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Seasonal influence on the cultivation of important oyster species and their productivity in east and south eastern coastal plains of Odisha

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Abstract

A trial was designed to cultivate the species year-round at bimonthly intervals from November 2018 to September 2019 in the ambient conditions in an effort to determine the seasonal influence on the cultivation of ten significant oyster species and productivity (Biological efficiency) in particular. This study assesses the biological efficiency of many Pleurotus species as well as the effect of spawning periods on the average weight of fruit bodies and sporophore weight. According to the findings, *Pleurotus ostreatus* continuously produced the largest average fruit body weight, reaching a peak of 17.56 g between November and December 2018. *Pleurotus citrinopileatus* also did well during this time.

Keywords: Pleurotus species, spawning period, biological efficiency, yield optimization, sporophores

Introduction

Since the Greek philosopher Theophrastus (372-287 B.C.) first mentioned mushrooms, they have been prized as a delicacy for more than two millennia. He emphasized their significance as food that may be harvested from fields, meadows, and farmlands. Global mushroom production has increased over time, reaching 5.0 million metric tons (Kues and Liu, 2000) [10]. *Agaricus bisporus* accounted for 73% of the 0.2 million metric tons of mushrooms produced in India in 2019–20, which was a fourfold increase. *Pleurotus* spp. (16%), *Volvariella* spp. (7%), and *Calocybe indica* (3%) were next in line (Agristat, 2020, Ahmad *et al*. 2009) [1, 2]. The ability of *Pleurotus* species to transform lignocellulose substrates into nutrient-dense food with low input needs and year-round cultivation potential because of species diversity makes them especially valuable. This study aims to assess the impact of different seasons on the yield and biological efficiency of different *Pleurotus* species in Odisha, determine the optimal spawning time for maximizing production, and identify promising, lesser-known species for commercial cultivation in varied agro-climatic zones. These findings will contribute to enhancing productivity and diversifying *Pleurotus* cultivation in Odisha’s mushroom industry.

Materials and Methods

Test fungus

Ten species of oyster mushroom were evaluated: *P. eous*, *P. florida*, *P. sajor-caju* (CTMRT strain), *P. citrinopileatus*, *P. fossulatus*, *P. flabellatus*, *P. platypus*, *P. ostreatus*, *H. ulmarius*, and *P. sajor-caju* (DMR strain). The fungi were obtained from the Centre for Tropical Mushroom Research and Training (CTMRT), Department of Plant Pathology, College of Agriculture, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar.

Maintenance of culture

Throughout the study, the fungi were kept on Potato Dextrose Agar (PDA) slants. Every two months, cultures were subcultured and kept at 25 ± 1 °C. Pure mycelial cultures that were 15 days old were employed in the research.

Cultivation of Pleurotus

Materials used for bag preparation

Bag preparation and mushroom growing were done using paddy straw from tall or enhanced Indica types. Using a chaff cutter, well-dried, hand-threshed straw that was under a year old was chosen and cut to 1.5 to 2.0 inches. It took about 1.5 kg of dry straw each ba.

Farmhouse setup

The CTMRT farm and Krishi Vigyan Kendra in Kendrapara served as the sites for the tests. The farmhouse's dimensions were 50 feet long by 20 feet wide. Its floor was cemented, while its roof was made of asbestos. An ideal habitat for growing mushrooms was created by the broad windows that were covered with fine wire mesh to guarantee enough ventilation.

Light, air, and humidity management

To let in morning and evening light, gunny sacks were placed over windows and opened from east to west. The sand on the floor was maintained moist, water was sprayed, and gunny sacks were saturated to maintain humidity.

Temperature Control

eurotus species' mycelial development was kept between 20 and 30 °C. Between November 2018 and February 2019, the trials were carried out.

Setup of raised racks and shelves

To facilitate the test fungi's mycelial growth, a rack of three shelves was built in the incubation area, with the shelves spaced 2.5 feet apart. Within the farmhouse, completely colonized sacks were suspended in three levels on bamboo rods for fruit body induction.

Substrate preparation

Three bundles of paddy straw (~1,500 g) were chopped into 1.5–2.0 inches, packed in gunny bags, a Three bundles (about 1,500 g) of paddy straw were cut into 1.5–2.0 inch pieces, placed in gunny bags, and left to soak for six hours in a solution of 7.5 g bavistin and 125 ml formalin per 90 liters of water. The palm test verified that the straw had reached 65% moisture after it had been drained and spread out on a cement floor.

Paddy straw were soaked in a solution of 125 ml formalin and 7.5 g bavistin per 90 litres of water for 6 hours. The straw was drained and spread on a cement floor to achieve 65% moisture, confirmed by the palm test.

Spawning of the substrate

For spawning, freshly produced grain spawn that was 20–30 days old was purchased. For 48 hours, the procedure was conducted in a room that had been fumigated with 2% formalin beforehand. Each bag containing 1.5 kg of dry substrate contained 150 g of spawn, or 10% of the dry substrate weight. In addition to the 200 g of boiling wheat that was utilized as a supplement, the spawn was carefully removed from the container and separated into four sections. One piece of spawn and one piece of boiled wheat were positioned close to the edge of each layer of the straw substrate, which was piled to a thickness of 5–6 inches inside 80 cm × 40 cm polythene bags. Four substrate layers were seeded with the

The bags were securely tied and perforated with 10-15 small holes (0.5-1.0 cm) on all sides, including 2-4 holes at the bottom, to ensure proper drainage and gas exchange (Hemalatha *et al*., 2017) [7].

Crop Management

Incubation

Spawned bags were incubated on shelves without ventilation or additional humidity. The temperature in the incubation room was monitored daily.

Fruit body induction

Once the spawned bags were confirmed to be fully colonized with a thick mat of mycelium on the straw substrate, the polythene bags were cut open. The compacted substrate was then placed on wooden shelves in the cropping room. Conditions were maintained with 200 lux light for 12 hours a day, a temperature range of 20–30 °C, and 70–80% humidity. The substrate was sprayed with water twice daily to maintain adequate moisture for the developing mycelium (Hemalatha *et al*., 2017) [7].

Fruiting and harvest

Fruiting bodies were picked within three days of the bag being opened, and primordia or hyphal knots showed up three to four days later. The mushrooms were harvested by gently tugging or twisting them. Over the course of a 45–60 day crop period, fruiting proceeded for three to four flushes.

Yield

The yield of *Pleurotus* species varied depending on species productivity, environmental conditions, and aftercare.

Results

Traditionally, *Pleurotus* spp. is grown during winter months (November-February) in the state of Odisha. However, in an attempt to find out the seasonal influence on the cultivation of ten important oyster species and productivity (Biological efficiency) in particular, a trial was formulated by cultivating the species round the year at bimonthly interval from November 2018 to September, 2019 in the ambient situation. The data recorded on yield and yield attributing parameters were analyzed and presented in Table -1 to 6.

Analysis of data showed significant difference among the six dates of spawning of 10 test species evaluated. It was observed that both the November and January spawning were associated with low incubation period (12.17-19.00 d) in comparison to the rest four periods. The incubation period lengthened as the spawning period progressed further from January to May indicating its direct relationship with the prevailing atmospheric temperature. Further, kharif spawning in the month of July and September indicated fluctuations towards lower/higher side in respect of the length of the incubation period. The results, therefore, revealed the superiority of November and January spawning having given a acceptable spawn run period (Table-1).

Days to pin head emergence was also found shorter in November and January spawning (14.00-20.00 d). However, the length increased with the progress in spawning dates with the exception of May spawning which was still longer. Days to pin head emergence was lowest (14.00 d) in May spawning of *P. flabellatus*. However, significant difference was observed among the spawning dates of 10 *Pleurotus* species evaluated in the investigation (Table-2).

Crop duration (time taken for first flush) was found to be minimum (15.67- 22.16 d) during November and January spawning with little deviation in *P. sajor-caju* (DMR strain). Summer crops showed lengthy duration (17.17-24.83 d) and kharif crops were having moderate duration (16.17-22.67 d). Relation of crop duration with the prevailing climatic condition was observed distinctly in the investigation (Table-3).

Average weight of fruit bodies (g) followed the same trend and were found significantly different among the spawning dates. The weight of fruit bodies varied from 4.69 g in *P. sajor-caju* (CTMRT strain) raised in the month of January to 17.56 g in *P. ostreatus* raised in the month of November. Summer season was found inferior in respect of the average weight of fruit bodies (3.66-5.10 g), whereas, the kharif season produced fruit bodies with moderate weight (4.84-16.34 g) indicating the superiority of winter season in producing robust fruits (Table-4).

The total weight of sporophores was found significantly highest in winter season crop (552.83 g-1100.00 g) in comparison to summer (23.00.144.67 g) and rainy season (204.17-655.33 g). Accordingly the biological efficiency varied significantly among the spawning dates. A biological efficiency of 110% was realized in the November sown crop of *P. ostreatus* as against 1.73% realized in the May sown crop of *P. platypus*. This indicated the inferiority of summer and kharif season crops in yielding oyster mushroom appreciably (Table. 5, 6).

Discussion

Unlike other cultivated mushrooms, species of *Pleurotus* exhibit much diversity in their adaptability to varying agro-climatic conditions. The European strains fruit well at low temperature (below 12 ºC) whereas the white types come up well at relatively higher temperature (up to 30 ºC). *Pleurotus florida* and *P. sajor-caju* being very popular in the Eastern parts of the country are produced both during the rainy and winter seasons with varying degrees of success. In the investigation on seasonal influence on mushroom productivity, findings revealed that the cultivation of this mushroom was possible round the year with differential success. The total weight of sporophores was found significantly highest in winter sown crop (552.83 g-1000 g) in comparison to summer (23.00-144.67 g) and rainy season (204.17 g – 655.33 g). Accordingly the biological efficiency varied significantly among the spawning dates. A biological efficiency of 110% was realized in the November sown crop of *P. ostreatus* as against 1.73% realised in the May sown crop of *P. platypus*. This indicated the inferiority of summer and kharif sown crops in yielding oyster mushroom appreciably. Various workers have shown to recover good yields out of oyster mushroom raised during rainy/winter seasons at a temperature of 17.2-35ºC and relative humidity 70-90% (Bano and Rajarathnam, 1982; Shanmugam, 1986 and Sanger *et al*., 2006) [3, 16, 14].

The effect of spawning periods on the average weight of fruit bodies for various *Pleurotus* species and *Hypsizygus ulmarius*. *P. ostreatus* achieved the highest average fruit body weight during November-December 2018, aligning with previous research that indicates cooler temperatures enhance mushroom yield and quality by minimizing competition from contaminants and providing optimal growth conditions (Deora *et al*., 2022) [5]. Similarly, *P. citrinopileatus* performed well during this period but experienced a decline in subsequent months, suggesting that temperature fluctuations and reduced humidity negatively affect its growth, as supported by research on mushroom cultivation under varying climatic conditions.

P. florida maintained stable production throughout the study, with peak performance observed in January-February 2017. This finding is consistent with reports that *P. florida* is resilient to moderate winter conditions. The variability in *H. ulmarius* yields, with significant production observed in September-October 2019, underscores its adaptability to various environmental conditions, consistent with findings reported by Mahalakshmi *et al*. (2016) [11].

The results of this study clearly demonstrate that the spawning period has a significant impact on the sporophore weight of *Pleurotus* species, with substantial seasonal variations observed. The highest sporophore weights were recorded during the November-December period, indicating that cooler temperatures and possibly higher humidity during this time create favorable conditions for sporophore development. This finding is consistent with other research suggesting that *Pleurotus* species tend to thrive in cooler climates (Hemalatha *et al*., 2017; Deora *et al*., 2022) [8, 5].

In contrast, the decline in sporophore weight observed during the warmer months of March-April and May-June can be attributed to less favorable conditions, such as higher temperatures and lower humidity, which hinder mushroom growth (Chhata & Thakore, 2010) [4]. The partial recovery in sporophore weight observed in July-August and September-October is likely due to the onset of cooler temperatures and increased moisture, which benefit mushroom cultivation. This highlights the importance of optimizing environmental conditions to maximize Pleurotus yields throughout the year. Overall, while Pleurotus mushrooms can be cultivated year-round, their productivity is significantly higher during the winter months.

The study's findings, which show highest biological efficiency for *Pleurotus* species and *Hypsizygus ulmarius* during cooler months (November-December), align with existing literature. Research supports that cooler temperatures and higher humidity enhance mushroom growth, as noted by Bano and Rajarathnam (1982) [3] and Shanmugam (1986) [16]. Conversely, the drop in efficiency during warmer months (May-June) matches observations from Chhata and Thakore (2010) [4] and Hemalatha *et al*. (2018) [8], who found that higher temperatures and lower humidity hinder mushroom productivity. The partial recovery in efficiency during July-August and September-October is consistent with the idea that cooler transitional periods improve conditions for mushroom cultivation, as demonstrated by Hemalatha *et al.* (2017) [7] and Sanger *et al.* (2006) [14]. Overall, these results underscore the importance of aligning spawning periods with favorable environmental conditions to maximize mushroom yield and efficiency.

Table 1: Effect of period of spawning on days to spawn run of *Pleurotus* spp

Sl. No.	Period	*P. eous*	*P. florida*	*P. sajor-caju* (CTMRT strain)	*P. citrinopileutus*	*P. fossulatus*	*P. flabellatus*	*P. platypus*	*P. ostreatus*	*H. ulmarius*	*P. sajor-caju* (DMR strain)
1	1.11.2018	12.17	15.50	18.67	14.83	17.67	15.17	16.50	15.17	16.33	19.00
2	1.01.2019	12.50	16.00	18.33	15.00	18.00	15.67	16.00	15.50	16.67	18.50
3	1.03.2019	13.83	15.67	18.67	16.00	18.17	16.50	16.67	16.00	17.67	20.17
4	1.05.2019	15.83	17.50	19.50	17.17	18.50	17.17	17.33	16.83	18.67	20.50
5	1.07.2019	14.83	18.33	18.50	19.00	19.50	22.33	18.00	20.17	17.33	19.83
6	1.09.2019	14.67	18.33	19.00	17.83	19.00	22.17	16.83	20.33	16.83	19.67
	CD (0.05)	0.88	1.11	NS	0.85	0.86	0.91	0.88	1.07	0.70	1.02
	CV (%)	5.30	5.57	5.75	4.28	3.91	4.22	4.40	5.20	3.40	4.38

Table 2 Effect of period of spawning on days to pin head emergence of *Pleurotus* spp.

Sl. No.	Period	*P. eous*	*P. florida*	*P. sajor-caju* (CTMRT strain)	*P. citrinopileutus*	*P. fossulatus*	*P. flabellatus*	*P. platypus*	*P. ostreatus*	*H. ulmarius*	*P. sajor-caju* (DMR strain)
1	1.11.2018	14.00`	15.83	19.33	16.33	20.00	17.17	17.00	17.50	16.50	19.67
2	1.01.2019	14.17	16.50	19.67	16.67	19.50	17.50	17.33	17.67	16.83	19.83
3	1.03.2019	15.33	17.00	20.00	16.83	20.00	18.83	18.33	18.50	19.00	21.33
4	1.05.2019	16.67	18.00	21.00	19.50	20.83	23.00	20.50	21.50	20.83	21.83
5	1.07.2019	16.83	17.17	21.00	19.00	19.50	22.00	18.00	21.83	17.33	19.83
6	1.09.2019	15.67	17.33	20.50	19.33	19.17	20.83	17.83	21.50	17.33	19.33
	CD (0.05)	1.05	0.92	1.18	0.95	0.80	1.10	0.81	0.98	0.81	0.92
	CV (%)	5.71	4.57	4.90	4.43	3.39	4.66	3.76	4.17	3.81	3.82

Table 3: Effect of period of spawning on time taken for first flush of *Pleurotus* spp.

Sl. No.	Period	*P. eous*	*P. florida*	*P. sajor-caju* (CTMRT strain)	*P. citrinopileutus*	*P. fossulatus*	*P. flabellatus*	*P. platypus*	*P. ostreatus*	*H. ulmarius*	*P. sajor-caju* (DMR strain)
1	1.11.2018	16.33	20.17	21.83	19.17	20.83	19.17	19.67	18.50	19.00	22.16
2	1.01.2019	15.67	20.83	22.33	19.17	20.83	19.83	19.83	19.00	19.50	21.83
3	1.03.2019	17.17	21.17	22.67	20.50	21.67	20.17	21.17	19.50	21.50	22.16
4	1.05.2019	18.50	22.83	24.83	22.50	23.00	22.33	22.50	21.33	23.17	23.16
5	1.07.2019	16.83	20.83	22.83	19.50	22.17	19.67	20.00	19.00	18.50	22.67
6	1.09.2019	16.17	21.00	22.17	19.80	22.33	19.67	19.83	19.00	18.83	21.50
	CD (0.05)	0.91	1.32	0.91	1.03	0.91	0.98	1.03	0.90	0.82	0.91
	CV (%)	4.58	5.27	3.38	4.37	3.52	4.10	4.25	3.92	3.46	3.47

Table 4: Effect of spawning period on the average weight of pleurotus spp. fruit bodies

Sl. No.	Period	*P. eous*	*P. florida*	*P. sajor-caju* (CTMRT strain)	*P. citrinopileutus*	*P. fossulatus*	*P. flabellatus*	*P. platypus*	*P. ostreatus*	*H. ulmarius*	*P. sajor-caju* (DMR strain)
1	1.11.2018	6.23	7.94	4.92	12.47	5.54	6.66	8.06	17.56	15.82	7.29
2	1.01.2019	6.19	8.08	4.69	10.04	5.70	6.54	7.53	15.49	14.18	6.74
3	1.03.2019	4.73	5.01	3.73	7.06	5.40	5.63	6.70	10.93	11.87	5.95
4	1.05.2019	5.10	4.51	3.66	4.15	4.46	4.62	5.06	4.90	4.54	16.43
5	1.07.2019	6.70	4.84	5.18	10.94	5.84	6.09	5.83	10.23	15.08	6.11
6	1.09.2019	6.84	5.98	5.82	10.97	5.60	6.13	6.36	10.43	16.34	5.73
	CD (0.05)	0.72	0.46	0.52	1.04	0.75	0.61	0.71	0.68	0.90	1.93
	CV (%)	10.09	6.41	9.40	9.40	11.59	8.63	9.13	4.92	5.85	20.16

Table 5: Effect of spawning period on the weight of *pleurotus* spp. Sporophores

Sl. No.	Period	*P. eous*	*P. florida*	*P. sajor-caju* (CTMRT strain)	*P. citrinopileutus*	*P. fossulatus*	*P. flabellatus*	*P. platypus*	*P. ostreatus*	*H. ulmarius*	*P. sajor-caju* (DMR strain)
1	1.11.2018	989.00	796.17	920.83	682.50	580.33	642.67	803.33	1100.00	986.17	908.83
2	1.01.2019	976.67	791.33	825.00	662.17	580.33	552.83	774.50	893.33	838.33	821.67
3	1.03.2019	423.83	324.33	316.00	307.83	323.67	351.17	418.17	305.33	300.50	299.50
4	1.05.2019	135.83	144.67	90.00	22.83	18.83	19.33	17.33	28.50	23.00	77.00
5	1.07.2019	352.67	323.83	429.83	525.50	314.50	428.33	375.17	204.17	423.50	407.67
6	1.09.2019	670.17	327.00	536.83	615.33	448.33	497.00	424.00	257.83	655.33	513.00
	CD (0.05)	32.79	35.93	33.62	55.00	32.04	37.24	25.36	28.15	36.97	27.08
	CV (%)	4.80	6.96	5.44	9.86	7.14	7.54	4.55	5.09	5.78	4.51

Table 6: Effect of spawning period on the biological efficiency of *Pleurotus* spp

Sl. No.	Period	*P. eous*	*P. florida*	*P. sajor-caju* (CTMRT strain)	*P. citrinopileutus*	*P. fossulatus*	*P. flabellatus*	*P. platypus*	*P. ostreatus*	*H. ulmarius*	*P. sajor-caju* (DMR strain)
1	1.11.2018	98.90	79.62	92.08	68.25	58.03	64.26	80.33	110.00	98.62	90.88
2	1.01.2019	97.75	79.13	82.50	66.21	58.03	55.28	77.45	89.33	83.83	82.16
3	1.03.2019	42.38	32.44	31.60	30.78	32.36	35.11	41.81	30.53	30.05	29.95
4	1.05.2019	13.38	14.46	9.00	2.28	1.88	1.93	1.73	2.85	2.30	7.70
5	1.07.2019	35.26	22.38	42.98	52.55	31.45	42.83	37.52	20.41	42.35	40.76
6	1.09.2019	57.02	32.70	53.68	61.33	44.83	49.70	42.40	25.78	65.53	51.30
	CD 0.05)	3.23	3.59	3.36	5.50	3.20	3.72	2.53	2.81	3.69	2.70
	CV (%)	4.74	6.95	5.44	9.86	7.14	7.54	4.55	5.09	5.78	4.51

Summary and Conclusion

The effect of period of spawning on yield and yield attributing parameters revealed that the total weight of sporophores was found significantly highest in winter season crop (552.88 g-1100.00 g). Accordingly the biological efficiency varied significantly among the spawning dates. A biological efficiency of 110% was realised in the November sown crop of *Pleurotus ostreatus* as against 1.73% realized in the May sown crop of *Pleurotus platypus*.

Author Contributions

Manoj Kumar Rout, Kailash Behari Mohapatra: Investigation, formal analysis, writing— original draft, Validation, methodology, writing—reviewing. Uttam Kumar Behera, Susanta Kumar Swain, Jayant Kumar Mahallik,:—Formal analysis, writing—review and editing.-Soubhagya Behera, Chita Ranjan Sahoo Sarita Pradhan

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request. Declarations Ethical Approval Not applicable. Consent to Participate Not applicable. Consent to Publish Not applicable. Conflict of Interest The authors declare no competing interests.

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