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Growth Behaviour of *Ganoderma lucidum* on Different Substrates

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Reishi mushroom (*Ganoderma lucidum*) is one of the medicinal mushrooms considered as "Elixir of life". It grows on different agricultural and forest byproducts during rainy season. In order to study the yield potential of *Ganoderma lucidum,* five locally available substrates such as paddy straw, sugarcane bagasse, maize stalk, saw dust and coir pith were evaluated at Centre of Tropical Mushroom Research and Training (CTMRT), Department of Plant Pathology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar. Mushroom bags were prepared using processed sterilised substrates. During growth period data on days to spawn run, days to pin head initiation, days to first harvest, biological efficiency (%), average number of fruiting bodies per bag, yield (g/bag), size of pileus (mm) and stipe length (mm) were recorded. The recorded data were analysed with RBD using MS Excel. Among the substrates, highest yield (31.3g) of mushroom was recorded with 15.6% biological efficiency from saw dust followed by coir pith (13.3% BE). However, early spawn run and pinhead formation was recorded from paddy straw substrate with 22.5days and 33.0days respectively. Significantly poor spawn run was observed as in case of

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sugarcane bagasse with 5.5 per cent biological efficiency. Similarly maximum pileus size 78.0 mm was recorded in mushroom harvested from saw dust followed by paddy straw (55.0mm) and coir pith (52.3mm).

Keywords: Ganoderma lucidum; substrates; biological efficiency; growth behaviour.

1. INTRODUCTION

Ganoderma lucidum is a facultative parasitic fungus, belongs to family Ganodermataceae, order Polyporales under the phylum Basidiomycete. It is considered as one of the most important medicinal mushrooms and popularly known as Reishi mushroom. It has been utilised as medicine since long years in China and Japan (Ravi et al., 2025). Now, it is being cultivated in different states of India like Tamil Nadu, Kerala, Karnataka, Maharashtra, Himachal Pradesh and Uttarakhand in smaller scale than other countries for use of different ayurvedic products (Kaushik et al., 2025). More than 400 bioactive compounds have been identified with antioxidant, analgesic, antifungal, antiviral, antiparasitic, antitumor, cardiovascular, antidiabetic properties (Chang and Buswell, 1999). It is a nutraceutical that not used as food directly but its extracts are used for dietary supplements. The mushroom requires 25^{o}C to 30^{o}C with higher per cent of humidity. It grows naturally on different forest plants such as hardwood logs of oak, beech and plum etc (Kapoor & Sharma, 2014). However, different agricultural wastes like paddy straw, wheat straw, mustard wastes and coir pith are used to grow the mushroom commercially in indoor conditions (Soh et al., 2021). The productivity, morphometrics and other qualitative traits of mushroom also vary depending upon the substates that used for cultivation. Hence, different locally available agricultural wastes were evaluated to assess the growth behaviour with respect to productivity and morphometrics of *Ganoderma lucidum.*

2. MATERIALS AND METHODS

2.1 Collection and Maintenance of Culture

In order to conduct the experiment, the pure culture of the test fungus, *Ganoderma lucidum* was collected form ICAR-Directorate of Mushroom Research, Chambaghat, Solan (HP).

The pure culture of the fungus was maintained on potato dextrose agar (PDA) slant throughout the period of investigation. The fungus was sub cultured at an interval of two months and stored at 25±1^{o}C. Fifteen days old pure mycelia cultures of test fungus were used in various studies.

2.2 Preparation of PDA Medium

The most common medium, Potato Dextrose Agar (PDA) was used for culture of *Ganoderma lucidum*. Two hundred gram of peeled and sliced potato was boiled in 500ml of distilled water till potatoes were soft. Then the extract was filtered through cheese cloth and was collected in a graduated cylinder. Twenty gram of agar powder was boiled in 500ml of distilled water till the ager was dissolved completely. Both the solutions were subsequently mixed. Twenty gram of dextrose was added and the volume was restored to 1000 ml by adding fresh distilled water. Before sterilization, aliquots of 10 ml were taken in culture tubes for preparation of agar slants. Media to be poured into petri dishes were taken in Erlenmeyer conical flasks. The culture tube and conical flasks were plugged with non-absorbent cotton and autoclaved at 15 p.s.i. for 15-20 minutes. Slants were prepared by putting still hot tubes in slating position for solidification.

2.3 Preparation of Spawn

For preparation of spawn, bold and healthy wheat grains were cleaned and washed several times to remove the suspended particles or foreign materials. The grains were boiled with water in a container for about 30 minutes till they become soft. The boiled grains were spread on a sieve under shade to decant excess water. The cooled grains were mixed with 2% calcium carbonate on dry weight basis to avoid clumping of grains and improve alkalinity. The grains were filled up 2/3 portion of the available space of the spawn bottles and plugged with non-absorbent cotton, neither very tight nor very loose and sterilized in an autoclave at 22 lbs p.s.i. for 2 hours followed by cooling. For inoculating the bottles hygienically, the inoculation chamber was sterilized by putting 35ml of formalin (37-41% formaldehyde) and 17.5 g of potassium permanganate in a glass container and closing the room for overnight. Alternatively, the

chamber was exposed to ultra violet rays for 30 minutes prior to inoculation. The sterilized and cooled bottles were aseptically inoculated under laminar flow with mycelia bits of 15 days old mycelium culture and properly labelled. These inoculated bottled were incubated at 25±1 ^{o}C in B.O.D. incubator for two weeks. The bottles were shaken at 4 days interval to allow proper spread of mycelium between the grains. The bottles were then completely colonized by the mushroom mycelium in about two weeks and that time the spawn was ready for cultivating mushroom in large scale.

2.4 Preparation of Substrates and Bags

All the experiments were carried out in the growing room at Centre of Tropical Mushroom Research and Training (CTMRT), Department of Plant Pathology, College of Agriculture, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar. Five locally available different agricultural wastes such as paddy straw, maize stalk, sugarcane bagasse, coir pith along with saw dust were collected for evaluation. The individual collected dried substrates were soaked in water for 6hours followed by drying under shade to maintain a moisture level of 60 per cent. Prior to soaking, all the substrates except coir pith and saw dust were chopped two-inch size. About 200g of substrates on dry weight basis were filled in polypropylene bags and sterilized in an autoclave at 15psi for 30 minutes. The sterilized bags were allowed to cool at room temperature. After cooling, the bags were inoculated with spawn under aseptic condition. The experiment was conducted in quadruplicate.

2.5 Care and Harvest

The prepared bags were incubated in dark room for spawn run. The bags were then exposed to light and ventilation which induced pin head initiation. An average temperature of 30-32^{o}C with high moisture was maintained for proper growth and development of mushroom. Data on duration of spawn run, initiation of pinheads, days to first harvest and overall mushroom yield expressed as biological efficiency were recorded. The fully grown matured mushrooms were harvested and biological efficiency was calculated using following formula (Royse 1985).

$$\text{Biological efficiency } (\%) = \frac{\text{Fresh weight of mushroom (g)}}{\text{Dry weight of substrate (g)}} \text{X } 100$$

3. RESULTS AND DISCUSSION

The data on evaluation of different substrates on productivity of *Ganoderma lucidum* presented in Table 1 revealed that days to spawn run in bags varied from 22.5 days to 44 days. Early spawn run (22.5 days) was observed in paddy straw followed by coir pith (28.3 days), sawdust (33.0 days) and maize stalk (34.5 days) respectively. The maximum days (44.0 days) for spawn run was taken by sugarcane bagasse. Similarly, early pin head initiation was observed in paddy straw (33.0 days) which was statistically at par with that of coir pith (33.8 days), followed by maize stalk (38.0 days), sawdust (39.0 days) and sugarcane bagasse (52.5 days) respectively. Days to first harvest of mushroom was recorded from 53.0 days to 65.8days. Early harvest of mushroom in 53.0days was recorded as in case of paddy straw substrate which was at par with that of coir pith (54.8 days) and saw dust (55.3 days). Maximum duration of 65.8 days for first harvest was observed in sugarcane bagasse followed by maize stalk (57.8 days). Similarly, yield of mushroom ranged from 11.0g to 31.3 g per bag containing 200g of dry substrate. Maximum 31.3g mushroom with 3.3 numbers of mushroom was recorded from the bags containing saw dust which was at par with that of coir pith (26.5 g/bag, 3.8 numbers of mushroom). Lowest amount of mushroom (11.0 g) was recorded from sugarcane bagasse with 1.3 numbers of mushroom. Among the agricultural wastes, paddy straw resulted maximum production than maize stalk and sugarcane bagasse.

From the Table 2, the size of pileus and stipe length varied from 32.8 mm to 78.0mm and 37.3mm to 60.5 mm respectively. Maximum pileus size 78.0 mm was recorded in mushroom harvested from saw dust followed by paddy straw (55.0mm) and coir pith (52.3mm). Least pileus size 32.8 mm was observed in mushrooms that harvested from sugarcane bagasse followed by maize stalk (46.3mm). Maximum stipe length 60.5 mm was recorded as in case of paddy straw followed by saw dust and coir pith each having 50.8 mm.

Production and productivity of *G. lucidum* depend upon different ligno cellulosic wastes. Among five different substrates, saw dust resulted maximum yield of mushroom which was statistically at par that of coir pith. Thiribhuvanamala and Krishnamoorthy (2021) reported highest production of *G. lucidum* from coconut wood log

Table 1. Evaluation of different substrates on productivity of *Ganoderma lucidum*

Sl. No.	Substrate	Days to spawn run (d)	Days to pin head initiation (d)	Days to 1st harvest (d)	No. of fruiting bodies	Yield (g)/ bag	BE (%)
1	Paddy straw	22.5	33.0	53.0	3.3	23.3	11.6
2	Maize stalk	34.5	38.0	57.8	1.5	18.3	9.1
3	Sugarcane bagasse	44.0	52.5	65.8	1.3	11.0	5.5
4	Saw dust	33.0	39.0	55.3	3.3	31.3	15.6
5	Coir pith	28.3	33.8	54.8	3.8	26.5	13.3
	SE(m)±	0.5	0.5	0.9	0.2	2.1	-
	CD(5%)	1.7	1.5	2.7	0.7	6.4	-

Table 2. Morphometrics of *Ganoderma lucidum* as influenced by different substrates

Sl. No.	Substrate	Average size of cap (mm)	Average stipe length (mm)
1	Paddy straw	55.0	60.5
2	Maize stalk	46.3	49.5
3	Sugarcane bagasse	32.8	37.3
4	Saw dust	78.0	50.8
5	Coir pith	52.3	50.8
	SE(m)±	2.0	1.6
	CD(5%)	6.0	5.0

saw dust and production of mushroom may be due to presence of specific nutrients available in the substrate. Koutrotsios et al. (2019) reported that increase of β-glucan, a polysaccharide in fruiting bodies of *G. lucidum* which was harvested from Olive leaf pruned residues and further explained that substrates which are richer in phenolic and antioxidant compounds may play a great role in increasing of mushroom production. This result supports the present findings with respect to sawdust and coir pith that used in the experiment. Least production of mushroom per bag was recorded from sugarcane bagasse. Geetha et al. (2012) reported that days to complete spawn run and first harvest of *G. lucidum* from sugarcane bagasse were 45 days and 68 days respectively which corroborates the present result in case of sugarcane bagasse. Ninluam et al. (2016) reported maximum *G. lucidum* production from sugarcane bagasse in comparison to saw dust which contradicts the present findings in case of sugarcane bagasse and saw dust. Spawn run of *G. lucidum* completed within 22.5days on paddy straw with an average yield of 23.3 g/bag. But, Geetha et al., 2012 reported sparse spawn growth and poor production of mushroom from paddy straw. Poor production of the mushroom may be due to use of poor quality paddy straw used for production of *G. lucidum.* However, there is a positive correlation between cellulose and lignin content of the substrates and productivity of mushroom yield (Funda, 2020). Angelova et al, 2022 reported high content of cellulose, hemicellulose, holocellulose and lignin in the substrates are the main reason for poor mycelia growth of *G. lucidum.* Zhu, 2024, reported coconut saw dust increased significantly the yield and biological efficiency of *G. lucidum.* Ince et al, 2024 observed addition of corn cob to the substrate enrich the protein and mineral content of Ganoderma fruiting body without decreasing the yield and biological efficiency. Luo et al, 2024 reported the impact of substates on the composition of bioactive compound of *G. lucidum* and further research needs to explore.

4. CONCLUSION

Development of mushroom depends on various climatic conditions and substrate compositions. Similarly, productivity varies based on the specific substrate used during cultivation. Among the five different substrates, saw dust resulted maximum production of *Ganoderma*. But it is suggested to evaluate the saw dust from different broadleaf plants for the maximum productivity. It is also essential to study the medicinal values of mushroom harvested from different saw dust in comparison to other substrates. Successful commercial cultivation requires selection of substrates that are both affordable and easily accessible. Further research is necessary to enhance the qualitative traits of mushroom for entrepreneurial opportunities as well as health benefits.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declair that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT etc) and text to image generators have been used during writing or edition of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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