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Cultivation of Oyster Mushroom (*Pleurotusostreatus*) using Bio-fertilizers to Enhance Yield: A Review

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Abstract: The present review compiles the technology for cultivation of oyster mushroom, problems experienced during its cultivation and biofertilizer technology to combat the problems.Mushroom cultivation is a profitable agri-business. Incorporation of non-conventionalcrops in existing agricultural system can improve the economic status of the farmer. Mushrooms are thesource of protein, vitamins and minerals and are anti-cancerous, anti-cholesterol, and anti-tumorous. Sawdustproduced highest yield, biological efficiency and number of fruiting bodies, recommended as a bestsubstrate for Oyster mushroom cultivation. Oyster mushroom proved to be one of the easiest to be grown, though it faces yield, nutrient, size issues. Biofertilizer includes certain bacteria such as Azotobacter, Rhizobia and Phosphate solubilizing Bacteria proved to yield better result.

Keywords: Bio- fertilizer, Cultivation,Oyster mushroom

Introduction

Mushroom cultivation technology, being relatively newer field and also because of unique way of raising the mushroom crop compare to cereals, pulses and vegetables, the role of microbial inoculants in it have not been studied much. Mushroom generally requires agro based substrate for their production. Microbial inoculants thrive well on these materials and hence chances of deriving benefits from microbial inoculants in mushroom cultivation technology are very high. In spite of previous research on microbial effect on mushroom production little information is available on different microbial community effect in the casing on mushroom sporophore formation. The presence of microbial population both in compost and casing soil plays vital role in *P. ostreartus* cultivation. The microbial biomass present in compost affects the mycelial spread during spawn run phase, while in casing soil it triggers the induction of reproductive phase of the *P. ostreartus* life cycle.

Review Literature

Oyster mushrooms (Pleurotus species), the third largest commercially produced mushroom in the world are found growing naturally on rotten wood material. Oyster mushroom (Pleurotus sp.) belonging to Class Basidiomycetes and Family Agaricaceae is popularly known as 'Dhingri' in India and grows naturally in the temperate and tropical forests on dead and decaying wooden logs or sometimes on dying trunks of deciduous or coniferous woods. It may also grow on decaying organic matter. And rotten wood material. It is rich in Vitamin C and B complex and the protein content varies between 1.6 to 2.5 percent & mineral salts required for the human body. The niacin content is about ten times higher than any other vegetables. Oyster mushroom can grow at moderate temperature ranging from 20 to 300 °C and humidity 55-70% for a period of 6 to 8 months in a year. The best growing season is during March/April to September/October and in the lower regions from September/October to March/April.

Oyster Mushroom Cultivation

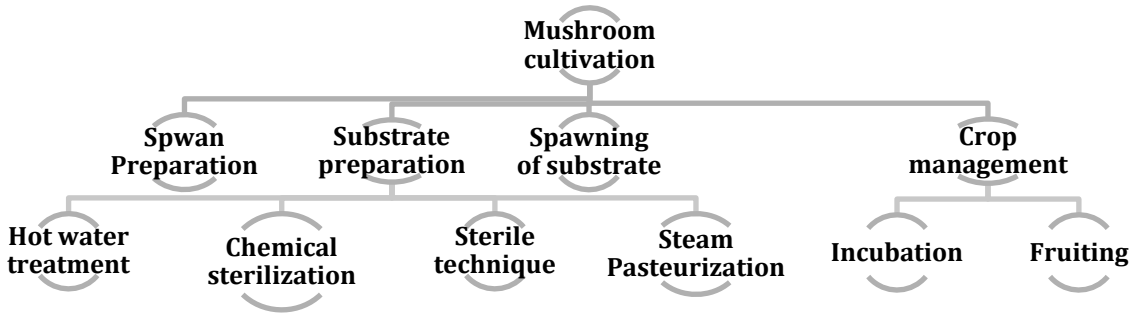
Oyster mushroom growing on straw can be fragmented into 4 segments:

1. Spawn Preparation

Substrates for oyster mushroom and their nutrition quality:

Agricultural-remains having cellulose and lignin which assists in more enzyme growth of cellulose that is corresponded to more yield. These include straw of wheat, ragi and paddy, leaves and stalk of maize, cotton

and millets used citronella leaf, saw dust, cotton waste, used tea leaf waste, sunflower stalks, dried grasses, dehulled corncobs, pea nut shells, and synthetic compost of button mushrooms etc.



Methods of substrate preparation: The mycelial growth can take place on a simplewater treated straw but there are number of other cellulolyticmolds already present on straw, which compete with *Pleurotus* mycelium duringspawn run and also secrete toxic metabolites hampering its growth. The popular methods of substrate preparationare as follows.The accepted practices of substrate preparation are:

i. Steam pasteurization

Socked substrate is loaded in woodentrays and then kept in a pasteurization room at 58-62°C for 4 hours. Temperature of the pasteurization room is changed by means of thesteam through a boiler.

ii. Hot water treatment

The substrate after cutting (3-5 cm) is wetted in hotwater for Wheat straw: 1 to 2 hours at 80°C and for Paddy straw: 85°C for 30- 45 minutes. After draining, spawn is added at room temperature. This treatment enables
mycelial growth takes place easily.

iii. Chemical sterilization technique

Various species of *Gliocladium, Penicillium, Doratomycs, Aspergillus* and*Trichoderma*, spp. are the common fungi on the substrate duringoyster mushroom production. The presence of the fungi does not allowthe mycelium to grow on the substrate. In order to kill or suppressed for25-40 days after spawning avoid the mould growth the substrate istreated with steeping in a chemical solution of carbendazim 50% WP(37.5 ppm) and formaldehyde (500 ppm) for a period of 16-18 h. Thetechnique, which was standardized at DMR, Solan by Vijay and Sohi in1987, follows galvanized drum with 90 liters of water was taken ortub of 200 liters capacity. Approximately about 10 to 12 kgs of substrateis soaked in water .In another plastic container, Bavistin 7.5 g and 125 mlformaldehyde (37-40%) is dissolved in water and slowly added to thedrum which containsthe substrate. Straw is balled and coated with apolythene sheet. After completion of 15 to 18 h the substrate isremoved from drum and surplus water is drained.

iv. Sterile technique

The substrate was cut into small pieceswhich was soaked into water and after removing of excess water, thestraw is placed in the polythene cover which is heat resistant andsterilized in an autoclave at 20 p.s.i. for 1-2 hours followed by additionof spawn under sterile conditions.

3. Spawning of substrate

Freshly prepared (20-30 days old) grain spawn is best for spawning. Thecomplete procedure is done in the sterile conditions which is previouslytreated with 2%formaldehyde before 48 hours. The spawn 2 to 3% ofthe wet wt. of the substrate spawn is required11. 300gm of spawn isrequired for about 8-12 kg of wet substrate

or 2 to 3 kg of dry substrate.Spawn can be mixed thoroughly or mixed in layers. Spawning is done inpolythene bags (60 x 45 cm) of 125-150 gauze thickness. Small holes aredone in all the sides of the cover including bottom so that the excesswater for draining. Punctured bags give more and fast crop (4-6 days)than non-punctured bags because of accumulation of high CO_2, whichreduces fruiting.

4. Crop Management

(A) Incubation

The polythene bags which are spawned are moved to dark roommycelium growth, the growth of the mycelium takes place between 10to 33°C, but it grows maximum at 22 to 26°C.

(B) Fruiting

The last stage of mushroom cultivation is fruiting, this happened afterthe fully growth of mycelium on the substrate, if any contaminated bags are observed should be removed and the half-colonized bags kept formore days for complete growth. The size of the fruit depends on thehumidity of the substrate, the fruits are bigger in size with morehumidity (85-90%) and the fruits are smaller in size at the humidity (65-70%) and the concentration of CO_2during harvesting should be less than 600 ppm. or 0.6%. Properventilation has to be provided during fruiting.Currently, high biofuel prices have caused an increase in food prices andfood scarcity in many countries (World Bank, 2008).

Few of the reported pharmacological actions with their chemical constituents are reported inthe Table 1.

Table 1: Pharmacological effects and chemical constituents of Pleurotus

Pharmacological effect	Chemical constituents	References
Anticancer	Water soluble protein (or) polysaccharides	Jedinak A *et. al* (2010) Wu *et. al* (2011) De Silva DD *et. al* (2012) [56,57,58] Bokek P &Galbavy S (2001) Wang H &Ng TB (2000)
Antioxidant	β-D Glucan (pleuran) Lectin	Zhang YX et al (2012) Mitra P et al (2013) [59,60,61,62]
Antitumor	β-D Glucan (pleuran) Glycopeptide s Proteoglycans	Bokek P &Galbavy S (2001) Li et al (1994) Sarangi I et al (2006) Silva S. et al (2012) Devi KSP et al (2013) [59,63,64,65,66]
Antiviral	Ubiquitin-like protein	Wang H &Ng TB (2000) Ei-Fakharany et al (2010) [60,67]
Antibacterial	β-D Glucan (pleuran), silver nanaoparticles(AgNPs)	Karacsonyi S &Kuniak L (1994) Mirunalini S et al (2012) Vamanu E et al (2012),[68,69,70]
Antidiabetic	Unspecified bioactive	Krishna S & Usha PTA (2009) Ghaly et al (2011) [71,72]

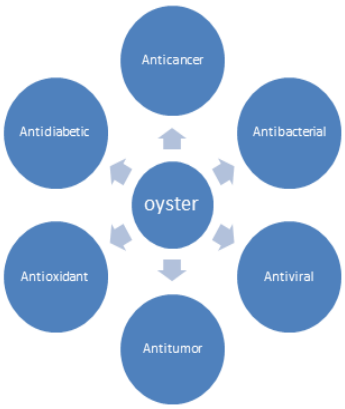


Figure 1 Pharmacological application

Oyester Mushroom Cultivation Problems

Problems associated with the violation of substrate preparation technology, climatic and sanitary incubation parameters etc., are as follows:

1.The block has brown streaks from the perforations,
2. The second flush gives a very low yield or no yield at all. Such problems are observed when the substrate moisture is insufficient.
3. As Fungi cannot sufficiently absorb the nutrients due to lack of moisture. On the remains of the clusters, moisture begins to accumulate and a secondary bacterial infection develops, therefore they surprisingly look wet, not dry.
4. Mold in the block – green (trichoderma) or black (mucor)
5. The appearance of green mold in the slots of blocks during the overgrowth.
6 Condensate and water-logged substrate condensation can occur due to the sudden changes in temperature of the room where the blocks are overgrowing.
7 Abnormal development of primordia, the presence of "cones" Indicates temperature and humidity swings during incubation processbefore the development of primordia, then – gradual increase to 85-90%.
8 Long stems caused by high Co_2 levels in the room they are in.

Technology to Combat Problem

Biofertilizers are new advancementsto combat the described issues for mushroom cultivation.

1. Role of Biofertilizers in Mushroom Cultivation

Microwave vacuum pyrolysis of waste palm shell (WPS) was performed to produce biochar, which was then tested as bio-fertilizer in growing Oyster mushroom (*Pleurotusostreatus*). The pyrolysis approach generated a biochar containing a highly porous structure with a high BET surface area (up to 1250 m2/g) and a low moisture content (≤ 10 wt%), exhibiting desirable adsorption properties to be used as bio-fertilizer since it can act as a housing that provides many sites on which living microorganisms (mycelium or plant-growth promoting bacteria) and organic nutrients can be attached or adsorbed onto. This could in turn stimulate plant growth by increasing the availability and supply of nutrients to the targeted host plant. The results from growing Oyster mushroom using the biochar record an impressive growth rate and a monthly production of up to about 550 g of mushroom. The shorter time for mycelium growth on whole bag log (30 days) and the highest yield of Oyster mushroom (550 g) was obtained from the cultivation medium added with 20 g of biochar. Our results demonstrate that the biochar-based bio-fertilizer produce from microwave vacuum pyrolysis of WPS show exceptional promise as an alternative growing substrate for mushroom cultivation.

2. Rhizobia as biofertilizers for mushroom cultivation.

In Iran, rhizobia can be used as biofertilizers for increasing the harvest and nutritional quality of cultivated mushrooms more efficiently. To prove this, processed wheat grains were incubated separately with pure mycelium alone of American oyster mushroom (*Pleurotusostreatus*), together with a 2×2 cm yeast mannitol agar slab containing *Bradyrhizobiumelkanii*, a rhizobial stain used for soyabean biofertilizers. It was found that pure mycelium together with *B. elkanii* increased ash, Ca, P, K and protein contents by 128, 16, 3, 17 and 24%, respectively. It also increased biological efficiency and dry matter content of mushroom by 10 and 30%, respectively, and decreased time to primordial initiation by about 7 h. Therefore, the use of rhizobia as biofertilizers in mushroom cultivation seems to be a promising method of producing a higher yield of mineral and protein-rich mushroom more efficiently, which should be further developed for other types of mushrooms.

3 Effect of Liquid Biofertilizers on Button Mushroom Yield

Present research work has been carried out to understand the effect of liquid biofertilizers on button mushroom yield. The application of at the time of casing gave slightly better result followed by application of biofertilizers at the time of spawning. All the treatments of biofertilizers i.e. Azotobacter and PSB either alone or in combination were found significantly effective in improving growth and yield of *A. bisporus* as well as effect on parameters of compost and casing like nitrogen and phosphorus content. However, the phosphate solubilizing bacteria either alone or in combination performed better as compared to Azotobacter alone. The reduction in time taken for pinhead initiation and button formation (2-5) days after casing was observed in *A. bisporus* due to application of biofertilizers. Significantly increased in number of fruits per bed as well as average weight of fruit body due to use of bioferilizers as compared to uninoculated treatments. The treatments of microbial inoculants showed an increase of 17.47 per cent to 64.19 per cent in yield of button mushroom and recorded biological efficiency of 19.97 per cent to 27.92 per cent. Nitrogen and phosphorus content in spent compost showed decline over initial value. Low reduction of N-content was observed in Azotobacter inoculated treatments and low phosphorus content in PSB inoculated bags. Highest contamination was recorded in the control treatment. There was decline in population of Azotobacter and phosphate solubilizing bacteria in compost and casing after harvest of mushroom over initial standard population. Among the different treatments tested, the treatment of Azotobacter + PSB @ 25 ml/kg casing, was found to be very effective because it showed significant increase in number of fruits per bed (185.75); improvement in average weight of fruit body (15.02 g), increased in yield 2.792 g/10 kg of compost i.e. 64.19 per cent higher and 27.93 per cent higher biological efficiency. Highest N- content in casing 0.17 per cent. PSB (B. megaterium) @ 25 ml/kg of casing showed significant reduction in days required for pinhead initiation and days required for button formation i.e. 12.25 and 16.25 days respectively.

Conculsion

The key to success in mushroom growing is the careful observance of the technological regulations of the enterprise. And the key components of this success are a qualitative sterile mycelium, properly selected technologies for mushroom bock raw materials processing (classical hydrothermal treatment for small enterprises and tunnel pasteurization for medium and large ones) and the availability of quality microclimate systems in the growing rooms. Besides biofertilizers proves to be the most important technology for oyster mushroom cultivation. It plays key role in increasing yield and combatingpeculiar problems faced during the cultivation of Oyster mushroom.

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