesses a cultivation technology that is relatively straightforward, and is well-received by consumers. The plant exhibits promising potential and its cultivation has been implemented as a small-scale industry. The necessary raw materials are abundantly available within our nation. Despite the commercialization of paddy straw, there remains a lack of comprehensive understanding regarding mushroom biology and the appropriate production procedures. In light of these considerations, the current study sought to assess the impact of varying spawn substrates, as well as a variety of substrate supplementation materials, on the growth parameters and harvests of the Paddy straw mushroom.

## Materials and Methods

The present investigation was carried out at the mushroom farm of Visva-Bharati, Department of Plant Protection, PSB, Bolpur, Birbhum, and West Bengal. The test fungi were obtained from Centre of Tropical Mushroom Research and Training, Orissa University of Agriculture and Technology, Bhubaneswar and were maintained for further study on Potato Dextrose Agar (PDA) medium. Selected healthy grains (Wheat grain, Jowar grain, maize grain paddy straw and rice) were boiled and it was spread on a thin polythene sheet to remove excess water. To maintain proper PH Calcium carbonate of 2% dry weight of grains were mixed and 200 grams of grains were transferred to 25 $\mathrm{cm} \times 15\, cm$ polypropylene bags and plugged it with nonabsorbent cotton. The cotton plugged glass bottles are sterilized at 22 psi for 2 hours then allowed to cool for overnight and transferred to inoculation chamber. Under sterilized laminar flow chamber over flame of spirit lamp a small quantity of stock culture were transferred to polythene bags of size 25 cm × 15 cm. Inoculated bags were kept at $28 \pm 1$ °C. After complete mycelial growth of bags it is ready to transfer on bed substrate.

In case of substrate supplementation, different supplemented material viz., water hyacinth, rice flour, gram dhal powder, mustard oil cake and @ 2% (dry weight basis) were applied during the cultivation. The amendments underwent sterilisation using an autoclave at a temperature of 121 °C, with a pressure of 15 lbs, for duration of 10 minutes. The aforementioned supplements were evenly distributed throughout the substrate layers during the spawning process in order to promote optimal mycelium growth. Inorganic amendment Urea @ 2% mixed in clean water for 12–18 hours in a cemented water tank. The excess of water was drained on by placing bundles on raised bamboo platform. These were evaluated for the test fungus's ability to colonize, pin head initiation, yield enhancement, and biological efficiency. As a control, only paddy straw was used.

### Bed Preparation

Indoor cultivation of paddy straw was done and various methods of cultivation were employed during the experiment to improve the biological efficiency.

To arrange the beds, four bundles were positioned adjacent to each other, followed by another four bundles placed in a similar manner but from the opposite side. This arrangement ensured that the open ends of the bundles overlapped in the middle, resulting in the formation of a single layer consisting of eight bundles. The second, third, and fourth layers were constructed in a manner consistent with the number of layers specified for each treatment. Intermittent spawning was conducted at a rate of 2% on a dry weight basis, with the spawning occurring between the first, second, third, and fourth layers. The spawning was performed with a margin of 12 cm–15 cm from the edges. The beds were compressed from above and subsequently enveloped with a pristine, see-through plastic sheet in order to uphold a consistent level of humidity (ranging from 80% to 85%) and temperature (ranging from 30 to 35 ℃). Following a period of 7 to 8 days subsequent to spawning, the plastic sheets were extracted, while maintaining a temperature range of 28 to 32 ℃ and a relative humidity of approximately 80%. Mushrooms started appearing after 4–5 days of sheet removal and the beds were kept for next 20 days for cropping. When necessary, the bags were sprayed with tap water once or twice per day to maintain a relative humidity between 80 and 85 percent. The Biological Efficiency (B.E.) was computed using Chang's (1981) [16] standard formula.

$$\mathrm{B.E}(\%) = \frac{\text{Fresh weight of mushroom}}{\text{Air} - \text{dried substrate}} \times 100$$

## Results and Discussion

In the present study, various spawn substrates and substrate supplementation materials were evaluated to determine their effects on Spawn run, Average number and weight of sporophores, Total bed yield and Biological efficiency. In case of different spawn substrates (Wheat grain, Jowar grain, maize grain paddy straw and rice), it is clear from the table 1 that the spawn produced from different substrates tested for cultivation of paddy straw mushroom showed different response in terms of yield, biological efficiency and spawn run period. All the spawn substrates proved their suitability in cultivation of paddy straw mushroom in the locality and produced fair quantity of yield. However, Jowar grain proved its superiority among all the spawn substrates tested and gave highest yield and biological efficiency (2021 g and 15.79%) followed by the spawn produced from wheat grain, maize grain and rice grain which exhibited (1746 g and 13.31%) and (1551 g and 12.08%) and (1320 g and 10.3%) respectively (Fig.1). Chopped paddy straw spawn was found to be less suitable under the conditions which gave 1207 g yield and 9.42% biological efficiency. However, the response of Jowar and wheat grain spawn was found to be good in terms of yield and biological efficiency (Fig.1).

**Table 1:** Evaluation of suitable spawn substrates for higher biological efficiency of Paddy straw mushroom.

| Spawn substrates | Spawn run (in days)* | Average number of sporophores* | Average weight of sporophores (g)* | Total bed yield (g)* | Average bed yield (g)* | Biological efficiency (%) |
|---|---|---|---|---|---|---|
| Wheat grain | 9.00 | 23.50 | 18.68 | 1746.5 | 436.63 | 13.60 |
| Jowar grain | 9.25 | 28.25 | 18.08 | 2021.5 | 505.38 | 15.79 |
| Maize grain | 10.75 | 24.00 | 16.15 | 1551.0 | 387.75 | 12.08 |
| Rice grain | 14.50 | 23 | 14.34 | 1320 | 330.00 | 10.31 |
| Paddy straw | 12.75 | 25.00 | 12.25 | 1207 | 301.75 | 9.42 |
| SE m(±) | 0.47 | 1.73 | 1.39 | | 26.97 | 1.45 |
| CD@ | 1.42 | 5.23 | 4.18 | | 81.31 | 4.38 |
| CV% | 8.35 | 14.45 | 18.09 | | 14.56 | 23.73 |

*Average of three replications

**Table 2:** Evaluation of different supplements for increasing the biological efficiency of Paddy Straw Mushroom (*Volvariella volvacea*)

| Supplements | Spawn run (in days)* | Average number of sporophores* | Av. wgt. of sporophores (g)* | Total bed yield (g)* | Average Yield (g)* | Biological efficiency (%) |
|---|---|---|---|---|---|---|
| Water hyacinth@ 2% | 9.25 | 25.00 | 18.40 | 1840 | 460.00 | 14.37 |
| Rice flour@ 2% | 10.00 | 19.50 | 25.78 | 2008.7 | 502.18 | 15.38 |
| Gram dhal flour@ 2% | 8.75 | 20.6 | 29.74 | 2452.2 | 612.68 | 17.67 |
| Oil cake@ 2% | 10.00 | 14.25 | 12.98 | 748 | 184.90 | 5.8 |
| Urea@ 2% | 10.50 | 10.50 | 8.68 | 364 | 91.00 | 2.8 |
| Control | 9.50 | 28.00 | 15.6 | 1756.5 | 436.80 | 13.7 |
| SE m (±) | 0.22 | 1.26 | 1.44 | | 27.67 | 0.91 |
| CD @ 1% | 0.66 | 3.73 | 4.29 | | 82.21 | 2.70 |
| CV % | 4.56 | 12.15 | 16.51 | | 14.49 | 17.21 |

*Average of three replications

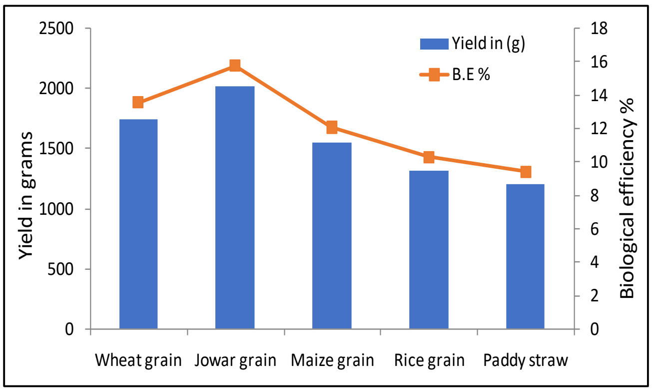


**Fig 1:** Effect of spawn substrates on yeild and biological effciency

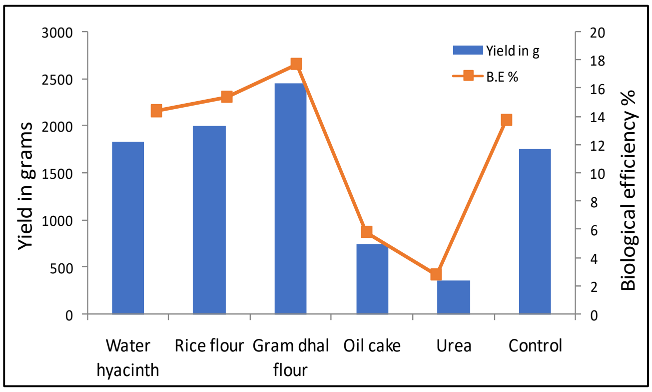


**Fig 2:** Effect of supplements on yeild and biological effciency

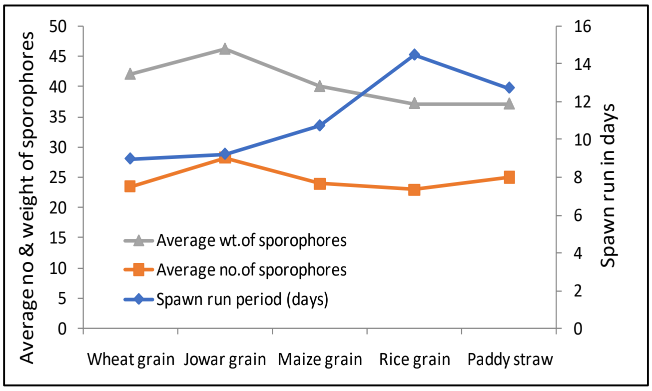


**Fig 1.1:** Effect of supplements on spawn run period, number and average weight of sporophores

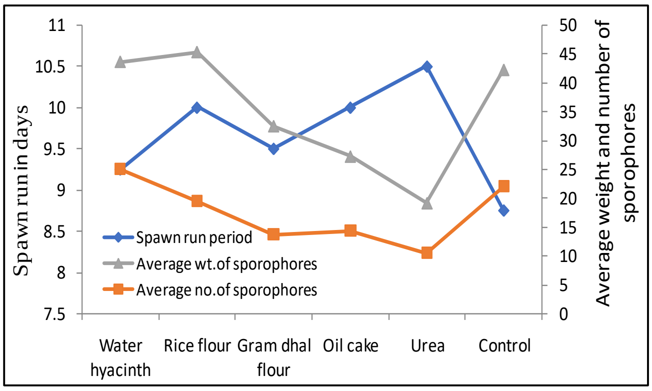


**Fig 2.1:** Effect of supplements on spawn run period, number and average weight of sporophores

**Graph 1:** Graphical representations on effect of Different spawn substrates and Nutritional supplements.

Significant relationship was existed among the different spawn substrates tested. Spawn run period was found minimum (9.0 days) in the beds produced from wheat grain spawn followed by Jowar grain (9.25 days), maize grain (10.75 days) and rice grain (12.75 days). Maximum time (14.50 days) was taken by chopped paddy straw spawn. The relationship between treatments in term of spawn run period was found to be significant (Fig.1.1). The effects of various spawn produced from different substrates were assessed further on the average number and weight of sporophores.

Maximum average weight of sporophore (18.68 g) was observed from the beds prepared from wheat spawn which was significantly superior amongst all the spawn substrates followed by Jowar spawn (18.08 g), and rice grain spawn (14.34 g).Smaller sizes of sporophores were noticed in the beds of chopped paddy straw spawn (12.25 g). The observed differences in the rate of spawn run and yield can be attributed to variations in grain size. According to Mamiro and Royse (2008) [10], it has been observed that smaller grains possess a higher density of inoculation points per kilogram compared to larger grains. This characteristic may contribute to the enhanced yield and biological efficiency of Jowar grain spawn beds. In a study conducted by Solangi (1988) [15], the suitability of four distinct grain types for spawn preparation was examined.

The findings indicated that sorghum grains exhibited the highest level of suitability, followed by maize, wheat, and pearl millet grains, in that order. Jiskani *et al*. (2000) [8] conducted a study in which they cultivated spawn on sorghum grains and observed comparable outcomes. According to Sandeep Kumar (2016) [13], it was observed that the sorghum grain based spawn exhibited the highest count of fruiting bodies.

When evaluating various nutrient supplementation options, Table 2 demonstrates that the majority of supplements, such as water hyacinth, rice flour, and gram dhal flour at a concentration of 2%, had a positive impact on the yield and biological efficiency of *Volvariella volvacea.* The utilization of mustard oil cake and urea resulted in a decrease in yield compared to the control group. Highest yield and biological efficiency (2452.2 g and 17.67%) were obtained from the substrate supplemented with 2% red gram flour followed by rice flour (2008.7 g and 15.38%), water hyacinth (1840 g and 14.38%). Significant differences were observed among the treatments over control (paddy straw). Mustard oil cake and urea contributed negatively towards the yield and produced (748 g and 5.8%) and (91 g and 2.8%) respectively (Fig 2). Spawn run period was found minimum in red gram flour supplemented beds (8.75 days) followed by water hyacinth 2% (9.25 days) and control (9.50 days). Maximum time was taken by rice flour, urea and oil cake supplemented beds for completing the spawn run (10 days, 10 days, 10.5 days) respectively. Maximum average weight of sporophore (29.7 g) found in red gram flour supplemented beds followed by rice flour, water hyacinth and control (25.7 g, 18.4 g, 15.6 g) respectively. Minimum sized sporophores were obtained from mustard oil cake and urea supplemented beds (12.98 g) and (8.68 g) respectively (Fig. 2.1). Spawn run period was found minimum in red gram flour supplemented beds (8.75 days) followed by water hyacinth 2% (9.25 days) and control (9.50 days). Maximum time was taken by rice flour, urea and oil cake supplemented beds for completing the spawn run (10 days, 10 days, 10.5 days) respectively.

Maximum average weight of sporophore (29.7 g) found in red gram flour supplemented beds followed by rice flour, water hyacinth and control (25.7 g, 18.4 g, 15.6 g) respectively. Minimum sized sporophores were obtained from mustard oil cake and urea supplemented beds (12.98 g) and (8.68 g) respectively (Fig. 2.1). Additions of external nutrients have been evaluated with a substantial impact on mushroom yield and quality. The results obtained with 2% red gram flour were confirmed the findings of Mohapatra, (2014) and Biswas, (2014) [11, 2]. Asthana (1947) [1] reported better yields with the incorporation of red gram dal powder to beds.

Ink caps (*Coprinus spp*.) are found in beds supplemented with urea. Ink caps have an average pH about 8. The appearance of ink caps during spawn run is commonly observed on mushroom beds in northern India (Kaul *et al*., 1978; Garcha 1983) [9, 7]. Ink caps appear if the compost contains too much nitrogen. These are genuine indicator moulds benefited from insufficiently converted N constituents like $NH_3$. (Sharma *et al* 2005) [12].

**Conclusion**

From the present study it can be concluded that Jowar as spawn substrate and supplementation of Red gram flour with bed substrate resulted shortest spawn run period and earlier primordial initiation on substrate. Moreover, Highest yield and biological efficiency (2021 g and 15.79%) were obtained from the beds prepared from Jowar grains followed by wheat grain, maize grain and rice grain as spawn substrate on cultivation which exhibited (1746 g and 13.31%) and (1551 g and 12.08%) and (1320 g and 10.3%) respectively. Mixing of gram dal flour @ 2% at the time of spawning had increased the yield up to the level of 28.38%. Therefore, 2% gram dal flour as nutrient supplement and Jowar grain as spawn substrate may be recommended for farmers to get attractive fruit body as well as higher yields in commercial production of *Volvariella* spp. and also for other paddy straw mushrooms.

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