Current Journal of Applied Science and Technology

39(27): 28-34, 2020; Article no.CJAST.60350
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Assessment of Scope and Efficiency of Off-Season Rice Straw Mushroom (*Volvariella volvacea* L.) Cultivation in Coastal Odisha

N. Mahapatra[1], F. H. Rahman[2*], P. Mishra[1], T. R. Sahoo[1], P. K. Sahoo[1] and S. N. Mishra[1]

[1]Krishi Vigyan Kendra Kendrapara, Orissa University of Agriculture and Technology, Kendrapara, Odisha, India.
[2]ICAR- Agricultural Technology Application Research Institute Kolkata, Bhumi Vihar Complex, Salt Lake, Kolkata – 700097, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author NM designed and executed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author FHR edited the whole draft. Authors PM and TRS managed the analyses of the study. Authors PKS and SNM managed the literature searches and recorded feedback. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i2730917
Editor(s):
(1) Dr. Awadhesh Kumar Pal, Bihar Agricultural University, India.
Reviewers:
(1) Carlos Augusto Martínez Mamián, University Foundation of Popayán, Colombia.
(2) Tadeu Ferreira, Fluminense Federal University, Brazil.
Complete Peer review History: http://www.sdiarticle4.com/review-history/60350

Original Research Article

Received 15 June 2020
Accepted 20 August 2020
Published 07 September 2020

ABSTRACT

A field experiment was conducted in the farmers' field in Ratanpur, Marshaghai block of Kendrapara district in Odisha, an adopted village of Krishi Vigyan Kendra, Kendrapara under the National Innovations in Climate-Resilient Agriculture (NICRA) project with the objective of determining the productivity of rice straw mushroom in off-season (Month of November) under different cultivation systems. Keeping in view the need to develop more resilient technology for farmers to combat the current scenario of changing climate and market demands along with generation of additional income, the possibility of growing this tropical mushroom during winter month was tested. The experiment was laid out in a randomized block design with 4 number of treatments and 6 replications with ten beds (blocks) taken in each replication. The treatments undertaken were as

**Corresponding author: E-mail: fhrahmancal@gmail.com;*

follows, T_1- Rice straw mushroom cultivation in shade net, T_2- Rice straw mushroom cultivation in poly house, T_3- Rice straw mushroom cultivation in thatched roof and T4- Outdoor Rice straw mushroom cultivation. It was concluded from the findings that poly house system outperformed the other three cultivation systems *i.e.* shade net, thatched house and open situations in terms of yield maximization, gross and net return during the off-season (November). The poly house system produced 10.8 - 76.4% higher yield in comparison to other three systems with increased net returns and B:C ratio of 1.78 suggesting it to be the best cultivation system for off-season production of rice straw mushroom.

Keywords: Rice straw mushroom; poly house; shade net; thatched roof; Coastal Odisha.

1. INTRODUCTION

Mushroom is a macro fungus with a typically large fruiting body, also known as *Basidiocarp*, which is visible to the naked eye and easily handpicked and this fruiting body is mostly referred as mushroom [1]. At present, consumption and demand of mushrooms have become popular worldwide and keep on escalating gradually due to their high food and medicinal values. These are often used as alternate food sources, being rich in protein (20-35%) of intermediate quality between the vegetables and animal sources. These also contain essential amino acids and vitamins especially, thiamine (B_1), riboflavin (B_2), Niacin (B_3), pantothenic acid (B_5), ascorbic acid (c) and vitamin-K in larger amounts where as Vitamin A,D and E in lower amount having higher digestibility (72-83%) Mushrooms being low in calories, fat, cholesterol, zero in sugar and starch and high in K/Na ratio, protein and fibre content, provide to be an excellent food choice for patients with obesity, hypertension, irregular carbohydrate metabolism, heart disease, diabetes, beriberi, hyperacidity and constipation. F.A.O. has recognized mushrooms as a source for supplementing protein nutrition in developing countries that particularly depend on cereal as their main source of food [2].

Straw mushroom (*Volvariella* sp.) prefers a temperature range of 25 to 40°c and hence is grown in both summer and rainy seasons. It is not cultivated during winter months from November to February in the state of Odisha. Rice straw mushroom (*Volvariella volvacea*), also known as Warm Mushroom, Chinese mushroom or straw mushroom is the simplest and widely cultivated type of mushroom from Africa to India in the west as well as to the far East. Around 100 species or varieties of *Volvariella sp.* are identified worldwide, but only four are cultivated in Asia namely, *V. bakeri*, *V. esculenta*, *V. diplasia* and *V. volvacea*. About 13 species of rice straw mushroom are found in India out of which three species are primarily cultivated *i.e.*, *V. volvacea*, *V. diplasia* and *V. esculenta* [3, 4].

The tropical plains of India offer the finest climatic conditions suitable for the cultivation of *Volvariella sp.,* with a prolonged growing season from March to October, providing an ideal temperature for fruiting bodies. Currently rice straw mushroom is most widely cultivated in the coastal states of India *i.e.*, Andhra Pradesh, Kerala, Tamil Nadu, West Bengal and Odisha as these provide the favourable climatic condition for it. Even though Odisha provides a favorable agro-climatic condition to take up cultivation of various species, still rice straw mushroom is mostly favored over others being low labour, investment and space intensive along with an extensive availability of rice straw, the primary raw material at a cheaper price, as Rice is the major crop of the state. Rice straw mushroom is mostly preferred by people of Odisha, particularly among vegetarians, due to its exceptional flavor and taste. Odisha is also a leading state in terms of rice straw mushroom production *i.e.* 8007 ton per annum, contributing about 80% of total mushroom production in India *i.e.* 10,000 t / annum [5, 6]. Being a fast growing mushroom it can complete its crop cycle in 3 weeks time and takes only 8-10 days for primordial development under favorable weather conditions. Therefore, currently 12-15 crops of rice straw mushroom are being taken up by farmers within 8-10 months in a year. This mushroom is preferably a tropical mushroom requiring a temperature range of 25-40°c, however, cultivation has been made possible in off-season (winter)also by manipulating the growing conditions. It was reported that the indoor cultivation technology developed in 1970s has made it possible for cultivation of Rice straw mushroom by using cotton waste leading to higher yields [7]. It was further reported that best yields of *Volvariella sp.* were obtained in July where as in November and December no fruiting bodies are obtained under

natural climatic conditions [8]. The demand for this mushroom is increasing due to its taste and there is scope to fetch more return during off season. Further, rice straw is a cheaply available major waste in coastal districts of Odisha. Therefore, new technological interventions need to be undertaken to take up year round cultivation of rice straw mushroom. In this context, this experiment was carried out to assess the feasibility of off-season cultivation of *Volvariella volvacea* in poly house.

2. MATERIALS AND METHODS

The experiment was carried out in the farmers' field at Ratanpur, Marshaghai, Kendrapara district, Odisha to determine the productivity of rice straw mushroom in winter months. This was adopted village of Krishi Vigyan Kendra, Kendrapara under the umbrella of National Innovations in Climate-Resilient Agriculture (NICRA) project, where in, several climate-resilient agriculture and allied activities were undertaken to develop new interventions and technologies in the current changing climate scenario. The experiment was laid out in a randomized block design with 4 treatments and 6 replications. Ten beds (blocks) were taken in each replication. The treatments undertaken are as follows,

T_1- Rice straw mushroom cultivation in shade net
T_2- Rice straw mushroom cultivation in polyhouse
T_3- Rice straw mushroom cultivation in thatched roof
T_4- Outdoor Rice straw mushroom cultivation

The trial was conducted in the winter month of November. Beds were raised in each situation as per the prescribed standard protocols [9]. Rice straw of uniform length was obtained and soaked for 8-10 hours in clean water and excess water was drained off from the substrate to 65% substrate moisture by keeping it inclined for 4-6 hours. The substrates were pasteurized chemically by adding 125 ml formalin and 7.5 g Carbendazim to every 90 liters of water used for soaking [10].

The beds of 1.5 ft x1.5 ft x 1.5 ft (length x breadth x height) size were prepared by using 15 bundles (about 10 kg dry weight) of rice straw. Straw bundles of 1.5 ft. length and 15 cm diameter were used. Two soaked straw bundles with their butt ends on one side were placed length wise close to each other on the platform. Then another set of two bundles were placed over them in similar manner but with the butt ends on the opposite side. This was the first layer where straw bundles were placed in east-west direction. Mushroom spawn bits (one fourth of a bottle) were placed in peripheral line and pulse powder sprinkled on the spawn bits. Similarly in second layer, the first two bundles were placed in opposite north-south direction *i.e.*, butt ends right angle to the butt ends of first layer and then another two bundles were placed also in the same direction with butt ends on the opposite side in order to complete the second layer. Mushroom spawn bits (one fourth of a bottle) were placed in peripheral line and pulse powder sprinkled on the spawn bits. The third layer was prepared over the second layer in east-west direction *i.e.*, similar to the first layer with their butt ends opposite to the second layer. Mushroom spawn bits (one half of a bottle) were placed on the entire surface and pulse powder sprinkled on the spawn bits. The fourth or top most layer was prepared over the third layer but in a similar way to the second layer setting the butt ends opposite to the third layer. The thickness of the first, second and third layers was 5" each, where as the fourth layer was around 3" thick. Therefore, in 1^{st}, 2^{nd} and 3^{rd} layer four bundles were used in each layer but in the 4^{th} layer only two bundles were used. Lastly, after making the bed, it was lightly hard-pressed to remove the air in between making it compacted and the excess straw coming from all sides were trimmed off to give a cube- shape.

The beds were covered with transparent polythene sheet till primordial initiation to maintain the required warmth and humidity. The harvest of the first flush took place around 8 to 10days after putting of spawn in the beds. After this the beds were covered again till harvest of the second flush. Proper care was taken to provide the required appropriate light intensity and humidity during the crop cycle.

The poly house, shade net and thatched roof systems were all constructed with ground area of 120 sq. ft (15 ft x 8 ft). The ground area taken in case of open system was also same as of the former systems to maintain uniformity. The poly house was a low cost one made of bamboo and LDPE films (white colour), where as the nets replaced the polythene sheets in shade net system. In thatched house system rice straw, tree branches and twigs etc were used as roof cover of the pre existing mud house used.

Table 1. Cost of production and Sale under different systems with details of cost of inputs involved

Parameters		Poly house	Shade net	Thatched house	Open
1.	Cost of construction of structures (including raw materials required and labour in Rs. / sq. m)	400	350	200	-
2.	Total cost of construction of structures (120 sq. ft)	4800	4200	2400	-
3.	Depreciation cost (all the structures can be used for production 8 times in 2 years span)	600	525	300	-
4. Cost of one Bed (Rs)	a) 15 bundles of rice straw (@ Rs 2 each) = Rs 30 b) Chemical cost = Rs 4 c) Labour cost = Rs 5 d) Spawn cost = Rs 17 e) Polythene sheet = Rs 4	60	60	60	60
4.	Total cost of beds (60 nos.)	3600	3600	3600	3600
5.	Total cost of production per crop	4200	4125	3900	3600
6.	Off-season price of selling mushroom (Rs per kg)	180	180	180	180

The beds were laid out in a triple layer system with 10 beds in one layer.

Observations on days taken to emergence of pinhead, days taken to first harvest (*i.e.* days post-spawning), number of fruiting bodies *i.e.* Spoprophores per bed, average weight of fruiting body (g) and total yield per bed (g) were recorded at respective periods of time expanding over a total length of three weeks of crop cycle. The yield and yield attributing parameters were then subjected to statistical analysis before drawing conclusions [11].The biological efficiency (%) was also calculated after final harvest using the following formula,

$$\text{Biological efficiency} = \frac{Total\ weight\ of\ Sporophores/bed\ (kg)}{Dry\ weight\ of\ substrate/bed\ (kg)} \text{x}100$$

Calculations of cost was based on gross returns, cost of cultivation, net returns and B:C ratio calculations. For calculation of the cost of production the following items were taken into account.

3. RESULTS AND DISCUSSION

The tropical rice straw mushroom (*Volvariella volvacea)* was cultivated in off season i.e. in the winter month of November in four different systems *viz.* shade net, poly house, thatched house and outdoor in farmers' place. Observations were taken on the yield attributing characters which are presented in Table 2.

Data presented in Table 2 revealed that the days to pinhead emergence was found to be significantly lowest for poly house cultivation (9.03 d), but was seen to be at par with thatched house (9.6 d). These were followed by shade net cultivation (10.63 d) which was significantly higher than poly house and thatched house cultivation practice. The number of days taken was significantly highest in case of outdoor cultivation (12.52). Thus poly house system resulted in early pin head emergence.

Significant difference was observed among the cultivation systems with respect to days to first harvest. The highest time was recorded for open cultivation (18.35 d) and lowest for poly house (14.14 d). The shade net and thatched roof cultivation systems were found to be statistically at par with each other taking 15.30 and 15.46 days to harvest, respectively. This indicated superiority of poly house over rest of the cultivation systems by a range of 7.5-22.9% earlier harvest of mushroom. Further the month of November was found to be equally suitable for three systems *i.e.*, poly house, shade net and thatched roof system with crop duration of (14.14-15.46 d).

The number of Sporophores *i.e.* fruiting bodies per bed and average weight of fruiting body (g) are the two major yield deciding parameters in *Volvariella volvacea.* The poly house system recorded significantly the highest number of sporophores per bed (44.50) followed by shade

Table 2. Effect of different cultivation systems on yield attributing characters of rice straw mushroom

Treatments	Days to emergence of pinhead	Days to first harvest	No. of fruiting bodies per bed	Average wt. of fruiting body (g)
T_1 - Shade net	10.63	15.30	39.47	15.41
T_2 - Poly house	9.03	14.41	44.50	16.46
T_3 - Thatched house	9.60	15.46	36.12	14.13
T_4 - Outdoor	12.52	18.35	26.43	13.76
C.D. (0.05)	0.965	1.041	0.887	1.317
SE (m)±	0.317	0.342	0.291	0.432
C.V. (%)	14.363	6	1.949	7.821

Table 3. Effect of different cultivation systems on rice straw mushroom yield per bed and biological efficiency

Treatments	Total yield per bed (g)	Biological efficiency (%)
T_1- Shade net	625.72	6.26
T_2-Poly house	693.54	6.94
T_3- Thatched house	552.42	5.53
T_4- Open	393.04	3.93
C.D. (0.05)	106.029	-
SE(m)±	34.857	-
C.V. (%)	15.08	-

Table 4. Income from off season rice straw mushroom cultivation

Cultivation System	Gross Cost (Rs)	Gross Returns (Rs)	Net Returns (Rs)	B:C Ratio
T_1- Shade net	4125	6757	2632	1.64
T_2-Poly house	4200	7488	3288	1.78
T_3- Thatched house	3900	5958	2058	1.53
T_4- Open	3600	4230	630	1.18

net system and thatched house system yielding 39.47 and 36.12 numbers of fruiting bodies per bed, respectively. The lowest value was recorded in open system (26.43). All treatments were significant with respect to each other. The average weight of fruiting bodies was highest in poly house (16.46 g) followed by shade net (15.41 g) which were statistically at par. The second group comprised of thatched house system and open system with average weight of fruiting bodies 14.13 g and13.76 g, respectively but both were at par with each other.

Observations were also recorded on the yield of mushroom per bed and the biological efficiency was also calculated as described in the material and method. The data are presented in Table 3 which revealed that the yield of mushroom per bed (g) followed a similar trend as the yield attributing characters. The poly house system yielded the highest (693.54 g) and the open system yielded the lowest (393.04 g). The shade net system produced the second highest yield (625.72 g) and was statistically at par with poly house system and thatched house system which yielded 552.42 g of mushroom. The poly house system gave 76.4%, 25.5% and 10.8% higher mushroom yield than the outdoor, thatched house and shade net system, respectively. The highest bio-efficiency of 6.94 % was achieved in poly house followed by shade net, thatched house and outdoor system with bio-efficiency of 6.26%, 5.53% and 3.93%, respectively.

The cost of production, gross return, net return and the B: C ratio for off season production of rice straw mushroom was also calculated to find out the income of the farmer and the same is presented in Table 4.

The data in the table revealed that the cost of production was highest (Rs.4200) in poly house but the gross return (Rs.7488), net return (Rs.3288) and B: C Ratio (1.78) were also the

highest. This indicated that the extra cost involved in the production process in poly house is compensated with elevated yields compared to other systems as well as higher market value due to availability in off season. The net returns in all the three systems were significantly higher than that obtained in the open system. Similar results were also reported by [12, 13]

Generally the month of November and onwards till February is not suitable for cultivation of *Volvariella volvacea* due to the lack of proper climatic requirements for the production *i.e.* high temperature (25- 40°C) and high humidity (75% - 90%). The outside temperature is around 23-27°C and RH is about 55-65% in this month, there by affecting the fruiting time, number and weight of fruiting bodies. The time required is generally higher by 3-5 days in winter season than that of summer and rainy seasons. Use of the poly house technology causes entrapment of the outgoing heat radiations inside leading to a phenomenon known as green house effect thereby causing a rise in temperature and RH. The poly house had a higher maximum and minimum temperature by 3-4°C there by retaining an average day temperature of 32-35°C. The RH was also increased by 5-10% after watering due to rise of heat inside the poly house, with an average value of 82.6%. The temperature of beds in the poly house were more than that in open system, further the rise in temperature of the beds after the watering occurred at a slower rate in open system but was rapid in poly house. It also provided shade and protection from night fog and dew, preferred for mushroom production during the trial interlude offering model conditions for rice straw mushroom cultivation. Open system does not give these required environmental controls as the indoor methods. This is in accordance with studies by [14,15]. The prerequisite of additional preliminary cost for construction of poly houses or shade nets is the core disadvantage of indoor cultivation method. The low cost bamboo based systems provided a cheap and effective alternative solution.

4. CONCLUSION

This experiment revealed that the poly house system outperformed the other three cultivation systems *i.e*. shade net, thatched house and open situations in terms of yield maximization, gross and net return during the off-season (November). Indoor cultivation method in low cost poly house can be utilized for cultivation of rice straw mushroom (*Volvariella volvacea*) profitably in off-seasons in Odisha, however this has to be standardized as per the local raw material availability, climate, farmer requirement and market demand before taking it up on commercial scale.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Chang ST, Milles PG. Recent trends in world production of cultivated edible mushrooms. Mushroom Journal. 1991;504:15-18.
2. Chang ST, Milles PG. *Volvariella.* A high temperature cultivated mushroom. (In) Mushroom Cultivation, National Value, Medical effect and Environmental impact. CRC Press. Boca Raton Florida. 2004;227-304.
3. Rath GC, Mohapatra HC. Cultivation of Rice Straw Mushroom in Orissa. Science and Culture. 1975;41(7):319-320.
4. Roy A, Sur CK, Samajpathi N. Edible Mushrooms of West Bengal-III. Volvariella. Indian Agriculture. 1978;22:61-63.
5. Verma BN, Prasad PK, Sahu KK. Mushrooms: Edible and medicinal cultivation, conservation strain improvement with their marketing. Daya Publishing House. A division of Astral International Pvt. Ltd., New Delhi; 2013.
6. Thakur MP, Mahapatra KB. Tropical Mushroom: Present status, constraints and success Story in: Processing of Indian mushroom Conference. 2013;42-43.
7. Chang ST. The origin and early development of straw mushroom cultivation. Economic Botany. 1977;31(3):374-376.
8. Pani BK, Naik RP. Yield performance of rice straw mushroom (*Volvariella sp*.) under natural climatic conditions in Odisha. Environment and Ecology. 1998;16(4):968-969.
9. Quimio TH, Chang ST, Royse DJ. Technical guide for mushroom growing in the Tropics. Plant Production and Protection paper 106: FAO, Rome. 1990;155.
10. Mohapatra KB, Behera B, Mahapatra SS. Effect of substrate quality and bed dimension on production of Straw

mushroom *Volvariellavolvacea*. Indian Journal of Mushroom. 2010;29(II):6-9

11. Gomez AK, Gomez AA. Statistical Procedure for Agricultural Research. JohnWiley and Sons Publications, New York; 1984.
12. Rajapakse P. New cultivation technology for rice straw mushroom (*Volvariella volvacea*). Proceedings of 7th Interntionational Conference on Mushroom Biology and Mushroom Products (ICMBMP7). Arcachon, Framce. 2011;446-451.
13. Sahoo AK. Study on Improvement of Bio-efficiency of straw mushroom (*Volvariella sp.*) in Orissa. *Ph. D Thesis*. Orissa University of Agriculture and Technology, Bhubaneswar, India; 2014.
14. Chang ST. *Cultivation of Volvariella mushrooms in South-East Asia*. (In.) Tropical Mushrooms: Biology, Nature and Cultivation methods (Chang, S. T. and Quimio. T. H. Eds.). 1982;221-252.
15. Thakur MP, Yadav V. Modern Technique of cultivation of rice straw mushroom in a commercial scale. (In) Emerging area of Mushroom Diversity, Production and Post-Harvest Developments. (Eds.) Department of Plant pathology, Indira Gandhi Agricultural University, Raipur, India. 2006;10-25.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/60350