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Research Article

FIRST ATTEMPT OF AN ORGANIC CULTIVATION OF RED *GANODERMA LUCIDUM* UNDER SUBTROPICAL HABITAT AND ITS ECONOMICS

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ABSTRACT

Objective: *Ganoderma lucidum* is a highly priced medicinal mushroom occurs both in temperate and tropical zones. In the present study an attempt was made to develop organic cultivation technique on polypropylene bags under subtropical habitat.

Methods: Mother culture was procured from NRCM, Solan. Locally available substrate (Sawdust, wheat bran, rice bran, maize flour, and bagasse) was used for artificial cultivation. Grain master was prepared with fresh unbroken grains. The moistened sawdust powder was blended with dry rice bran, dry wheat bran, maize flour and bagasse for organic cultivation. The heat resistant polypropylene plastic bags were filled with the substrate. These bags were sterilized and then cooled overnight and aseptically spawned with the grain master and immediately transferred to the workstation.

Results and Conclusions: The spawn run was completed in 51 days. Then spawn bags were exposed to 30±1ºC and 90-95% RH. The first primordial initiation was noticed after 35 days. Vegetative and fruiting phase were completed in 67 days and 92 days respectively. Interval between two flushes was 65 days and total period of crop was recorded as 224 days. The total yield was 570 Gms. No pest attack was seen during cultivation. Results are comparable to other workers. The economics of artificial cultivation is encouraging and promising. Farmers are strongly recommended for its cultivation under subtropical habitat.

Keywords: *Ganoderma*, Organic cultivation, Subtropical habitat, Substrate, Economics.

INTRODUCTION

Ganoderma lucidum (Fr.) P. Karst is a small white rot basidiomycete's fungus that grows on decaying logs and trees stumps in both temperate and tropical zones. In central Himalayas, it is reported from oak strands Almora and Pithoragarh [1]. The fruit bodies of *Ganoderma* have been used in Traditional Chinese Medicine for more than 4000yrs [2]. *Ganoderma* has been used in TCM as a remedy to treat more than 20 different illnesses which include migraine and headache, hypertension, arthritis, bronchitis, asthma, anorexia, gastritis haemorrhoids, hyper-cholesterolaemia, nephritis, dysmenorrhoea, constipation, lupus erythematosis, hepatitis, leucopoenia, cardiovascular problems and cancers [3, 4]. Water soluble polysaccharide is the main

bioactive ingredient in the *Ganoderma* fruiting body which has been found to be medically active in several therapeutic effects such as an ti-tumour, anti-inflammatory and anti-viral [5]

A successful artificial cultivation of *Ganoderma lucidum* has been reported on most broad leaf hardwood trees and commonly used species include oak, pecan, and elder, elder, choke, cherry and plum [6, 7]. Moreover *Ganoderma* species can be cultivated on the sawdust which may originate from different kinds of trees [8, 9]. Artificial cultivation of *Ganoderma lucidum* is still in infancy in India in comparison to several countries of the world (China, Japan, Taiwan, Korea, and North America) where it is being cultivated on large commercial scale. Very few studies have been carried out on the feasibility of cultivation of *Ganoderma lucidum* in India [10, 11]. Scope of market for *Ganoderma* based products is enormous in national and international markets both but the paucity of knowledge on its cultivation practices is the main constraints.

Considering the medicinal value of this mushroom and its suitability for cultivation in Uttarakhand, an attempt was made to develop organic cultivation technique on polypropylene bags.

MATERIALS AND METHODS

Materials

All the chemicals and reagents used were of pure quality. The sawdust, rice bran, wheat bran, maize flour and bagasse were purchased from local market of Dehradun. The mother culture of Red *Ganoderma lucidum* was procured from National Research Centre for Mushroom (NRCM) Chambaghat, Solan (HP) and preserved at 4ºC at the work station (Fig.1).

Preparation of Grain master

We used fresh, unbroken, insecticide or fungicide untreated and insect undamaged wheat grains for the grain master preparation. 6 kg wheat grains were washed (04 times with fresh water) (Fig.3). The soaked grains were treated with 10 ml of the yellowish sodium hypo chloride for 05 minutes to disinfect the material. The treated grains were washed several times to get rid of disinfectant. The resultant grains were boiled with equal volume of fresh water till the grains became soft. The grain splitting and the oozing out of starch from the grains were conspicuously absent. The content of the container were sieved off to rig of excess water, and spread over the cotton cloth, and fan dried. The resultant grains absorbed three kg of water. The 4.5 g $CaCO_3$ per kg and 12 g $CaSO_4$ per kg were added to the whole contents and hand-mixed thoroughly. The clumping of grains was conspicuously absent i.e., the grains separation was completely achieved with additions of $CaCO_3$ and $CaSO_4$ to the grains.

The pH was found alkaline (> pH 7). The 16 bottles (each being 250 g capacities) were filled with these contents, cotton plugged and autoclave for sterilization at 15 lbs psi for 1.45h and transferred to aseptic chamber. In laminar flow chamber each bottle was inoculated with subculture and incubated at 30± 1˚C.

Substrate preparation

The substrate preparation involved the initial soaking of 54 kg of sawdust for 12 hr, followed by draining off water. The moistened sawdust powder had 60-70 % moisture and was blended with 5.5 kg dry rice bran, 5.5 kg dry wheat bran, 1.08 kg of maize flour and 0.2 kg of bagasse. The mixture was hand-mixed ensuring conspicuous absence of any splinter and bigger wood pieces (Fig.4)

Inoculation

The heat resistant polypropylene plastic bags (each measuring 40x 60 cm) were filled with the substrate (3kg per bag). Each bag was centrally holed, sterilized at 15lbs psi and 121ºC for 1.45h. These bags were then cooled overnight and aseptically spawned with the grain master @ 20g/kg in a laminar flow chamber applying Spot Spawning method and immediately transferred to the work station and placed at the vertical racks (Fig.5).

Work Station

The work station measuring 18 x 8 was equipped with 03 racks (7 x 5 each) (Fig.5). The growing space had reasonable ideal conditions. The conspicuous absence of light was insured at the initial stages (time of seeding). The temperature was maintained at 30±1ºC. The humidity was found as 75-85%. After complete spawn run, the polypropylene cover rolled back to expose the upper surface of the spawn run block. The opened bags were exposed to temperature of 30± 1 ºC and relative humidity of 90-95%.The diffused light was provided for 12h/day and to facilitate ventilation in rooms, doors were kept open for 30 min x 3 times a day.

Observations on days required for primordial initiation, number of fruit bodies, yield etc were recorded (Table 1). The harvested fruit bodies were shade dried by placing the fruit bodies with the underside of the pileus facing down. The data was analyzed statistically.

Economics Analysis

In order to assess the economic profitability of the mushroom production at subtropical habitat the cost benefit analysis was done on pilot scale production, using yield on sawdust with different organic supplements. The formula adopted was that of Abbot and Makeham [12]. The results were subjected to sensitivity analysis for optimistic, expected and pessimistic yield scenario. Experimental yield was considered optimistic. A more realistic (expected yield) level would be 80% of the experimental yield whereas the pessimistic (poor yield) would be 60 % of experimental yield.

Thus to arrived at expected and pessimistic yield the experimental yield was multiplied by 0.8 and 0.6 respectively. Gross return was calculated by matching the actual total yield of red *Ganoderma lucidum* obtained from the hundred kg of the substrate with the average fungal market price (Rs 40/gm). Labour cost was calculated at the market rate on the hour basis @ Rs 12.5/h. Land rent or cost management and depreciation structural cost were not included since farmers are expected to incur these costs while doing the cultivation.

RESULTS AND DISCUSSION

Steps involved in organic cultivation of red *Ganoderma lucidum* under subtropical habitat are shown in Fig. 1-13. Observations on days were recorded in Table 1.The spawned bags were incubated in dark at 30±1ºC and complete spawn run took place in 51 days. At 30±1ºC and 90-95% RH, primordial initiation was very fast and took 35 days. Vegetative and fruiting phases were completed in 67 days and 92 days respectively. Irrespective of temperature and humidity, there were 2 flushes and the interval between the flushes was 65 days. Total yield was 570 Gms. Fruit bodies were single and kidney shaped. The pileus was broader, thick and had short stalk. The total duration of crop was 224 days. Negligible insect attack was observed on crop.

Steps involved in artificial cultivation of red *Ganoderma lucidum* under subtropical habitat

Fig. 1: Mother culture procured from Solan

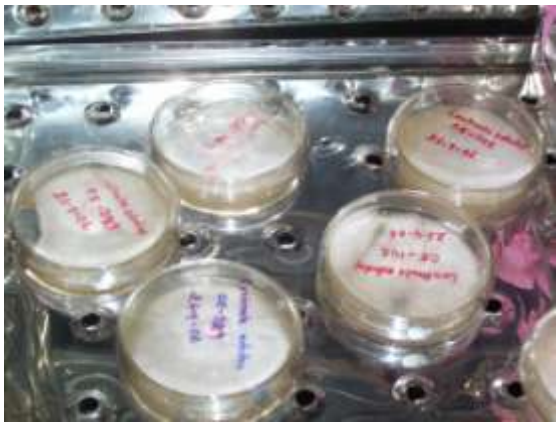

Fig. 2: Subculture from mother culture

Fig. 3: Preparation of Grain master

Fig. 4: Substrate preparation and inoculation

Fig. 5: Aseptic chamber

Fig. 6: Complete mycelium growth

Fig. 7: Cold shock treatment

Fig. 8: Tearing of bags

Fig. 9: Exposing the bags to light

Fig. 10: Primordial initiation

Fig. 11: Fruit body maturation

Fig. 12: Spore formation

Fig. 13: Mature Fruit bodies of *Ganoderma lucidum*

Thus, management of environmental parameters like humidity, temperature, oxygen through ventilation and light play a key role in the successful artificial cultivation of *Ganoderma lucidum* [11]. High relative humidity (85-95%), lowering of CO_2 and enhancement of oxygen in the cropping room were found to be essential for the formation and differentiation of pileus [13, 14].

Hence, 30±1ºC and 90-95% relative humidity were found to be ideal for the cultivation of *Ganoderma lucidum* under subtropical habitat. Our results are comparable to other workers, reported the temperature near to about 30º C as the required temperature of fructification [10, 15].

Economics of this study

The fixed production costs, variable production costs, returns and % profit are shown in Table 2, 3, &4 respectively. Table 4 shows that when 100kg of substrate was used, a return of 22800 Rs (on pilot scale) was obtained with a profit of 331.39 %. When the experimental yield was taken into consideration, the return of Rs 18240, with a profit of 245.13% was obtained with the consideration of the expected yield (80% of the experimental yield). The profit of 158.73 % was also found promising and encouraging suggesting possibility of the commercial production.

Table 1: Observations of organic cultivation of red *Ganoderma lucidum*

Parameters	Observations
Substrate moisture (%)	60-70
Temperature (º C)	30 ± 1
Humidity (%)	90-95
Spawn Run (days)	51
Vegetative phase (days)	67
Fruiting phase (days)	92
First harvest (days)	192
Second Harvest (days)	65
Total duration of crop (days)	224
Total yield (gms)	570
Fruit body	single
Total fruits	42

Table 2: Fixed production cost per 100 kg sawdust (excluding land rent and depreciation of building)

Items	Unit	Number	Unit cost (Rs)	Total (Rs)
Sawdust	Kg	100	1.50	150.00
Poly-bags	Piece	25	1.00	25.00
Grains	G	100	4.00	4.00
Cotton	Roll	01	54	54.00
Plastic pipe	Piece	01	20	20.00
Transport				500.0
Labour	H	320	12.5	4000
Total Expenditure				**5149**

Table 3: Variable production cost of organic supplements used per 100 kg of sawdust

Supplement	unit	No.	Unit cost (Rs)	Sub-cost (Rs)	Fixed-cost (Rs)	Grand-total (Rs)
Rice bran	Kg	10	6.00	60	-	-
Wheat bran	Kg	10	6.00	60	-	-
Maize Flour	Kg	01	12.00	12	-	-
Bagasse	Kg	0.25	20.00	05	-	-
Total				**137**	**5149**	**5286**

Table 4: Returns and profit % from organic cultivation of Red *Ganoderma lucidum* on 100 kg of sawdust with supplements Optimistic Yield (Experimental yield)

Yield in gms	570
Gross returns (Rs)	22800
Production cost (Rs)	5286
Returns (Rs)	17514
Cost/g of mushroom	9.27
Return/g of mushroom	30.72
% profit	331.39
Expected Yield (80% of Experimental yield)	
Yield in gms	456
Gross returns (Rs)	18240
Production cost (Rs)	5286
Returns (Rs)	12954
Cost/g of mushroom	11.59
Return/g of mushroom	28.41
% profit	245.13
Pessimistic Yield (60% of Experimental yield)	
Yield in gms	342
Gross returns (Rs)	13680
Production cost (Rs)	5286
Returns (Rs)	8394
Cost/g of mushroom	15.46
Return/g of mushroom	24.54
% profit	158.73

Calculated at the market price @Rs 40 per gram

CONCLUSION

The small number of positive hits in this study suggests that the subtropical habitat is also favourable for the artificial cultivation of Red *Ganoderma lucidum* upon self designed substrate under the applied conditions of 30±1ºC and 90-95% RH and other factors like oxygen, light etc. Economics of artificial cultivation of *Ganoderma lucidum* under the subtropical habitat was worked out to upscale its production at industrial level to make cost effective and job orientation programme. The economics of production is encouraging and promising. The economics gain appears to be on higher side. Our calculation placed our exercise at 100% profit. The farmers are strongly recommended for its cultivation at subtropical habitat.

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