IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

COMPARATIVE STUDIES ON GROWTH AND YIELD PERFORMANCE OF PADDY STRAW MUSHROOM (*VOLVARIELLA SPP*) ON AGRO-WASTE

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Abstract: The research experiment was carried out to investigate the cultivation of paddy straw mushroom on agro-wastes singly and in various combinations to find out the better substrate for mushroom cultivation . Results regarding the time required for completion of spawn running, formation of pin-heads and maturation of fruiting bodies on different substrates showed that in all the five cases, they appeared earlier on wheat(control) in both the species. Highest mycelia growth rate was found in wheat & rice bran (50:50) in *Volvariella volvaceae* and (75:25) in *Volvariella diplasia*. The time of fruiting for both species was shorter on wheat(control). Highest biological yield, *Volvariella volvaceae*(1380g),*Volvariella diplasia* (1263g) was obtained from (50:50) in *Volvariella volvaceae* and(75:25) in *Volvariella diplasia*. The lowest biological yield was found where the culture was on rice bran alone. The use of rice bran in mushroom cultivation enhances the biological recycling of nutrients.

Keywords: *Volvariella spp*., Substrate combination, Rice straw, Growth , Yield.

I. Introduction

The mushroom cultivation is a profitable agribusiness and paddy straw mushroom is a edible mushroom having excellent flavor and taste. Mushrooms are large reproductive species of edible fungi belonging to either Ascomycotina or Basidiomycotina. Mushrooms are heterotropic and depend upon the organic matter for nutrition and live saprophytically or parasitically or symbiotically on or with other organism. They can be found living on wood, leather, fur, hay, grass, paper, various straw etc (Balkrishnan and Nair, 1995; Pani and Naik, 1998; Yiliz, 1999). The importance of mushroom in the agrarian economy of the world needs no emphasis because of its nutritional and medicinal value. For a long time, wild edible mushrooms have played an important role as a human food and now-a-days is a leading food component. Mushrooms are the good source of protein, vitamins and minerals (Khan et al., 1981). Mushrooms contain about 85-95% water, 3% protein, 4% carbohydrates, 0.1% fats, 1% minerals and vitamins (Tewari, 1986). Mushrooms contain appreciable amount of potassium, phosphorous, copper and iron but low level of calcium. (Anderson and Feller, 1942). Mushroom protein is intermediate between that of animals and vegetables. (Kurtzman, 1976).Mushroom also contain appreciable amount of Niacin, pantothenic acid and biotin (Subramanian, 1986). It is rich source of minerals (Patrabansh

and Madan, 1997), antibacterial activity (Benedict and Brandy, 1972) and antitumourous or anticancerous activity. Mushrooms are useful against diabetes, ulcer and lungs diseases. (Quimio, 1976).

The history of mushroom cultivation is traced to the Roman. In early times, cultivation failed because the biology of fungi was not understood and this led to the initial problems of mushroom cultivation (Oei, 1996; Stamets, 2000). However, empirical methods for their cultivation are relatively recent (Martinez-Carrera, 2000). They were independently developed in China about 1,000 years ago for *Auricularia spp.* and *Lentinula edodes* (Berk.) Pegler, and in France about 350 years ago for *Agaricus bisporus* (Lange)Imbach. During the last 50 years, these methods have been significantly improved. Today, there is a better understanding of the biology, nature and development of many species of edible mushroom (Isikhuemhen *et al.*, 2000; Okhuoya, 2000; Okhuoya *et al.*, 2000; Kurtzman, 2000; Martinez- Carrera, 2000; Wuyep *et al.*, 2002).The technology of artificial cultivation of mushroom is somewhat recent innovation, incorporation of non- conventional crops in existing agricultural system can help in improving the social as well as economical status of small farmers. Cultivation of edible mushrooms is one of the most economically viable processes for the bioconversion of lignocellulosic wastes (Bano et al. 1993; Cohen et al. 2002).It can be grown on agricultural and industrial waste. More than the total produce from the land remain unused as waste in the form of straws, leaves, stems, roots etc. (Zadrazil, 1978). These waste can be recycled into food and environment may be less endangered by pollution (Hayes, 1978). The bioconversion of agriculture and industrial wastes into food has attracted the world attention in recent years. The mushroom cultivation is a highly efficient method of disposing of agricultural residues as well as producing nutritious food. Mushroom cultivation is highly labor intensive, short duration crop and land saving, can be welcomed by the poor farmers. At present mushroom production is approximately 1.5 million tons in the world.

Unlike other mushroom species, paddy straw mushrooms can be easily grown on varieties of natural substrates like rice bran, wheat bran, leaf litters ,straw and are the easiest, fastest and cheapest to grow, require less preparation time and production technology. Scarcity and high cost of these substrates have necessitated a search for alternative substrate. Mushroom substrate may be defined as a kind of ligno cellulose material which supports the growth, development and fruiting of mushroom. Cereals and pulses offer a potential alternative substrate source for mushroom cultivation. The objective of this work was to study the effect of wheat singly and in various combinations with rice bran on the linear mycelial growth and yield of paddy straw mushroom.

II. MATERIALS AND METHODS

Culture and Cultivation

Stock culture of *Volvariella spp.* were obtained from "Trinath Mushroom Farm" at Jagadalpur near Berhampur, Odisha. Pure culture lines during the period of study were maintained on Potato dextrose agar (PDA) medium and inoculated at an interval of fifteen days.

Spawn preparation and growth of *Volvariella spp.*

Agro-waste materials such as rice bran and wheat with different composition were used for determination of suitable spawn substrate. The Wheat grain, were washed several times to remove any suspended particles. The grains were boiled in a container with water till they soften and then spread over a polythene sheet under shade for draining excess water from grains surface. Each substrate like rice bran and wheat were soaked separately in water for about 8-9 hour and than excess amount of water was drained out. Then wheat grains and rice bran(w/w) in the ratio((100:0, 75:25, 50:50, and 25:75 dw/dw),each were spread over a polythene sheet .20g of Calcium carbonate were added to 1kg of each combination and mixed together properly in a container (Sanchez *et al.*, 2002). About 200g of each mixture was then transferred into a clean saline bottle. The bottles were plugged with non-absorbent cotton tightly, sterilized (22lb psi, 2hr) and cooled, inoculated with a pure culture mycelia and incubated at $(23 \pm 2)^0$C for 10 days. The linear mycelial growth of mushroom was measured for each treatment. The un-inoculated sterile saline bottle (15cm length) with grains (up to 12.5cm length) was used as control.

Bed Preparation and fructification of *Volvariella spp.*

Various agricultural wastes can be used in bed preparation. The present study was done with paddy straw. The tied paddy straw bundles were soaked in water for 12 to 16 hours and then kept in an inclined manner to remove excess water. Three soaked straw bundles with their butt ends one outside were placed lengthwise very close to each other on the bamboo frame. Then another set of three bundles were placed over them in similar manner but with butt ends on the opposite side and was the first layer. After 1st layer was completed, spawn bits of thumb size was put on the top of the layer .Same process repeated for five to six times but in opposite direction in each layer.

The inoculated beds were covered with polythene sheet and incubated at 38^0C to 40^0C temperature for ramification of the mushroom mycelia. After full ramification, polythene sheet were removed and watering on bed was done twice or thrice a day. The number of pinhead development was recorded. The harvesting was done in four flushes of one week intervals.

After the 1st flush, the beds were watered and covered regularly to harvest 2nd, 3rd and 4th flushes. The yield parameters recorded were, days taken for the completion of spawn running, time (days) taken for the first appearance of pin-head formation, time (days) taken for the maturity of fruiting bodies and yield of fresh mushroom on different composition of wastes.

III. RESULTS AND DISCUSSION

Spawn of each mushroom mycelium was prepared using grain and rice bran. The average linear mycelial growth of individual mushroom mycelium was noted from each of three replicates. The results regarding the completion of spawn running, pin-head formation, maturity of fruiting bodies, yield performance of *Volvariella volvaceae* and *Volvareilla diplasia* on different combination of waste were presented in Tables –1. Table -1 indicated the ability of wheat grain along with rice bran to facilitate faster mycelial growth of *Volvariella volvaceae*. Combination of 50% wheat and 50% rice bran had the shortest time for full mycelial growth (12 days) followed by combination of wheat and rice bran 75% and 25% (13 days), were as other combination of wheat and rice bran took nearly two weeks (15 days) for full growth of mycelium. Patra and Pani (1995) recorded 13-16 days on paddy straw. Similar findings were also reported by Jiskani et al. (1999). Rice bran shows more than 21 days for complete ramification of the mushroom mycelia.

From the Table-2 it was found that wheat grain along with rice bran 75% and 25% shows faster mycelial growth(11days) of *Volvariella diplasia* followed by wheat (12 days), and then 50% wheat and 50% rice bran (16 days) for full growth of fungus. Rest of the combination shows more than 21 days for complete colonization of the mushroom mycelia.

The effect of wheat grain along with different combination of rice bran on the yield of *Volvariella volvaceae* shown in Table -3 showed a little delaying response of three day more for pin head emergence in rice bran (9days) followed by wheat and rice bran (25% &75 %) (8days). In case of wheat, it took only 5 days for pin head emergence. However, other substrates showed 6-7days for complete pin head emergence.

From the Table-4 it was found that all the combination shows more than 7 days for pin head emergence whereas combination of wheat and rice bran (75% and 25%) and wheat alone showed 5 days for pin head emergence *Volvariella diplasia*.

The biological efficiency was affected by substrate. Wheat and rice bran spawn resulted with highest Bio-efficiency in *Volvariella volvaceae*(13.8%) , *Volvariella diplasia* (12.6%) and the largest number of mushroom production. Rice bran spawn yielded lowest with lowest biological efficiency (5.9%) in *Volvariella volvaceae* and (4.3%) in *Volvariella diplasia*.. Significant yield variations were recorded on different substrates at first harvest. The highest number of mushroom (93) and economical yield was recorded with wheat and rice bran(1380g) in *Volvariella volvaceae* and in *Volvariella diplasia*, the highest number of mushroom (84) and economical yield was recorded with the same combination(1263g)**.**

The economical yield decreases with decrease in average number of mushroom in other substrate. The lowest number of mushroom (34) and economical yield was observed in rice bran spwan in *Volvariella volvaceae* (594g) were as in *Volvariella diplasia* , the lowest number of mushroom (52) and economical yield was observed in same substrate as rice bran(437g).

DISCUSSION

The cultivation of edible mushroom using wheat and different combination of rice bran is a value added process as it gives base to growth of mushroom mycelium. *Volvariella* mycelia grows very well on a wide range of substrates, such as sugarcane baggage, waste tea dust, cotton wastes, oil palm pericarp wastes, oil palm bunch wastes, dry banana leaf and sawdust but their mean mycelia yields are comparably low in some of these wastes(Chen and Graham, 1973 and Chua and Ho, 1973) . Bolton and Blair 1982 and Fasidi, 1996, reported that rice husk is good for the production of *V. esculenta because* of its richness in oils and vitamins which are good stimulants for high mushroom yield. Substrate structure is an important factor for the growth of the mycelium as it should be suitable for penetration of the mycelium. Wheat is commonly used spawn for mushroom cultivation as it is cheaply and abundantly available and sustained faster growth rate of mycelium as compared to other substrates. Wheat grain alone takes nearly 18 days for complete ramification but supplemented with waste tea leaves gives faster mycelial growth and more yield than wheat alone (Bisht and Narsh, 1984). Supplementation of substrate has become one of the major aspects of mushroom cultivation. This is in order to boost the yield of mushrooms. Present study revealed that spawn made of wheat grains with rice bran sustained faster growth rate of mycelium. This implies that the carbohydrates present in rice bran were more effectively utilized by the mycelium for better vegetative multiplication and sporophore yield. This support the report of (Zadrazil, 1993) who reported that supplements usually change the decomposition rate and the sequence of decomposition of substrate components during mushroom growth. Supplementation of substrates with different levels of carbon and nitrogen-based additives enhances mushroom production (Zadrazil , 1993; Royse *et al*.,1990; Royse, *et al*., 1991; Fasidi, and Kadiri, 1993; Royse, 1996, Isikhuemhen, *et al*., 1999, and Stamets ,2000). However, the lowest mycelial growth was found with rice bran alone in *Volvariella volvaceae* and *Volvariella diplasia* .This support the work of (Okhuoya, *et al*., 2005 and

Quimio *et al*., 1990) and may be due to carbon to nitrogen imbalance in those combinations and secondly due to variation in concentration either above or below the required concentration that can promotes mycelial growth.

The cultivation of edible mushroom using agricultural residues such as rice and wheat straw is a value added process to convert these materials, which are otherwise considered to be wastes, for mushroom production. Mostly in sub-tropical countries agricultural waste plays a significant role in causing environmental pollution due to waste disposal problem. Wastes are either burnt or dumped nearby water bodies creating a health hazard to human life. *Volvariella* mycelium grows very well on a wide range of cellulosic wastes. Rice straw has been used for the indoor cultivation of paddy straw mushroom since the beginning of the 19th century, a practice from which the mushroom has been given the common name straw mushroom, and has been cultivated under natural conditions in many countries (Fasidi, 1996).Rice straw as the natural substrate on which *V. esculenta* grew and led to naming the mushroom as delicious straw mushroom was reported by Fasidi. Rice straw as substrate for mushroom bed is recommended for its cheapest quality and readily available in sub- tropical countries.

Volvariella volvaceae and *Volvariella diplasia* the yield potential of spawn raised on wheat grains and rice bran shows highest yield. The highest yield of *V. volvaceae* (1380g) and *Volvariella diplasia* (1263g) was obtained from wheat grain with rice bran. These results are in contrary to the report of Purkayastha *et al.* (Purkayastha, 1980) who reported that *Volvariella spp.* gave maximum growth and productivity on Wheat spawn. However the use of other combination as a spawn substrate may not be totally rejected as they are cheaper and easily available when compared to wheat grain. A higher biological efficiency was observed in supplemented substrate support the work of (Fasidi, and Kadiri, 1993 and Royse, 1996) on *Pleurotus tuberregium* and *Lentinus subnudu,* respectively.

CONCLUSION

The highest mycelial growth was found in wheat with rice bran combination spawn and recommended commercially since it support sporophore production. The highest yield of *V. volvaceae* and *V. diplasia* was obtained from wheat grain with rice bran. So the use of wheat grain supplemented with rice bran appears to be most suitable due to improved growth and sporophore production. Rice straw as substrate for mushroom bed is recommended for its cheapest quality and readily available in sub-tropical countries. The production of mushrooms worldwide is increasing at an annual rate of about 10%. India is a agricultural country and rich in agricultural waste. The cultivation of *Volvariella spp.* on these agro wastes decreases the environmental problem and provide a sustainable means of adding value to the farmers. Further work is in progress to improve growing conditions of spawning and increase the yield of *Volvariella spp* on more feasible and cheap recyclable residue.

Table -1 Effect of substrates on mycelial growth (cm) of *Volvariella volvaceae* per culture bottles after 6, 9, 12, 15, 18 and 21 days.

Substrates/Days	6	9	12	15	18	21
Wheat 100%	8.3±0.1	8.5±0.2	10.5±0.2	12.5±0.2	12.5±0.2	12.5±0.2
75%Wheat +2 5% Rice bran	6.4±0.2	9.8±0.2	11.5±0.2	12.5±0.2	12.5±0.3	12.5±0.1
50%Wheat + 50% Rice bran	10.8±0.2	12.3±0.1	12.5±0.1	12.5±0.1	12.5±0.1	12.5±0.1
25%Wheat + 75% Rice bran	5.2±0.1	7.5±0.1	9.0±0.1	10.1±0.3	11.6±0.2	12.5±0.1
Rice bran 100%	2.7±0.1	3.1±0.1	3.7±0.3	4.3±0.1	5.2±0.1	12.5±0.1

Each value is mean of 3 replicates ± SEM

Table -2 Effect of substrates on mycelial growth (cm) of *Volvariella volvaceae* per culture bottles after ±6, 9, 12, 15, 18 and 21 days.

Substrates/Days	6	9	12	15	18	21
Wheat 100%	7.0±0.1	9.6±0.1	12.5±0.2	12.5±0.1	12.5±0.1	12.5±0.1
75%Wheat +2 5% Rice bran	8.4±0.1	12.5±0.2	12.5±0.2	12.5±0.1	12.5±0.1	12.5±0.2
50%Wheat + 50% Rice bran	6.1±0.3	9.5±0.1	11.3±0.2	12.4±0.2	12.5±0.1	12.5±0.3
25%Wheat + 75% Rice bran	4.0±0.2	6.3±0.1	7.6±0.2	9.7±0.1	11.6±0.2	12.5±0.1
Rice bran 100%	2.8±0.1	3.0±0.1	4.2±0.2	5.0±0.2	8.3±0.2	10.6±0.1

Each value is mean of 3 replicates ± SEM

Table -3 Effect of spawn based on wheat grain with different combination of rice bran on fructification of *Volvoriella volvaceae*.

Spawn Substrate/Yields	Days for pin head emergence	Average no. of mushroom	Yield/Bed (g)	Bio-efficiency (%)
Wheat 100%	5	80	1280	12.8
75%Wheat +2 5% Rice bran	7	63	1130	11.3
50%Wheat + 50% Rice bran	6	93	1380	13.8
25%Wheat + 75% Rice bran	8	46	905	9.05
Rice bran 100%	9	34	594	5.9

Each value is mean of 3 replicates ± SEM

Table -4 Effect of spawn based on wheat grain with different combination of rice bran on fructification of *Volvoriella diplasia*.

Spawn Substrate/Yields	Days for pin head emergence	Average no. of mushroom	Yield/Bed (g)	Bio-efficiency (%)
Wheat 100%	5	71	1171	11.7
75%Wheat +2 5% Rice bran	5	84	1263	12.6
50%Wheat + 50% Rice bran	7	78	1153	11.5
25%Wheat + 75% Rice bran	8	61	730	7.3
Rice bran 100%	9	52	437	4.3

Each value is mean of 3 replicates ± SEM

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