Himachal Journal of Agricultural Research 49(2): 212-218 (2023)

Biofortification of wheat straw with organic additives and its effect on morphological parameters and biological efficiency of *Pleurotus ostreatus* (Jacq.) P. Kumm

Dipanshi Thakur*, Deepika Sud, Riya and Pardeep Kumar
Department of Plant Pathology, College of Agriculture
Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176062, India.

*Corresponding author: anshuthakursept@gmail.com
Manuscript Received: 08.08.2023; Accepted: 22.09.2023

Abstract

The experiment was conducted to evaluate the most effective organic supplement to enhance the morphological characters, yield and number of fruiting body per bag (NOFB) of *Pleurotus ostreatus*. Different organic additives viz., cereal flour (wheat, rice, maize), pulse flour (soybean, gram, chickpea, lentil and black gram) and cereal brans (wheat and rice) were evaluated on wheat straw. Wheat straw was supplemented with these additives at 2, 4 and 6% concentration and the results obtained revealed that the maximum number of fruiting bodies were recorded at 6% rice flour supplementation (30.73), maximum pileus diameter (7.84 cm) at 4% concentration, maximum stalk width at 2% concentration (1.92cm), highest biological efficiency (96.73%) was also recorded at 6% rice flour supplementation. It was observed that fortification of rice flour was beneficial in improving the morphological characters and yield of *P. ostreatus*. The results obtained in present investigations suggested supplementation of wheat straw with rice flour at 6% concentration is statistically superior over control and all other treatments.

Key words: *Pleurotus ostreatus*, biofortification, organic additives, biological efficiency

Mushroom is the fleshy fungi having spore-bearing reproductive structures growing on organic substrates. Due to the nutritional value and medicinal uses of mushrooms, they play a significant role in human food (Etich *et al*. 2013). Mushrooms have little calories but are high in protein and commonly referred to as vegetable meat. *Pleurotus* mushroom, often known as oyster or "*Dhingiri*" mushroom. It is cultivated in about 25 countries of Europe, America, and far-east Asia. It is the third most widely grown mushroom in the world, producing 8,75,000 metric tonnes annually (Chang and Miles 1982) and the second largest cultivated mushroom of India having annual production is 15,000 metric tonnes (Thakur and Mohapatra 2013). The cultivation of oyster mushrooms (*Pleurotus ostreatus*) has gained popularity and increased significantly worldwide for several reasons, including their ability to grow under a wide range of temperatures and their capacity to utilize various agro-based residues (Sharma *et al*. 2013). Sud and Jandaik (2007) evaluated available substrates like paddy, maize, soybean, mash and weed substrates (Lantana and Eupotorium) to grow two strains (HPAU-I and HPAU-II). Both strains preferred to grow on all substrates but soybean substrate resulted in higher biological efficiency. of *P. ostreatus* (Bhadana 2014) and (Josephine 2015) observed that organic supplements increased the yield and number of sporophores. To increase the yield, it has become standard practice to combine supplements with the basal substrate. Brans and cereal are recognized as active components that can be added to substrates to boost the output of mushrooms (Pardo –Gimenez *et al*. 2016). In the present study different organic additives *viz*., cereal flour (wheat, rice, maize) and pulse flour (soybean, gram, chickpea, lentil and black gram flour) and ceral brans (wheat and rice bran) were evaluated on wheat substrate for the impact on yield and quality

of oyster mushroom.

Materials and Methods

All the experiments were conducted on morphological characters and biological efficiency of *P. ostreatus* at Centre for Mushroom Research and Training unit, Department of Plant Pathology, CSKHPKV, Palampur.

Spawn Production: Spawn was prepared by using standard procedure (Royse 2003).

Substrate Preparation

Chopped wheat straw (4-5cm) was soaked overnight in fresh water to reach a moisture level of 70-75 %. The excess water was drained out. The pre-soaked straw was pasteurised by soaking it for one and a half hours in hot water at 75°C. Excess water was removed after pasteurisation by spreading the straw on pucca floor and allowed to cool. The suitable moisture content of the straw was determined by compressing the straw in the palm, about 65 % moisture was present. Then sterilized organic additives were mixed *viz*., flour of wheat, rice, maize, lentil, chickpea, gram, black gram, soybean as well as brans of rice and wheat were mixed individually in wheat substrate at three different concentrations on dry weight basis before spawning under aseptic conditions. All the treatments were replicated thrice. Then spawn was mixed with substrate and filled in polypropylene bags. Spawning was done under aseptic conditions. After spawning, the top of each polypropylene bag was secured with thread, and 10 to 15 pin head size holes were created with a sterile pin to achieve the best possible aeration. The spawned bags were then incubated for the spawn run in the growing room at a temperature of 21–25°C and 80% humidity.

Statistical analysis: The experiment was set in Complete Randomized Design (CRD), Analysis of variance (ANOVA) technique and critical difference (CD) was calculated at five percent level of significance for comparison with other treatment (Steel *et al*. 1997) in OPSTAT.

Result and Discussion

Effect of cereal flour, pulse flour and brans on morphological characters of *P. ostreatus*

The data presented in Table 1 indicates the morphological characters after fortification of wheat straw with cereal flours which revealed that the maximum numbers of fruiting bodies (average of three flushes) were recorded at 6% concentration of

Table 1. Effect of cereal flour supplementation on morphological characters of *P.ostreatus* on wheat straw

Treatment	NOFB	Pileus diameter (cm)	Stalk length (cm)	Stalk width (cm)
Wheat flour g/kg				
2%	22.20	6.92	3.59	1.12
4%	23.56	7.10	4.00	1.45
6%	25.42	7.50	4.56	1.48
Rice flour g/kg				
2%	26.54	7.25	3.42	1.92
4%	28.38	7.84	3.79	1.37
6%	30.73	7.52	4.20	1.42
Maize flour g/kg				
2%	25.24	6.82	3.29	1.15
4%	27.37	7.05	3.56	1.27
6%	30.48	7.81	3.94	1.45
Control	15.32	6.50	3.18	1.0
CD (P=0.05)	1.17	0.30	0.16	0.05

*NOFB= Number of fruiting bodies, Average of three replications

rice flour (30.73) followed by 6% maize flour (30.48) which was statistically on par with each other. The minimum numbers of fruiting bodies were recorded on control (15.32). Similar results were reported by (Kumar *et al*., 2020 and Soam *et al*., 2018). The maximum pileus diameter (7.84 cm) was recorded at 4% rice flour followed by 6% maize flour (7.81 cm) which was significantly different from control and minimum pileus diameter (6.50cm) was found on control. The highest stalk length was recorded on 6% wheat flour (4.56cm) followed by 6% rice flour (4.20cm) which was significantly different from each other treatments and control. The minimum (3.18cm) being on control. Similar results were observed by (Kumar *et al*., 2020). The maximum stalk width was recorded on 2% rice flour (1.92cm) followed by 6% wheat flour (1.48cm) and significantly varied from all other treatments. The minimum stalk width (1.00 cm) was recorded on control. Result from above experiment showed that fortification of rice flour at 6% concentration was beneficial in improving the morphological characters of *P.ostreatus*.

In Table 2 fortification of wheat straw with pulse flour showed that the maximum numbers of fruiting bodies were recorded at 6% soybean flour (26.15), followed by 4% soybean flour (25.60) which was statistically on par with each other. The minimum numbers of fruiting bodies were recorded on control (15.32). The maximum pileus diameter (7.29cm) was recorded at 6% chickpea flour followed by 4% chickpea flour (7.24 cm) which was significantly different from control whereas, minimum pileus

Table 2. Effect of pulse flour supplementation on morphological characters of *P. ostreatus* on wheat straw

Treatment	NOFB	Pileus diameter (cm)	Stalk length (cm)	Stalk width (cm)
Soybean g/kg				
2%	22.54	6.56	3.82	1.42
4%	25.60	6.72	4.35	1.64
6%	26.15	7.00	4.10	1.83
Chickpea g/kg				
2%	15.30	6.82	3.62	1.36
4%	17.26	7.24	3.97	1.28
6%	18.39	7.29	4.32	1.54
Lentil g/kg				
2%	22.47	6.45	3.42	1.14
4%	23.85	6.92	3.67	1.26
6%	20.19	7.35	3.92	1.35
Gram g/kg				
2%	18.64	6.42	3.52	1.16
4%	15.92	6.71	3.74	1.27
6%	20.75	7.00	3.56	1.20
Black gram g/kg				
2%	18.53	6.59	3.45	1.12
4%	17.58	6.64	3.62	1.42
6%	15.37	6.82	3.93	1.21
Control	15.32	6.50	3.18	1.0
CD (P=0.05)	0.74	0.25	0.19	0.06

*NOFB= Number of fruiting bodies, Average of three replications

diameter (6.50cm) was recorded on control. Similar results were reported by (Singh *et al*., 2107). The highest stalk length was recorded on 4% soybean flour (4.35 cm) followed by 6% chickpea flour (4.32 cm), minimum stalk length (3.18cm) was recorded control, maximum stalk width was recorded on 6% soybean flour (1.83 cm) followed by 4% soybean flour (1.64 cm) and was significantly different from each other. The minimum stalk width (1.00 cm) was recorded on control.

Data on fortification of wheat straw with cereal brans is presented in Table 3 and it was observed that maximum number of fruiting bodies (average of three flushes) at 4% concentration of wheat bran (23.72) followed by 6% wheat bran (22.53) which was significantly different from each other. (Rout *et al*. 2016) also found similar results. Whereas, minimum numbers of fruiting bodies were recorded on control (15.32). The maximum pileus diameter (6.95 cm) was recorded on 6% rice bran followed by 6% wheat bran (6.82 cm), minimum pileus diameter (6.50cm) was recorded on control. Highest stalk length was recorded on 2% wheat bran (3.80cm) followed by 4% rice bran (3.78cm) and minimum stalk length (3.18cm) was observed in control whereas, highest stalk width was recorded on 6% rice bran (1.54 cm) followed by 6% wheat bran (1.46 cm) and was significantly different from all other treatments. The minimum stalk width (1.00cm) was observed in control.

Effect of pulse flour, bran and cereal flour on Biological yield, Economical yield, Biological efficiency of *Pleurotus ostreatus* on wheat substrate

The data presented in Table 4 revealed that by using cereal flour, highest biological yield (192.54g)

Table 3. Effect of cereal brans supplementation on morphological characters of *P. ostreatus* on wheat straw

Treatment	NOFB	Pileus diameter(cm)	Stalk length (cm)	Stalk width (cm)
Wheat Bran g/kg				
2%	20.00	6.80	3.56	1.17
4%	23.72	6.73	3.78	1.25
6%	22.53	6.82	3.40	1.54
Rice Bran g/kg				
2%	18.00	6.58	3.80	1.24
4%	22.46	6.71	3.72	1.12
6%	20.72	6.95	3.64	1.46
Control	15.32	6.50	3.18	1.00
CD (P=0.05)	1.01	0.27	0.13	0.05

*NOFB= Number of fruiting bodies, Average of three replications

Table 4. Effect of cereal flour supplementation at different concentration on Biological yield, Economical yield, Biological efficiency of *Pleurotus ostreatus* on wheat substrate

Treatment	Biological yield g/kg	Economical yield g/kg	Biological efficiency %
Wheat flour g/kg			
2%	168.33	153.30	84.16
4%	180.52	164.49	90.26
6%	174.75	159.73	87.25
Rice flour g/kg			
2%	180.62	166.62	90.31
4%	188.56	169.38	93.28
6%	192.54	176.35	96.73
Maize flour g/kg			
2%	171.25	152.12	85.62
4%	179.69	160.45	89.37
6%	176.80	158.26	88.23
Control	140.32	130.53	70.12
CD (P=0.05)	10.20	5.41	4.14

* Average of three replications

economical yield (176.35g) and biological efficiency (96.73%) was recorded at supplementation of wheat straw with 6% rice flour followed by 4 % rice flour which produced 93.28% biological efficiency and was significantly different from control. The minimum biological yield (140.32g) economical yield (130.53g) and biological efficiency (70.12%) were recorded in control.

The data presented in Table 5 revealed that the highest biological yield (185.23g) economical yield (166.92g) and biological efficiency (92.50%) with pulses flour supplementation at 6% soybean flour followed by 2% soybean flour produced 91.27% biological efficiency which was statistically on par with each other and significantly different from control. Whereas data presented in Table 6 reveal that

Table 5. Effect of pulses flour supplementation at different concentration on biological yield, economical yield, and biological efficiency of *Pleurotus ostreatus* on wheat substrate

Treatment	Biological yield (g/kg)	Economical yield (g/kg)	Biological efficiency(%)
Soybean g/kg			
2%	177.74	159.58	88.20
4%	182.56	162. 40	91.27
6%	185.23	166.92	92.50
Chickpea g/kg			
2%	162.56	152.42	81.28
4%	169.24	154.17	84.62
6%	160.15	150.23	80.07
Lentil g/kg			
2%	142.52	132.21	71.26
4%	148.56	133.46	74.28
6%	150.24	135.29	75.12
Gram g/kg			
2%	158.27	148.23	79.85
4%	160.52	145.56	80.26
6%	163.75	148.23	81.52
Black gram g/kg			
2%	155.62	145.23	77.81
4%	152.69	137.25	76.34
6%	161.54	149.73	80.52
Control	140.32	130.53	70.12
CD (P=0.05)	6.56	6.40	3.60

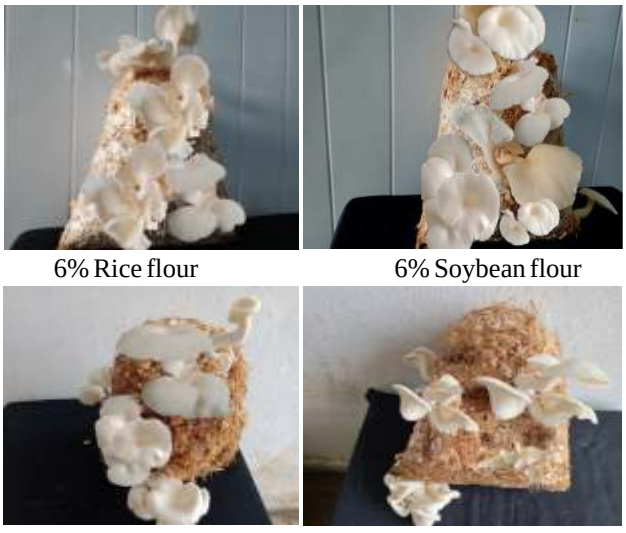
* Average of three replications

Table 6. Effect of cereal bran supplementation at different concentration on Biological yield, Economical yield, Biological efficiency of *Pleurotus ostreatus* on wheat substrate

Treatment	Biological yield (g/kg)	Economical yield (g/kg)	Biological efficiency(%)
Wheat Bran g/kg			
2%	165.43	142.27	82.62
4%	167.19	156.52	83.59
6%	164.21	149.73	82.10
Rice Bran g/kg			
2%	158.24	148.56	79.12
4%	162.17	140.17	81.56
6%	164.34	149.21	82.67
Control	140.32	130.53	70.12
CD (P=0.05)	8.38	5.49	4.01

* Average of three replications

fortification of cereal brans the highest biological yield (167.19g) economical yield (156.52g) and biological efficiency (83.59%) was observed at 4% wheat bran followed by 6% wheat bran (82.10%) which was statistically on par with each other and minimum biological yield (140.32g) economical yield (130.53g) and biological efficiency (70.12%) were recorded in control. Results are depicted in Fig.1. The similar results were reported by (Chaurasia 1997) and (Bahukhandi 1990) who observed that wheat straw substrate supplemented with rice flour gave maximum yield and biological efficiency of *Pleurotus* spp. Maheshwari *et al*. (2007) also observed that on addition of soybean meal and wheat bran to the substrate increased the yield. (Rout *et al*. 2016) also reported that wheat straw supplemented with boiled wheat could produce superior yield followed by wheat bran. (Singh *et al*. 2017) supplemented wheat straw with different pulse flour and reported maximum yield in pigeon pea flour followed by soybean flour while minimum yield was observed in control.



6% Rice flour 6% Soybean flour

4% Wheat Bran Control

Fig 1. Effect of cereal, pulse and bran in wheat straw at different concentration on biological efficiency of *Pleurotus ostreatus*

Conclusion

Bio fortification of wheat substrate with organic additives had a positive effect on morphological parameters and biological efficiency of *P.ostreatus*. Amongst cereal flour fortification with rice flour at different concentrations gave best results. Data revealed that at 6% concentration of rice flour gave maximum numbers of fruiting bodies (30.73) average of three flushes and highest biological efficiency (96.73%) were observed. However maximum pileus diameter (7.84 cm) was recorded at 4% rice flour and maximum stalk width was recorded on 2% concentration of rice flour (1.92cm). By fortifying wheat straw with pulses flour soybean flour gave best results. Maximum number of fruiting bodies average of three flushes (26.15), maximum stalk width (1.83 cm) and highest biological efficiency (92.50%) was recorded at 6% concentration of soybean flour and stalk length (4.35cm) was observed at 2% soybean flour. However, maximum pileus diameter was recorded at 6% chickpea flour (7.29 cm). By fortification with cereal brans it was concluded that wheat bran resulted in better morphological characters and biological efficiency as compared to control where no additives were added. Based on observation it can be concluded that all the cereal flour, pulse flour and cereal brans additives improved the morphological characters and biological efficiency of *P. ostreatus* but biofortification with rice flour at 6% concentration gave the best results.

Conflict of interest: There is no conflict of interest in this research paper.

References

Bahukhandi D 1990. Effects of various treatments on paddy straw on yield ofsome cultivated species of *Pleurotus*. Indian Phytopathology **43**(3): 471-472.

Bhadana NK 2014. Studies on production technology and major disease management of oyster mushroom. Ph.D thesis, Sardar Vallabhbhai Patel University of Agriculture and Techonolgy, Meerut.

Chang ST and Miles PG 1982. Introduction to Mushroom Science.In: Tropical Mushrooms: Biological nature and cultivation methods, eds Chang ST and Quimio TH. Chinese University Press, Hong Kong, pp 3–10.

Chaurasia VK 1997. Studies on production technology of *Pleurotus columbinus* at Raipur. M Sc Thesis, Indira Gandhi Agricultural University Raipur.

Etich OK, Nyamangyoku OI, Rono OI, Niyokuri JJ and Izamuhaye AN 2013. Relative performance of Oyster Mushroom (*Pleurotus florida*) on agroindustrial and agricultural substrate. International Journal of Agriculture and Plant Production **4** (1): 109-116.

Josephine RM 2015. A review on Oyster mushroom. International Journal of Current Research **7**: 11225-11227.

Kumar S, Singh G, Singh R, Mishra P, Sachan SK and Sengar RS 2020. Effect of different cereals flour additives on sporophores production of Oyster mushroom (*Pleurotus sapidus* and *Pleurotus flabellatus*). International Journal of Chemical Studies **8**(1): 698-701.

Maheshwari SK, Bhat NA, Masoodi SD and Kounser S 2007. Effect of agro-waste on spawn run, pin-head formation and yield of oyster mushroom (*Pleurotus flabellatus*) in Kashmir. Indian Journal of Mycology and Plant Pathology **37**: 375-376.

Pardo-Giménez A, Catalán L, Carrasco J, Álvarez-Ortí M, Zied D, Pardo J 2016. Effect of supplementing crop substrate with defatted pistachio meal on *Agaricus bisporus* and *Pleurotus ostreatus* production. Journal of Science and Food Agriculture **96**(11): 3838-3845.

Rout MK, Mohapatra KB And Mohanty P 2016. Influence of substrate, organic additive and period of cultivation on biological efficiency of *Pleurotus sajor-caju*. Advance Life Science **5**(1): 133-136.

Royse DJ 2003. Effect of different substrates (grain/straws) on spawn growth and yield of pink oyster mushroom *Pleurotus djamor* (Fr.). Journal of Mycology and Plant Pathology **33**(2): 265-268.

Sharma S, Yadav RKP and Pokhrel CP 2013. Growth and yield of Oyster mushroom (*Pleurotus ostreatus*) on different substrates. Journal on New Biological Reports **2**: 3-8.

Singh S, Singh G, Kumar V, Kumar B and Kumar A 2017. Assessment of different organic supplements (pulses flour) on growth and yield of oyster mushrooms. International Journal of Pure and Applied Bioscience **5**(2): 101-106.

Soam A, Singh G, Mohit, Ahmad S, Kumar S and Katiyar S 2018. Studies on effect of different organic additives wet weight basis cereal flour on fungal disease incidence and yield of oyster mushroom. Journal of Pharmacognosy and Phytochemistry **7**(4): 3222-3224.

Steel RGD, JH Torrie and DA Dickey 1997. Principles and Procedures of Statistics: Abiometrical approach, 3rd eds McGraw Hill Book Co., McGraw Hill Book Company, New York, USA, pp1-198.

Sud D and S Jandaik 2007. Effect of different substrates (grains/Straws) on spawn growth and yield of two strains of *Pleurotus ostreatus* in Himachal Pradesh. Indian Journal of Mushrooms **25**: 34-37.

Thakur MP and Mohapatra KB 2013. Tropical mushrooms: Present status, constraints and success story. Lead lecture presented in the Indian Mushrom Conference held from 16-17 April, 2013 at PAU, Ludhiana, Punjab.