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Sanika Joshi
Ph.D. Research Scholar, Department of Plant Pathology, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

PG Borkar
Associate Professor of Plant Pathology, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

AD Saykar
Student, Department of Plant Pathology, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

SV Pawar
M.Sc. Student, Department of Plant Pathology, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

Correspondence
SV Pawar
M.Sc. Student, Department of Plant Pathology, College of Agriculture, Dr. BSKKV, Dapoli, Maharashtra, India

Assessment of biological efficiency of *Pleurotus* Sajor Kaju, P. Florida, *P. Citrinopileatus* and Hypsizygus

Sanika Joshi, PG Borkar, AD Saykar and SV Pawar

Abstract
In order to find out the biological efficacy of four oyster mushrooms *viz. P. sajor caju, P. citrinopileatus, P. florida* and *H. ulmarius* was evaluated on paddy straw substrate. *H. ulmarius* was the best performer with highest BE (90.10%) which was followed by *P. citrinopileatus* (85.66%), *P. sajor caju* (77.68%) and *P. florida* (57.63%). The performance of *P. florida* was unsatisfactory in all the treatments. Cultivation of *Hypsizygus ulmarius* or *P. citrinopileatus* or *P. sajor-caju* should be preferred than that of *P. florida* under *Konkan* conditions.

Keywords: Biological efficiency and mushrooms

Introduction
Mushrooms are valuable food, which are low in calories, high in vegetable proteins, zinc, chitin, fiber, vitamins and minerals (Alam and Saboohi, 2001) [1]. The mineral salt content in mushrooms is superior to that of meat and fish and nearly twice that of the most commonly used vegetables. Mushrooms with their flavour, texture, nutritive value and high productivity per unit area have been identified as an excellent food source to alleviate malnutrition in developing countries. Fungi of the genus *Pleurotus* have an important place among the commercially employed basidiomycetes because they have gastronomic, nutritional and medicinal properties and can be easily cultivated on a large range of substrates (Chang and Hayes, 1978; Kumari and Achal, 2008) [2, 3]. *Pleurotus* spp. has a tremendous organoleptic and nutritional appeal (Garcha, 1997) [7].

Indian production scenario has been negligible amounting only to 50,000 tonnes per annum as against world production of 55 lakh tones (Banik, 2010) [5]. Demand for mushrooms is increasing day by day as people have realized that mushroom consumption is the best solution to a number of health problems such as high cholesterol, diabetes, hypertension, constipation and also have anti carcinogenic properties. Large varieties of biomass have been successfully utilized for cultivation of *Pleurotus* spp. Agro waste such as straws of cereals, sugarcane bagasse, weeds, left over's of the harvested crops, cotton waste, sorghum stalks, soybean stalks, maize cobs have been successfully used as substrates for cultivation of oyster mushrooms. But paddy straw is the most widely used substrate for commercial production of oyster mushroom (Mago *et al*., 2014) [6]. Substrate enrichment with protein rich supplements like wheat bran, rice bran, soybean flour have also been reported to be very effective in enhancing biological efficiency of oyster mushrooms. Although cereal straws have proved to be better substrates, their fortification with protein rich supplements definitely enhances the biological efficiency of mostly all the oyster mushrooms.

Though supplementation of substrates with protein rich supplements have been tried to increase the yield, use of micronutrients, growth regulators and chemical fertilizers for yield enhancement has not been investigated to a greater extent. Plant growth regulators play an important role in mycelia growth of mushroom under *in vitro* conditions (Maniruzzaman, 2004) [7]. Macro-and micronutrients, especially essential bio-metals are often used to increase the yield of medicinal mushroom biomass and their biological activity in the modern industrial cultivation. (Galeb *et al.*, 2014) [8]. *Pleurotus* species have the ability to absorb microelements from different cultivation media and thus they may present an excellent dietary source (Stajic *et al*., 2002) [9]. However, early colonization of the substrate and availability of required micronutrients to initiate fruit body formation has not been thoroughly investigated.

Thus with a view to increase the yield of mushrooms it was felt necessary to find out the ways to enhance the biological efficiency of four different oyster mushrooms.

Materials and Methods

Master Spawn Preparation

The spawn of oyster mushroom was prepared on wheat grains. One kg healthy and cleaned wheat grains were selected and washed thoroughly with tap water; wheat grains were soaked in cold water for 2 hrs and semi cooked to make them soft. Care was taken to avoid overcooking of grains which may affect the spawn quality. After cooking excess water was drained off and grains were uniformly spread on a clean plastic sheet on a table. Calcium carbonate (7%) was mixed on wet weight basis of the grains. About 250g quantity of treated grains was filled in 500 ml capacity conical flasks. These flasks were plugged with non-absorbent cotton and sterilized in an autoclave. After cooling at room temperature, the flasks were transferred in a laminar air flow cabinet, where they were exposed to UV light for 20 minutes and then aseptically inoculated with fresh mycelial bits taken from the previously prepared pure culture slants. Inoculated bottles were incubated at 28 ± 2^0C for 16-18 days. The fresh spawn with profuse mycelial growth was used for further experiments.

Biological efficiency of oyster mushrooms

a) Sanitation of incubation and cropping room

The incubation and cropping rooms were cleaned and disinfected by spraying 0.2 per cent carbendazim and 0.2 per cent dichlorovos (DDVP) with a knapsack sprayer. After spraying, the room was kept airtight for 24 hours and then opened for fresh air circulation.

b) Assessment of biological efficiency of oyster mushrooms on paddy straw substrate

Paddy straw was chopped into 5-7cm pieces. Required quantity of paddy straw was weighed on electronic balance. The straw substrate was transferred to gunny bags and soaked for 8 to 10 hours in cold water. The bags were removed from the water and were pasteurized in hot water (80-90^{0}C) for 30minutes. Excess water in the substrate was drained off by placing the gunny bags on a clean, cemented platform with desirable slope. The paddy straw was removed from the gunny bag and exposed to sunlight by spreading it on a clean and disinfected platform to ensure the moisture content of substrate is around 60%. Polypropylene bags of desired size were used to fill the beds. Before filling the beds, the polypropylene bags were disinfected with dettol. These bags were filled by placing 5-6 alternate layers of the substrate and spawn. Spawn was used @ 2 per cent on wet weight basis of the substrate. Each bag thus filled was plugged with cotton to provide proper aeration during spawn run. Mushroom beds were then stacked on iron shelves in spawn run room. Complete darkness and temperature around 25-30^{0}Cwas maintained in this room till completion of spawn run. Beds with full white mycelia growth were opened and transferred to the cropping room on wooden hangers. In cropping room, about 25-30^0 C temperature and 85-90 per cent relative humidity was maintained. The following observations were recorded for all the mushroom species under study.

1. Date of spawning
2. Days required for spawn run
3. Days required for pinhead initiation.
4. Total yield/ bed

The humidity in the cropping room was maintained within a range of 85-90 per cent with the help of mist blowers which were run for 5-10 minutes 4-5 times a day. Five replications were maintained per species. The experiment was laid in Completely Randomized Design (CRD).

Biological efficiency was calculated by the following formula.

$$\text{Biological efficiency} = \frac{\text{Fresh weight of mushrooms}}{\text{Dry weight of substrate}} \text{ X } 100$$

Results and Discussion

The biological efficiency of the four oyster mushrooms was studied on paddy straw substrate. It is revealed from the data presented in Table 1, that among the four species, minimum period (20 days) was required by *P. citrinopileatus* to colonize the substrate followed by *P. florida* (22 days) and *P. sajor-caju* (25 days) respectively. Maximum period (27 days) was by *H. ulmarius*. Early emergence of pin heads occurred on *P. sajor caju* beds (4 days after mycelial colonization) followed by *P. citrinopileatus* (5 days). They were followed by *H. ulmarius* which took 6 days for pinhead formation after opening of the mushroom beds. Delayed pin head formation was recorded only in *P. florida* where pin heads appeared 10 days after spawn run period. The overall spawn run period ranged between 20-27 days and pinhead initiation period between 4-10 days after opening of mushroom beds.

It is revealed from the data presented in Table 1 that all the treatments were statistically significant. The maximum biological efficiency was recorded in *H. ulmarius* (90.10 %) which was numerically the highest but it was statistically at par with that of *P. citrinopileatus* (85.664%), *P. sajor caju* performed satisfactorily with biological efficiency of 77.680 per cent. *P. florida* was the poorest performer with biological efficiency of just 57.63 per cent. The data indicates that the biological efficiency of *H. ulmarius* was the highest among all the four mushrooms, though it took more time for substrate colonization and pinhead formation than *P. sajor caju* and *P. citrinopileatus*. The biological efficiency of *H. ulmarius* on paddy straw was 68.84 per cent (Mungekar *et al*., 2013). Biswas and Kuiry (2013) [11] reported that, the biological efficiency of *H. ulmarius* was the maximum (156%) followed by *P. florida* (121.2%) and *P. sajor-caju* (115.5%). Mohapatra and Behera (2013) [12] found that *P. florida* performed better (BE-115.33%) than *H. ulmarius* (BE - 102.83%). The results of present study are in concurrence with those of Biswas and Kuiry (2013) [11] as *H. ulmarius* recorded maximum BE in both the cases as compared to other mushrooms. The results of Mohapatra and Behera (2013) [12] revealed that the BE of *H. ulmarius* (102.83%) was superior to that of the other mushrooms but inferior to *P. florida* (115.33 %). They also reported that the BE of *P. sajor-caju* was 77.08 per cent. These results are contradictory to present findings in case of *P. florida* (BE -57.63 %) but analogous in case of P. sajor-caju (BE -77.68 %). According to many workers, the biological efficiency of *P. florida* is better than other species of the genus *Pleurotus*. However the results of present study indicate that it is not suitable for cultivation under *Konkan* conditions. Temperature and relative humidity have profound impact on primordia initiation and development of all the mushrooms. During the present study it was observed that, the process of primordia initiation on the beds of all the mushrooms was normal but the primordia of *P. florida* developed into small sized fruiting bodies as compared

to other mushrooms and such small sized fruit bodies dried and turned brown within 3-4 hrs. This was not observed in other mushrooms. The reason for this may be attributed to slight rise in temperature which might have affected the fruit body development of *P. florida*. Perhaps, this mushroom requires a temperature of around 22-23^{0}C for basidiocarp development and other species sustained the rise in temperature beyond this range due to their genetic potential.

Table 1: Biological efficiency of oyster mushrooms

S. No	Species	Spawn run Period (days)	Pinhead formation (days after opening of bag)	Yield per 500g dry substrate (g)	BE (%)
1.	*P. sajor-caju*	25	4	390.20	77.680
2.	*P. florida*	22	10	300.08	57.630
3.	*Hypsizygusulmarius*	27	06	445.16	90.100
4.	*P. citrinopileatus*	20	05	425.06	85.664
	SE =				8.510
	CD 5% =				25.520
	CD 1 % =				35.170

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