Journal of Applied Horticulture, 26(1): 100-106, 2024
https://doi.org/10.37855/jah.2024.v26i01.19
Journal of Applied Horticulture
ISSN: 0972-1045

Unearthing growing capabilities of indigenous wild edible mushrooms from Punjab, India

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Abstract

Mushroom cultivation is a prevalent activity worldwide, although the domestication of native wild mushrooms is not fully recognised. For wild mushrooms to be economically feasible, they need to possess the ability to be cultivated. The objective of this study was to cultivate 18 wild mushrooms that were collected from their native environments utilising substrates that are readily available in the local area. Wild mushrooms were gathered and acquired using tissue cultures. All the wild mushrooms studied showed mycelial development on the substrates, except for *Podaxis pistallris, Amanita solitaria*, and *Collybia platyphylla. Pleurotus sapidus* and *Pleurotus floridanus* were able to produce fruit satisfactorily. The study revealed that specific wild mushrooms had the ability to produce fruiting bodies when grown on commercial substrates. While mushroom production was not seen in other natural cultures, these findings offer valuable information for improving growth circumstances in the future. Conducting surveys of natural habitats is crucial to guarantee the ongoing production of wild edible mushrooms, safeguarding endangered species and promoting a hopeful outlook for their sustainable utilisation.

Key words: Wild mushroom, domestication, *Pleurotus sapidus*, *Pleurotus floridanus,* yield

Introduction

The rising popularity of mushrooms is attributed to their unique biochemical composition, enriched with antioxidants, proteins, carbohydrates, lipids, enzymes, minerals, vitamins, and water, promising to enhance livelihoods. Despite recognising a few exotic mushroom varieties, many locally consumed wild mushrooms remain untapped due to a lack of information regarding their domestication and the challenges they face in their natural habitat (Kabacia and Muchane, 2023). Harvesting non-timber forest products, a common practice worldwide, includes gathering wild mushrooms during the rainy season, which are consumed by rural populations for food, medicine, and income (Kashiki *et al.*, 2021; Ngom *et al.*, 2022). The interest in collecting and consuming wild mushrooms stems from a long-standing tradition driven by hunger and curiosity to explore the nutritional value of fleshy basidiomycetes.

Mushroom cultivation serves as an effective bioconversion technology, transforming waste and wood into valuable resources and playing a vital role in sustainable agriculture and forestry. Despite India's rich fungal biodiversity, there has been limited enthusiasm for collecting and utilising wild mushrooms. The emergence of mushroom farming gained momentum following China's successful domestication of *Auricularia* species in 1100 A.D., followed by Shiitake (*Lentinula edodes*). The cultivation of the white button mushroom (*Agaricus bisporus*), the most popular variety, dates back to France in 1650 (Chang and Wasser, 2017), while paddy straw mushroom (*Volvariella volvacea*) cultivation began approximately 300 years ago in China. With a surge in domestication interest, progress in spawn production flourished during the 19th century. Despite the existence of about 650-700 edible mushroom species, only around 130 have been domesticated (Singh *et al.*, 2017).

The exploitation of wild mushrooms capable of thriving in controlled environments and flourishing on locally available substrates with desirable flavors and public acceptance holds promise for increasing value over time (Wendiro *et al.*, 2019). Cultivating wild mushrooms necessitates understanding their growth conditions in their natural habitat to optimize conditions during spawn formation and growth stimulation on readily available substrates (Kabacia and Muchane, 2023). This approach facilitates easier adaptation to mushroom farming, minimizing losses and maximizing value for money. Wild mushrooms garner global attention for their unique texture, aroma, taste, and flavor, particularly appreciated by rural communities (Fikadu, 2014). Thus, efforts should focus on preserving natural resources and exploiting them to develop drugs, nutraceuticals, and health promoters.

While India has conducted considerable research on the taxonomy and phylogeny of wild mushrooms, there has been relatively little focus on their domestication. Therefore, the objective of this study is to collect and document wild mushrooms from different zones of Punjab and domesticate them using locally available substrates.

Material and methods

The field survey was conducted during rainy season in the year 2017 and 2018 for collection of various fleshy fungi from different agro-climatic zones of Punjab, *i.e.* sub mountain undulating zone, undulating zone, central plain zone, western plain zone and western zone. These mushrooms were put on two domestication trials after procuring their cultures.

Procurement of the cultures: Mycelia was rescued aseptically with the help of a tissue culture technique using a potato dextrose medium (PDA) (Dhouib *et al.*, 2005).

Measurement of mycelial growth rate: This experiment was performed in a completely randomized design (CRD) with 3 replications and linear mycelial growth (mm) was measured on 8, 16 and 24th days after inoculation.

Biochemical assay: Wild mushroom cultures were grown on a mushroom minimal medium (Raper *et al.* 1972). Cellulases (Endo-β-D-1, 4 glucanase and cellobioase), total cellulases, and endo-Xylanase were estimated according to Mandels *et al* (1976) methodology. An assay of laccase (E.C.1.10.3.2) was done using Turner's method (1974). Methodology of Lowry *et al.* (1951) was followed to measure the protein content from crude enzyme extract.

Physico-chemical properties of habitat: Samples from the habitat were collected and estimated for texture, minerals (organic carbon, phosphorus and potassium), pH and water-holding capacity.

Domestication: Four different types of substrates (commercially used in the Punjab) were put on docket to domesticate the wild mushrooms. The four substrates, wheat straw, paddy straw, wheat straw and paddy straw (1:1) and compost based on paddy straw and wheat straw (2:1) were prepared as per the P.A.U. standards.

Results and discussion

Total 18 wild mushrooms (Fig. 1) were collected from different zones of Punjab and these wild mushroom samples were submitted to the Directorate of Mushroom Research, Solan, Himachal Pradesh, for preserving germplasm and assigning accession numbers (Table 1). The main taxonomic works on mushrooms to identify wild species were referred from WWW. mushroomexport.com.

Table 1. Identification of 18 wild mushrooms along with their accession numbers assigned by Directorate of mushroom research (DMRO), Chambhaghat, Solan, Himachal Pradesh, India

S. No.	Cultures	DMRO No.	Identified mushrooms
1	AMN 1	DMRO 729	*Pleurotus ostearatus*
2	AMN 05	DMRO 905	*Hypholoma capnoides*
3	AMN 14	DMRO 906	*Clitocybe gibba*
4	AMN 39	DMRO 907	*Pleurotus sapidus*
5	AMN 52	DMRO 908	*Podaxis pistallris*
6	AMN 54	DMRO 909	*Podaxis pistallris*
7	AMN 60	DMRO 910	*Amanita solitaria*
8	AMN 64	DMRO 911	*Amanita solitaria*
9	AMN 69	DMRO 912	*Agaricus pocilator*
10	AMN 71	DMRO 913	*Agrocybe pediades*
11	AMN 84	DMRO 914	*Lepiota cristata*
12	AMN 132	DMRO 915	*Collybia platyphylla*
13	AMN 170	DMRO 916	*Agaricus subrufescens*
14	AMN 201	DMRO 1015	*Lepiota procera*
15	AMN 202	DMRO 1016	*Pleurotus floridanus*
16	AMN 204	DMRO 1017	*Clitocybe gigentea*
17	AMN 205	DMRO 1018	*Pleurotus sp.*
18	AMN 206	DMRO 1019	*Lepiota procera*

Examination of natural habitat: Wild mushrooms were collected from tree trunks, humid soil, wooden stumps or tree roots. The texture of the habitat varied from sandy loam to loamy sand. The soil samples were collected from their habitat along with the wild mushrooms and further examined for organic carbon (OC), phosphorus (P), potassium (K), pH, and water-holding capacity. OC varied from 0.49 to 1.23%, pH was nearly neutral and water holding capacity was in the range of 58% to 85% (Table 2).

Examination of natural habitat is required to ensure the fruiting of wild edible mushrooms during their cultivation at the readily available substrate. Gezer and Kaygusuz (2015) examined the natural habitat of wild mushrooms. They recorded that mushrooms prefer loamy soil and humus as organic matter and macro- and microelements such as P, K, Ca, Mg, Cu, Fe, Mn and Zn are needed for the growth and reproduction of mushrooms. The habitat of a

Table 2. Physico-chemical properties of different soil samples from the habitats where the wild mushrooms were collected

S N.	.Cultures	Habitat	Texture	Minerals			pH	Water holding capacity (%)
				Organic carbon (%)	Phosphorus (kg/acre)	Potassium (kg/acre)		
1	*Pleurotus ostearatus*	Tree trunk	-	-	-	-	-	-
2	*Hypholoma capnoides*	Humus	Sandy loam	0.96	42.7	333	6.7	58.0
3	*Clitocybe gibba*	Humus	Loamy sand	0.81	18.7	280	6.5	88.0
4	*Pleurotus sapidus*	Wooden stumps	-	-	-	-	-	-
5	*Podaxis pistallris*	Humus	Sandy loam	0.51	40.6	517	7.4	71.8
6	*Podaxis pistallris*	Humus	Sandy loam	0.49	42.7	600	7.3	80.0
7	*Amanita solitaria*	Humus	Sandy loam	0.87	38.9	423	7.4	79.5
8	*Amanita solitaria*	Humus	Sandy loam	0.81	41.4	408	7.0	83.4
9	*Agaricus pocilator*	Humus	Sandy loam	0.79	39.1	519	7.5	72.0
10	*Agrocybe pediades*	Humus	Sandy loam	1.23	42.7	387	6.3	80.0
11	*Lepiota cristata*	Humus	Sandy loam	1.20	24.6	240	7.1	65.0
12	*Collybia platyphylla*	Tree root	-	-	-	-	-	-
13	*Agaricus subrufescens*	Humus	Loamy sand	0.97	42.7	225	6.8	85.0
14	*Lepiota procera*	Humus	Sandy loam	0.87	42.7	600	5.6	83.3
15	*Pleurotus floridanus*	Tree trunk	-	-	-	-	-	-
16	*Clitocybe gigentea*	Tree trunk	-	-	-	-	-	-
17	*Pleurotus sp.*	Tree trunk	-	-	-	-	-	-
18	*Lepiota procera*	Humus	Sandy loam	1.170	42.7	412	6.7	72.8

Fig.1. Fruiting bodies of mushroom cultures collected from wild

wild mushroom can't be explicated; it may be as large as a forest or a field, or as small as a rotting log. Fructification of mushrooms depends upon abiotic factors such as climate, heat, sunlight and pedological features of soil such as ability to hold water and air, pH, osmotic potential, salinity and minerals (Sumer, 2006). Fungi thrive in cold and humid climates, requiring water and oxygen as their primary nutritional needs. Potassium (K) and phosphorus (P) are essential elements for mushroom metabolism, typically absorbed from the environment as potassium phosphate. Additionally, mushrooms require other macro-elements such as carbon, nitrogen, and magnesium in substantial quantities, along with necessary micro-elements like iron, zinc, copper, manganese, and molybdenum (Agriculture and Food Development Authority, 2013; Carrasco *et al.*, 2018).

Spawning: Wild cultures were inoculated onto spawn bottles, and linear growth was monitored at 8, 16, and 24 days after inoculation. After 8 days, a significantly higher growth rate (29 mm) was observed in *Amanita solitaria* (AMN 60), while the growth rates of *Amanita solitaria* (AMN 64) and *Agaricus subrufescens* (AMN 170) were statistically similar to AMN 60 (Table 3).

The quality of spawn depends upon the mycelial growth of culture, aeration and grains used for spawning (Onyango *et al.,* 2011). Many different types of cereal grains such as wheat, rye, rice, millet and white maize (Stanley 2010) are used as base material for the preparation of spawn. Wheat grains are available in Punjab and used as substrate for spawn preparation (Gregori *et al.*, 2008).

Augmentation: Eighteen cultures were cultivated on wheat straw, paddy straw, and wheat straw-based mushroom compost, and their linear growth was measured. Each culture showed different growth rates on the three substrates, with *Pleurotus* cultures growing significantly faster on wheat straw, *Podaxis pistallris* on paddy straw and *Amanita solitaria* on wheat straw or paddy straw-based compost.

Table 3. Linear growth (LG) of wild mushroom cultures on wheat grains

S N.	.Cultures	Day		
		8	16	24
1	*Pleurotus ostearatus*	5.0	20.0	67.3
2	*Hypholoma capnoides*	11.3	26.6	60.3
3	*Clitocybe gibba*	20.6	50.6	81.6
4	*Pleurotus sapidus*	10.0	76.0	100.0
5	*Podaxis pistallris*	25.0	60.0	89.0
6	*Podaxis pistallris*	20.3	70.0	97.3
7	*Amanita solitaria*	29.0	73.3	99.3
8	*Amanita solitaria*	27.6	68.3	98.6
9	*Agaricus pocilator*	18.3	56.0	92.6
10	*Agrocybe pediades*	11.3	17.6	34.3
11	*Lepiota cristata*	6.6	17.6	49.3
12	*Collybia platyphylla*	7.0	13.3	30.3
13	*Agaricus subrufescens*	28.0	52.6	88.6
14	*Lepiota procera*	6.6	24.0	40.0
15	*Pleurotus floridanus*	17.6	39.6	71.0
16	*Clitocybe gigentea*	20.0	48.3	81.6
17	*Pleurotus sp.*	22.6	49.3	88.6
18	*Lepiota procera*	10.6	30.0	45.6
L.S.D. (P= 0.05%)		3.8	10.1	8.1

Fungi have a remarkable ability to grow on a wide range of substrates due to their extensive hyphal network, production of ligninolytic enzymes, large surface area, and adaptability to environmental factors such as temperature and pH (Singh *et al.*, 2022). It is mandatory to determine the efficiency of substrate to exhibit mycelial run as cultivation of mushrooms depends upon many factors like type of substrate, species of mushrooms, and rate of inoculumn, methodology for spawning and growing attributes of mushrooms. As depicted in Table 4, different substrates were analyzed to determine the ability of wild mushrooms to grow on various substrates. Tarko and Sirna (2018) demonstrated the ability of wild mushrooms to grow on various substrates, identifying sugarcane bagasse as the best substrate for *Pleurotus ostreatus.*

Biochemical assay: Edible mushroom production relies on oxidative and hydrolytic enzymes that degrade raw materials rich

Table 4. Effect of different substrates on linear growth (LG) of wild mushroom cultures

S N.	.Cultures	Wheat straw (mm)			Compost (mm)			Paddy straw (mm)		
		8 days	16 Days	24 Days	8 days	16 days	24 days	8 days	16 days	24 days
1	*Pleurotus ostearatus*	14.0	42.3	71.0	12.6	21.6	40.6	9.3	30.0	62.0
2	*Hypholoma capnoides*	0.0	14.3	33.0	0.0	8.6	23.6	0.0	20.0	38.6
3	*Clitocybe gibba*	35.0	57.3	79.6	11.6	22.3	37.3	15.6	28.3	49.3
4	*Pleurotus sapidus*	15.3	32.3	63.6	11.6	20.0	44.6	15.0	44.0	73.3
5	*Podaxis pistallris*	19.6	28.3	66.0	5.0	12.3	44.6	37.6	68.3	90.6
6	*Podaxis pistallris*	24.3	38.6	64.0	11.0	27.3	58.3	31.0	57.6	78.0
7	*Amanita solitaria*	10.0	21.6	50.3	10.6	34.3	55.6	6.0	21.0	36.6
8	*Amanita solitaria*	7.4	21.6	45.0	35.0	89.0	100.0	3.3	10.0	27.6
9	*Agaricus pocilator*	7.0	27.6	70.3	37.6	71.0	90.0	14.3	14.3	26.6
10	*Agrocybe pediades*	15.3	21.0	33.0	0.0	24.3	45.0	17.6	26.6	40.0
11	*Lepiota cristata*	7.6	20.0	42.0	17.6	32.6	58.0	14.3	26.0	42.0
12	*Collybia platyphylla*	0.0	10.6	28.0	0.0	15.3	33.0	0.0	10.0	24.3
13	*Agaricus subrufescens*	6.0	32.3	61.6	6.6	45.6	77.6	7.6	30.3	53.3
14	*Lepiota procera*	0.0	13.6	40.0	11.6	31.6	41.6	0.0	7.6	47.0
15	*Pleurotus floridanus*	19.3	53.0	90.0	4.6	32.0	67.3	16.0	47.6	84.6
16	*Clitocybe gigentea*	18.3	36.6	69.6	5.0	10.6	37.0	8.3	17.6	37.3
17	*Pleurotus sp.*	31.0	52.3	79.3	9.3	23.3	44.3	12.3	20.6	51.6
18	*Lepiota procera*	14.0	25.0	53.7	18.3	41.6	70.3	8.3	17.6	44.0
	LSD = 0.05%	3.6	4.8	8.2	9.1	7.4	7.5	4.1	5.9	7.8

in cellulose, hemicellulose, and lignin into simpler molecules for nutrition, supporting fruiting body development (Huang *et al.*, 2019). In this study, wild mushroom cultures were assessed for their enzyme production involved in lignocellulosic substrate degradation.

The evaluation revealed that wild mushroom cultures produce lignolytic enzymes in sufficient quantities to degrade lignocellulosic substrates (Table 5). *Pleurotus* species showed the highest xylanase production, with *P. ostreatus* having the highest laccase activity followed by other *Pleurotus* species.

Wild mushrooms produce abundant extracellular enzymes to thrive on complex raw materials and complete their life cycle, considering the importance of enzyme secretions, different lignocellulosic enzymes were estimated and it was recorded that all wild cultures produce ample amount of degrading enzymes. In agreement to that, many workers studied extracellular enzyme explaining the highest specific activity of Xylanase (Getachew *et al.,* 2016), laccase in the *Pleurotus* species (Nadeem *et al.,* 2014) and laccase activity in cauliflower mushroom (*Sparassis latifolia*) (Sou *et al.,* 2017).

Two trials were conducted over consecutive growing seasons. In the first trial, the spawn of wild mushroom cultures was inoculated onto various substrates, resulting in mycelial growth in several cultures (Table 6). However, some cultures showed minimal growth on certain substrates. In the second trial, two cultures could fruit on wheat straw, while mycelial growth was observed for all cultures except three *i.e.*, *Podaxis pistallris* (AMN 54), *Amanita solitaria* (AMN 60), *Collybia platyphylla* (AMN 132) (Table 7). Commercial cultivation of wild mushrooms is essential for making them available to consumers. Many researchers have successfully cultivated wild strains of various mushrooms, although some strains showed good mycelial growth but failed to fruit, indicating challenges in commercial cultivation (Salmones, 2018; Reyes *et al.*, 2009; Thongklang *et al.*, 2014; Rizal *et al.*, 2016). Similar results were found with *Macrolepiota procera* and *Lepiota procera* in this study and by others (Pekşen and Kibar, 2017; Thawthong *et al.*, 2014). Considerable amount of lignolytic enzymes in *Pleurotus* species empower the mycelia to proliferate on various lignocellulsic substrates, hence, produce fruiting bodies (Niazi and Ghafoor, 2021). Accordingly, fruiting bodies appears in two cultures of *Pleurotus species i.e., P. sapidus* (AMN 39), *P. floridanus* (AMN 202).

Yield attributes: A field experiment evaluated the growth and yield potential of two wild mushrooms, *P. sapidus* (AMN 39) and *P. floridanus* (AMN 202), compared to two commercial

Table 5. Extra-cellular enzymes produced by wild mushroom cultures

S. No.	Culture	Mycelium biomass (g/L)	Endo-β-1,4-Glucanase (U/mL)	Cellobioase (U/mL)	Total Cellulases (U/mL)	Endoxylanase (U/mL)	Laccasse (U/mL)
1	*Pleurotus ostearatus*	4.13	0.009	0.089	0.154	0.724	2.14
2	*Hypholoma capnoides*	3.87	6.970	0.024	0.038	0.58	0.032
3	*Clitocybe gibba*	3.00	0.544	1.42	0.345	6.06	1.064
4	*Pleurotus sapidus*	3.87	0.738	0.68	1.24	0.138	1.15
5	*Podaxis pistallris*	6.41	3.917	2.07	1.03	10.79	0.129
6	*Podaxis pistallris*	6.13	6.222	1.85	2.56	14.43	0.074
7	*Amanita solitaria*	5.40	2.633	0.018	0.015	0.84	0.26
8	*Amanita solitaria*	2.73	4.392	0.035	0.163	15.04	0.0096
9	*Agaricus pocilator*	2.47	6.22	0.227	0.084	2.060	0.0145
10	*Agrocybe pediades*	3.80	0.198	0.478	0.876	4.68	0.035
11	*Lepiota cristata*	3.73	1.858	1.79	2.21	11.89	0.12
12	*Collybia platyphylla*	3.73	0.359	0.018	0.135	2.13	0.65
13	*Agaricus subrufescens*	5.87	6.633	8.84	2.60	22.17	0.103
14	*Lepiota procera*	3.60	1.00	0.468	1.54	8.019	0.020
15	*Pleurotus floridanus*	4.27	1.748	0.111	0.161	2.38	1.94
16	*Clitocybe gigentea*	3.27	2.737	0.131	0.038	0.185	1.37
17	*Pleurotus sp.*	3.40	3.813	0.081	0.780	2.008	1.26
18	*Lepiota procera*	5.73	1.388	0.341	0.153	7.05	0.049

Table 6. First trial of cultivation of wild mushrooms on different substrates

Mushroom	Wheat straw	Paddy straw	Wheat straw+ Paddy straw (1:1)	Wheat straw based compost	Wheat straw + Paddy straw (2:1) compost
Pleurotus ostearatus	Mycelial run	Mycelial run	Mycelial run	Scanty growth	Scanty growth
Hypholoma capnoides	Scanty growth	Scanty growth	Scanty growth	No growth	No growth
Clitocybe gibba	Mycelial run	Mycelial run	Mycelial run	Mycelial run	Mycelial run
Pleurotus sapidus	Mycelial run	Mycelial run	Mycelial run	Mycelial run	Mycelial run
Podaxis pistallris	Scanty growth	Scanty growth	Scanty growth	Scanty growth	Scanty growth
Podaxis pistallris	No growth	Scanty growth	Scanty growth	Scanty growth	Scanty growth
Amanita solitaria	No growth	Scanty growth	Scanty growth	No growth	No growth
Amanita solitaria	No growth	No growth	Scanty growth	Scanty growth	Scanty growth
Agaricus pocilator	Mycelial run	Mycelial run	Mycelial run	Mycelial run	Mycelial run
Agrocybe pediades	Mycelial run	Mycelial run	Myclial run	Mycelial run	Mycelial run
Lepiota cristata	Mycelial run	Mycelial run	Mycelial run	Mycelial run	Mycelial run
Collybia platyphylla	No growth	No growth	Scanty growth	Mycelial run	Mycelial run
Agaricus subrufescens	Mycelial run	Mycelial run	Mycelial run	Mycelial run	Mucelial run

Table 7. Second trial of cultivation of wild mushrooms on different substrates

Mushroom	Wheat straw	Paddy straw	Wheat straw+ Paddy straw (1:1)	Wheat straw based compost	Wheat straw + Paddy straw (2:1) compost
Pleurotus ostearatus	Pin head	Mycelial run	Mycelial run	Scanty growth	Scanty growth
Hypholoma capnoides	Scanty growth	Scanty growth	Scanty growth	Mycelial run	Mycelial run
Clitocybe gibba	Mycelial run	Mycelial run	Mycelial run	Mycelial run	Mycelial run
Pleurotus sapidus	Fruit body	Mycelial run	Mycelial run	Mycelial run	Mycelial run
Podaxis pistallris	Scanty growth	Mycelial run	Mycelial run	Scanty growth	Scanty growth
Podaxis pistallris	No growth	Mycelial run	Mycelial run	Scanty growth	Scanty growth
Amanita solitaria	No growth	Mycelial run	Mycelial run	Scanty growth	Scanty growth
Amanita solitaria	Scanty growth	Mycelial run	Mycelial run	Mycelial run	Mycelial run
Agaricus pocilator	Mycelial run	Mycelial run	Mycelial run	Pin head	Pin head

Table 8. Comparison of yield potential of AMN 39 (*Pleurotus sapidus*) and AMN 202 (*Pleurotus floridanus*) *vis a vis* commercial strains of *Pleurotus sajor-caju* and *Pleurotus florida*

Cultures	Pinning after spawning (d)	Yield (kg/q of dry substrate)	No. of fruiting bodies/q of dry substrate	Average weight of fruiting body (g)	Pileus size	Colour	Stipe length (cm)	Stipe thickness (cm)
AMN 39 (*Pleurotus sapidus*)	25	40	580	7.1	5.2 cm	White	2-3	1.05
AMN 202 (*Pleurotus floridanus*)	28	47	640	6.5	6 cm	White	1-2	0.70
Pleurotus sajor-caju	19	52	795	6.8	6 cm	White	0.5-1	0.60
Pleurotus florida	21	60	850	7.4	5.4 cm	White	1-2	1.00
LSD (P=0.05) = 0.05%	-	14.34	75.6	0.5	-	-	NS	0.2

Pleurotus species (Table 8). The wild mushrooms showed lower yields but were comparable to one of the commercial strains. The pinning process took longer for the wild cultures compared to commercial species.

While wild strains of mushrooms can be successfully cultivated, their yield is generally lower than that of commercial strains. For instance, *Pleurotus* species cultivated from wild sources typically yield between 61-796 g/kg wet substrate, whereas strains from wild sources often produce lower yields (Vetayasuporn, 2007). Some experiments cultivating wild strains of *Agaricus flocculosipes* yielded very few fruit bodies, indicating the challenges of cultivating wild strains with high yields (Thongklang *et al.*, 2014). Preparation of substrates suitable for fruiting of wild strains using compost or other substrates is important to test fruiting capability of wild mushrooms before introducing them to market. Further work can be done to improve to culture and improve these wild strains genetically to increase yield (Thawthong *et al.,* 2014, Thongklang *et al.,* 2014).The cultivation of wild mushrooms is increasing, suggesting their potential for use in various industries for food, medicine, and other purposes.

In conclusion, this study comprehensively evaluated wild mushrooms from Punjab, including conservation and taxonomic identification. Examining natural habitats emphasized the importance of soil composition for successful cultivation. The study also explored spawning and augmentation techniques, highlighting the potential for commercial cultivation. Despite lower yields compared to commercial strains, wild mushrooms show promise for various industries. Further research could enhance their utilization in food, medicine, and industry.

References

Carrasco, J., D.C. Zied, J.E. Pardo, G.M. Preston and A. Pardo-Gimenez, 2018. Supplementation in mushroom crops and its impact on yield and quality. *AMB Expr.,* 8: 146.

Chang, S.T. and S.P. Wasser, 2017. The cultivation and environmental impact of mushrooms. *Environ. Sci*., (c), pp.43, Oxford University Press, USA.

Degreef, J., B. Kasongo, E. Niyongabo and A. De Kesel, 2020. Edible mushrooms, a vulnerable ecosystem service from African miombo woodlands. *Biotechnol. Agron. Soc. Environ.*, 24: 70-80.

Dhouib, A., M. Hamza, H. Zouari, T. Mechichi, R. H'midi, M. Labat, M.J. Martínez and S. Sayadi, 2005. Autochthonous fungal strains with high ligninolytic activities from Tunisian biotopes. *Afr. J. Biotechnol*., 4: 431-436.

Fekadu, A. 2014. Cultivation of *Lentinus edodes* on teff straw (agricultural residue) at Dilla University, Ethiopia. *The Asia J Appl. Microbiol*., 1: 49-59.

Getachew, F., M. Alemu and A. Kebede, 2016. Production, purification and characterization of Xylanase from Oyster Mushroom (*Pleurotus spp.*). *J Nat. Sci. Res*., 6: 1-11.

Gezer, K. and O. Kaygusuz, 2015. Soil and habitat characteristics of various species of mushroom growing wild in the Gireniz Valley, Turkey. *Oxid. Commun.,* 38: 389-397.

Gregori, A., B. Pahor, R. Glaser and F. Pohleven, 2008. Influence of carbon dioxide, inoculums rate, amount and mixing of casing soil on *Agaricus blizei* fruiting bodies yield. *Acta Agric. Slovenica*, 91:371-78.

Huang, L., N. Sun, L. Ban, Y. Wang and H. Yang, 2019. Ability of different edible fungi to degrade crop straw. *AMB Exp.,* 9: 4.

Kabacia, S., N. and M.N. Muchane, 2023. Domestication of wild edible mushrooms in Eastern Africa: A review of research advances and future prospects, Mantar Dergisi, 14(1): 22-50.

Kashiki, B.N., K.A. De, E.K. Mukala, K. Bostoen and J. Degreef, 2021. Edible fungi consumed by the Lamba and Bemba people of Haut-Katanga (DR Congo). *Eur. J Agric. Food Sci.*, 3: 41-46.

Lowry, O. H., N.J. Rosebrough, A.L. Farr and R.J. Randall, 1951. Protein measurements with Folin Phenol regent. *J Biol. Chem*., 193:265-75.

Magingo, F.S., N.M. Oriyo, A.K. Kivaisi, and E. Danell, 2004. Cultivation of *Oudemansiella tanzanica* nom. prov. on agricultural solid wastes in Tanzania. *Mycologia*, 96: 197-204.

Mandels, M., R. Andreotti and C. Roche, 1976. Measurements of saccharifying cellulose. *Biotechnol. Bioeng. Symp.*, 6: 21-23.

Nadeem, A., S. Baig and N. Sheikh, 2014. Mycotechnological production of laccase by *Pleurotous Ostreatus*- P1 and its inhibition study. *J. Animal. Plant Sci.,* 24: 492-502.

Ngom, K., G. Nakabonge, J. Ssekandi, B.D. Akowedaho, I. Balde and K. Noba, 2022. Diversity of Basidiomycetous Macrofungi from Mpanga Forest in Mpigi District, Central Uganda. *Ann. Res. Rev. Biol.,* 37:24-56.

Niazi, A.R. and A. Ghafoor, 2021. Different ways to exploit mushrooms: A review. *All Life,* 14: 450-460.

Onyango, B.O., V.A. Palapala, P.F. Arama, S.O. Wagai and B.M. Gichimu, 2011. Morphological characterization of Kenyan native wood ear mushroom [*Auricularia auricula* (L. ex Hook.) Underw.] and the effect of supplemented millet and sorghum grains in spawn production. *Agric. Biol. J. North Am.,* 2: 407-417.

Pekşen, A. and B. Kibar, 2017. Investigations on the cultivation of wild edible mushroom *Macrolepiota procera. Intern. J. Agric. Wildlife Sci.,* 3: 68-79.

Raper, C.A., R.E. Miller and J.R. Raper, 1972. Genetic analysis of the life cycle of *Agaricus bisporus. Mycologia.,* 64:178-84.

Raymond, P., A.M. Mshadete and A.K. Kivaisi, 2013. Cultivation of Oyster mushroom (*Pleurotus* HK-37) on solid sisal waste fractions supplemented with cow dung manure. *J. Biol. Life Sci.*, 4:1.

Reyes, R., L. Lopez, S. Kalaw, K. Kumakura, T. Kikukawa and F. Eguchi, 2009.*Coprinus comatus*, a newly domesticated wild nutriceutical mushroom in the Philippines. *J. Agric. Technol*., 5: 299-316.

Rizal, L.M., K.D. Hyde, E.C. Samantha, C. Karunarathna, P. Kakumyan and S. Chamyuang, 2016. First successful cultivation of the edible mushroom *Macrolepiota dolichaula* in Thailand. *Chiang Mai J Sci.*, 43:959-71.

Salmones, D. 2018. Cultivation of Mexican wild strains of *Agaricus bisporus*, the button mushroom, under different growth conditions *in vitro* and determination of their productivity. *Base,* 22: 1-9.

Singh, A., V.D. Rajput, S. Rawat, P. Kumar, O. Singh, S. K. Singh, A. Bind, A.K. Singh,, R. Sharma and T. Minkina, 2022. Mushroom as a Key to Food Security, Human Health, and Expunging Environmental Pollution. *App. Mycol. Agric. Foods: Indus. Appl*. Sanjay K. Singh, Deepak Kumar, Md. Shamim, & Rohit Sharma (Eds.) © 2024 Apple Academic Press, Inc. Co-published with CRC Press (Taylor & Francis)

Singh, M., S. Kamal and V.P. Sharma, 2017. Status and trends in world mushroom Production-I. *Mush. Res.*, 26: 1-20.

Sou, D.H., R. Rhim, K.K. Hyeon and P. Hyun, 2017. The mycelial growth and ligninolytic enzyme activity of cauliflower mushroom (*Sparassis latifolia*). *Forest Sci. Technol*., 13:158-63.

Stanley, H.O. 2010. Effects of substrates of spawn production on mycelial growth of Oyster mushroom species. *Agric. Biol*., 1: 817 -20.

Sümer, S. 2006. *General Mycology*. Nobel Publications, Ankara.

Tarko, D.B. and A.M. Sirna, 2018. Substrate optimization for cultivation of *Pleurotus ostreatus* on lignocellulosic wastes (coffee, sawdust and sugarcane bagasse) in Mizan–Tepi University, Tepi Campus, Tepi Town. *J. App. Biol. Biotechnol*., 6: 14-20.

Thawthong, A., S.C. Karunarathna, N. Thongklang, E. Chukeatirote, P. Kakumyan, S. Chamyuang, L.M. Rizal, P.E. Mortimer, J. Xu, P. Callac and K.D. Hyde, 2014. Discovering and domesticating wild tropical cultivatable mushrooms. *Chiang Mai J. Sci*., 41: 731-64.

Thongklang, N., P. Sysouphanthong, P. Callac and K.D. Hyde, 2014. First cultivation of *Agaricus flocculosipes* and a novel Thai strain of *A. subrufescens. Mycosphere,* 5: 814-20.

Turner, E.M. 1974. Phenoloxidase activity in relation to substrate and devolpmental stage in mushroom *Agaricus bisporus. Transactions British Mycol. Soc*., 63:541-47.

Vetayasuporn, S. 2007. Using cattails (*Typha latifolia*) as substrate for *Pleurotus ostreatus* (Fr.) Kummer cultivation. *J. Biol. Sci.,* 7: 218-21.

Wendiro, D., A.P. Wacoo and G. Wise, 2019. Identifying indigenous practices for cultivation of wild saprophytic mushrooms: responding to the need for sustainable utilization of natural resources. *J. Ethnobiol. Ethnomed.*, 15: 1-15.

Received: December, 2023; Revised: January, 2024; Accepted: February, 2024