IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 16, Issue 8 Ser. II (August. 2023), PP 01-10
www.iosrjournals.org

Evaluation Of Different Agricultural Wastes For Oyster Mushroom Production At Bundelkhand Agro-Climatic-Zone Situation Of India

R.K. Prajapati, B.S.Kirar, Jaipal Chhigarha and Neha Singh Kirar*
Krishi Vigyan Kendra, Tikamgarh (M.P.) 472001
*College of Agriculture, Gwalior (M.P.)**

Abstract
The study results showed that wheat straw showed no contamination, whereas there was contamination in other substrate used from weeks 1 to 4. At harvest, a significantly higher mushroom fresh mass yield was obtained in wheat straw than other substrates and lowest in saw dust. Higher number of pin head in small size recorded in pluses crop straw like soybean, chickpea and black gram straw than wheat straw compared with mustard and saw dust. The results demonstrated that all agriculture wastes substrates could be used as a viable alternative or in combination with fifty percent ration with wheat to the commonly used wheat straw. Oyster mushroom production could create employment opportunities to the Bundelkhand youth, farmers and farm women. The best natural management could be bringing sustainability in farmer livelihood by reduction in migration to the metro-cities from villages. The impact of climate change on villagers' life could be minimized through mushroom production. The mal-nutrition might be defeated by including the mushroom in daily diet.

Keywords: *Colonization, Substrates, Agricultural wastes, Oyster mushroom and Pleurotus spp.*

Date of Submission: 21-08-2023 Date of Acceptance: 31-08-2023

I. Introduction

The Tikamgarh district comes under Bundelkhand Agro-climatic Zone (BACZ) sub-region consists of Madhya Pradesh (M.P.). In this region, the receives about 1000.1 mm of rain. The climate here is dry and sub-humid. Soil erosion rates are high in this region and land productivity is low. There are waste-lands here at about 37% which is proportionately much higher than other area. About 45% of the land is cultivated here. About one third of the agricultural area is irrigated. The hottest days are May and the coldest days are in December to January. But locally the temperature is very high. The average annual temperature here is more than 25°C. In summer the average temperature is around 30°C and in May-June the temperature goes up to 40°C. The total population of BACZ is around 13.6 million (Census, 2011). While 79% of the population lives in rural area. In recent years, due to lack of employment and lack of opportunities in this area, the poverty situation has become serious. There is a clear variation in the inter-regional distribution of the population. Bundelkhand plains have high population density while plateau region has low population density. However, BACZ has seen high population growth in recent decades. BACZ is one of the poorest regions not only in Uttar Pradesh (UP) and Madhya Pradesh (MP), but in the whole of India. Agriculture is the basic occupation of rural people and forms the basis of rural economy. A small section of the rural population depends on non-agricultural occupations such as carpentry, pottery, basketry, etc. But these businesses are also indirectly dependent on agriculture. The number of days of rain in BACZ has come down from 52 to 24 (IMD). Due to uncertainty and irregularity of the year in the region, agriculture has to face the problem of drought every year. Agricultural crops or various other livelihoods such as fishing.

This is an arid region where agriculture depends heavily on the monsoon. Here the Kharif crop is rainfed. Soybean, black gram, green gram, sesame, groundnut, maize, millets and sorghum while in Rabi season mustard, chickpea, peas are the major crops along with vegetables, forage, spices and fruits. The wheat crop grown in irrigated areas. Uncontrolled grazing by stray animals is a major problem in the area. The wells were part of the Bundelkhand culture and were considered sacred places, but in the present times this trend has ended, due to which the problem of water in this area is becoming more and more difficult. A large number of lakes and embankments were built here in the medieval period by the Chandela and Bundela kings, but at present these structures are either destroyed or on the verge of destruction due to lack of maintenance. Due to lack of rainfall and failure of crops, employment of seasonal agricultural laborers who were now forced to migrate to metro-cities. According to the report of the Migration Society's Internal Committee, so far more than 62 lacs farmers have migrated from BACZ due to starvation and drought tragedy and four thousand farmers have committed suicide in indebtedness. (Yadav, 2019)

The studied carried by Krishi Vigyan Kendra (KVK) situated at Tikamgarh District for development of small scale agriculture industries opportunities for marginal and small farmers which share 75% part of whole farmers having 01-5 ha land. The cultivated area in district about above two lacs in which major availability of substrates for mushroom growing were wheat, mustard, chickpea, soybean, black gram, sugarcane and saw dust. The farmers not well used straw yielded from these crops while using in feed for animal, fuel purposes or leaved over in field.

The KVK have been conducting skill development trainings since 2019 to continue among the farmers, farm women and unemployed rural youth to create the employment opportunities with availability of crops straw growing in the distract and best management of natural resources. As per the climatic condition for mushroom cultivation, the oyster mushroom was taken for studies, the substrate for successful mushroom cultivation, three factors must be considered, namely reliable spawn, good agricultural substrate and a conducive environment (Rajapakse *et al.* 2007). Substrates in mushroom cultivation have the same function as soil in plant production (Kwon and Kim, 2004). Many species of *Pleurotus* are commonly grown on a wide range of lingo-cellulosic materials (Sanche, 2004). Different substrates can be recommended per region due to local availability of agricultural wastes (Cohen *et al.* 2002). The ideal medium for cultivation of edible fungi must be sterile and rich in essential nutrients (Wood and Hartley 1988; Kwon and Kim 2004), such as nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and iron (Fe). Most commonly used substrates include saw dust, cotton seed straw, cereal straw, corn cob, sugar cane straw and other plant fibers with high cellulose content (Ragunathan *et al.* 1996; Kwon and Kim 2004). According to Labuschagne *et al.* (2000), wheat straw has been the main substrate used for cultivating *Pleurotus ostreatus*. However, Bughio (2001) successfully planted *Pleurotus ostreatus* on a combination of wheat straw, cotton boll straw, paddy straw, sugarcane and sorghum leaves. The substrate can also be supplemented, if necessary, with additional N-sources, such as wheat bran, oat bran, copra cake (from spent coconut), rice bran, sorghum or millet in order to obtain quality mushrooms. Additives such as gypsum, limestone and chalk can function as pH buffers in a substrate (Kwon and Kim 2004). Although *Pleurotus* species can be produced from various substrate types or residues, productivity and biological efficiency will vary according to strains and substrates used (Bernardi *et al.* 2007). Different substrates can, therefore, be recommended per region depending on local availability of agricultural wastes (Cohen *et al.* 2002). Cultivation of oyster mushrooms using different substrates has been studied extensively (Poppe 2004). However, there is no specific information on the usage of soybean, black gram, mustard, chickpea, sugar cane and saw dust as alternatives to wheat straw for oyster mushroom cultivation. These agricultural wastes substrates can be freely collected from the farmer field and saw dust are waste products from saw wood-milling company of the district. These different agricultural wastes substrates need to be studied in order to determine their suitability for use by both commercial and small-scale farmers in mushroom production. Therefore, the present study was conducted to investigate the suitability of different substrates (wheat mustard, chickpea, soybean, black gram, sugar cane and saw dust) with regard to the rate of colonization amongst the substrates, the amount of contamination, and to compare mineral content of the substrates and nutritional differences between oyster mushrooms produced.

II. Materials and methods

The experiment was conducted in a custom-made growth room at the demonstration unit of Krishi Vigyan Kendra, Tikamgarh (M.P.) and at villages on mushroom growing farmers hut. (24.74° N, 78.83°E, 357 m above sea level). The temperature (°C) and relative humidity (RH %) in the mushroom growth room were measured by using a hygrometer. Experiments were designed and pasteurization of agricultural wastes substrates were carried out, the layout of the experiment was a completely randomized design with 7-treatments consisting of a factorial combination of 7-types of substrates and two levels of drainage, with each treatment replicated four times. The7-types of substrates were wheat straw (control), mustard, chickpea, soybean, black gram sugarcane straws and saw dust. The wheat straw (10 kg), mustard straw, chickpea, soybean, black gram, sugarcane each 15 kg and saw dust (20 kg) were sterilized with (formalin@125 ml and carbendazim) @7 gram)/100 liter of water by dipped each straw, separately in 200 liter drum containing 100 ml of water for 18-hours with tight its open mouth of drum to preserved formalin gas. After 18-hours the water were filtered and substrates were dried up to 60% of moisture. Spawn were inoculated after that immediately. Culture bags were 45 µm polyethylene bags filled with a mixture of substrate and spawn (@1-kg) to a total weight of 10 kg. All straw substrate were sourced from farmer field and saw dust was sourced from a Saw dust Wood Cutting Company of the Tikamgarh district. The cultured bags were hanged in local cottage huts at farmers' field and in demonstration unit at KVK. 20-number minute hole made in each bags around to drain out excess moisture and proper aeration and in un-drained bags were not treated for such a conditions. The temperature, humidity and darkness were maintained and hygrometers were placed in dark room for observation of climatic parameter.

Required humidity and temperature were maintained through spraying of water on gunny bas which were hanged around wall of cottage/huts rooms. The mushroom rooms were opened for two hour to provide natural light and passing of CO_2 level in the room properly for growth of fungus.

Observation and Data collection

The observations were made regularly and data was recorded. The cultured bags were evaluated for both colonization and contamination. Evaluation for colonization began shortly after inoculation until full colonization, whereas contamination by mostly Aspergillus, Penicillium and Trichoderma species was evaluated on a weekly basis using a rating-scale method of between 0 and 100% as outlined by Tesio (2003). After full colonization, culture bags were cross cut from top to bottom to facilitate growth of mushroom flushes. Mature oyster mushrooms were harvested three weeks after planting. These were pulled manually from the culture bags and kept in brown paper bags to avoid moisture loss, and taken to the laboratory for post-harvest analysis. Growth parameters recorded included cumulative number of harvests, number of flushes, number of caps and fresh mass.

Post-harvest analysis

After recording growth parameters, samples were kept in two separate plastic bags with caps or stalks and stored in a deep freezer (−21 °C) for further analysis. These samples were analysis for chemical composition in Laboratory. Mineral analysis of samples of substrates were analyzed at soil science using standard procedures (for P, K, Mg, Fe, calcium [Ca], zinc [Zn], copper [Cu], manganese [Mn] and boron [B]) as outlined by Isaac and Johnson (1992). The nutrient concentrations were measured with an atomic absorption flame spectro-photometer.

Analysis of chemical composition of oyster mushrooms

Both caps and stalks (100 g each) were chemically analyzed for ash, carbohydrates, dry matter, moisture, fat and protein content. Organic matter was analyzed using the method outlined by Harris (1970). Carbohydrates, moisture content, crude protein, ash and fat were analyzed using appropriate methods outlined by Greenfield and Southgate (2003). Dry matter content was determined using the method outlined by Mertens (2002). Fats were dissolved in ether and evaporated at 105 °C using the Kjeldahl method outlined by Greenfield and Southgate (2003).

Cost and economic analysis of substrates

The substrates of wheat, mustard, chickpea, soybean, black gram, sugarcane straw were abundance available in the villages because of a large of area cultivated in the district. These were collected free of cost by the farmers but rate of each one straw could be taken in calculation average rate value for each straw like wheat (Rs. 50), mustard (Rs. 30), chickpea(Rs 40), soybean (Rs. 20), black gram (Rs. 40) sugarcane (Rs. 25) and saw dust (Rs.60) each were quantity used for experiment. In addition, these substrates were stored for three months to leach out compounds responsible for inhibiting mushroom growth. As saw dusts were collected for from a milling company of the Tikamgarh to the experimental site, costs were considered as value of sold. The other costs involved in mushroom experiment were added, immediately. In Tikamgarh district city market, the oyster mushrooms was sold for Rs. 250/kg, whereas oyster mushrooms were sold for Rs.200/ kg in local village retail markets.

Statistical analysis

Statistical analysis and interpretations were based on comparison of treatment means, as well as comparison between cumulative number of harvests, number of flushes, and number of caps and fresh mass. The collected data were subjected to analysis of variance (ANOVA) using the SAS 8.2 software package.

III. Results and discussion

(a) Rate of colonization

The mean daily temperature in the growth room varied between 23.5 and 31.5°C (Table1 & Figue1) during full colonization with mycelia and fruiting, whereas RH was between 62% and 98%. These temperatures appear ideal because Shah *et al.* (2004) reported an optimal temperature of 25°C for full mycelia colonization and fruiting. There were highly significant differences ($P < 0.05$) in the percentage colonization of wheat straw compared with mustard, chickpea, soybean, black gram, sugarcane straws and saw dust from day 01 to day 21. On 21-day , wheat straw showed 100% colonization compared with chickpea(60%), black gram(60%), sugar cane(60%), soybean (50%), mustard (33%) and 30% colonization for least in saw dust (30%) (Table2&3).The mustard straw and saw dust showed lower rates of colonization compared with that of wheat straw from days 01 to 21. This might be due to low degradation rate and substances contains in straw//saw dust affect the mycelia growth, it taken more days to attain full colonization in comparison to wheat straw with mycelia, whereas full colonization of mustard straw and saw dust was attained on days 30-35 days. The present results were not inconsistent with the findings of Tan (1981), Shah *et al.* (2004), Mondal *et al.* (2010), Mashudu , *et al.* (2015) and Khan *et al.* (2012) who reported that spawn took 2–3 weeks (14–21 days) to achieve full colonization. Moreover, Khan (2009) reported that *Pleurotus ostreatus* took 24–25 days for completion of spawn running on wheat straw substrate.

Table 1: Mean temperature and relative humidity recorded from 1-21 September 2021 in a hut house during the experiment

Date	Min temp ^{0}C	Max ^{0}C	Mean temp ^{0}C	RH (%)
1 Sept., 2021	28	32	29.5	75
2 Sept., 2021	26	29	27.5	83
3 Sept., 2021	28	31	29.5	78
4 Sept., 2021	26	27	26.5	94
5 Sept., 2021	26	32	29.0	81
6 Sept., 2021	25	25	25.0	94
7 Sept., 2021	31	32	31.5	62
8 Sept., 2021	26	27	26.5	88
9 Sept., 2021	28	28	28.0	83
10 Sept., 2021	24	26	25.0	96
11 Sept., 2021	25	28	26.5	86
12 Sept., 2021	24	24	24.0	94
13 Sept., 2021	30	30	30.0	77
14 Sept., 2021	26	26	26.0	90
15 Sept., 2021	25	27	26.0	88
16 Sept., 2021	24	24	24.0	94
17 Sept., 2021	24	24	24.0	94
18 Sept., 2021	23	24	23.5	98
19 Sept., 2021	27	27	27.0	86
20 Sept., 2021	28	27	27.5	91
21 Sept., 2021	25	29	27.0	88

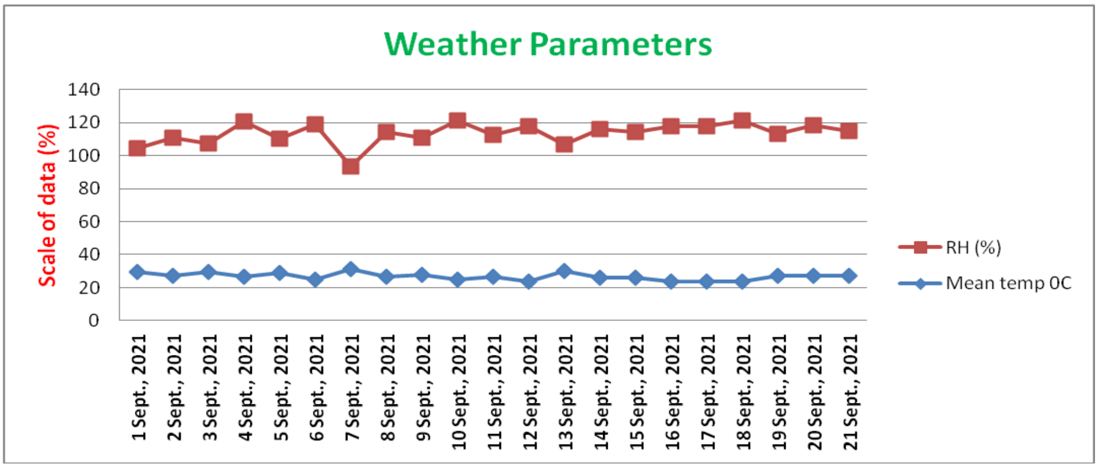

Figure-1 Mean temperature and relative humidity recorded from 1-21 September 2021 in a hut house during the experiment

This might be due to the environmental conditions and the ability of available minerals in wheat straw to support oyster mushroom growth. From days 01 to 21, no significance difference in percentage colonization was observed between the growing media.

Table. 2 Colonization (%) of *Pleurotus florida* for agricultural wastes substrates (wheat, mustard, chickpea, soybean, black gram, sugarcane straw and saw dust from day 01 to day 21.

Substrates	Growth of colonization of mycelium on different agricultural wastes substrates (%)																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Wheat (Control)	3.1	6.3	12.4	18.8	22.3	25.4	28	32.5	34	38.5	42.3	45	48.9	52.4	56.8	62.4	68.9	75.9	83.8	95	100
Mustard	1.2	2.4	4.8	7.2	10.1	12.4	13.8	15.3	16.5	18.9	20.4	21.7	22.2	24.3	25.7	26.1	28	29.4	31	32	33
Chickpea	2.6	4.7	8.3	11.4	14.2	17.3	20.3	23.2	25.9	28.3	31.5	34.2	37.4	40.3	44.1	43.3	46.3	48.2	52.4	55.3	60
Soybean	2.3	4.6	8.8	12.1	14.1	17.1	20	23	25.2	28	31.1	33	36.4	39.3	43.1	41.3	43.3	45.2	47.4	48	50
Black gram	2.7	5	9.7	12.2	15.2	18.3	21.3	25.2	28.9	30.3	34.5	36.2	39.4	42.3	44.1	46.3	48.3	50.2	53.4	56.3	60
Sugarcane	2.8	5.2	10.1	13.5	16.8	21.4	22.6	28.9	32.1	33.2	37.4	40.2	43.5	46.2	49.1	43.3	46.3	48.2	52.4	55.3	60
Saw dust	1.1	2.2	4.3	6.2	8.2	10.2	11.4	12.4	13.5	14.6	15.9	16.9	18.2	20.2	22.3	23.4	24.8	25	27.9	28.1	30
LSD ($\alpha < 0.05$)	Ns	ns	ns	ns	Ns	ns	ns	ns		Ns	ns	ns	ns		Ns	ns	ns	ns		Ns	ns
P-value	0.0	2.1	3.2	4.4	3.5	2.1	3.77	4.3	2.3	7.0	1.3	2.1	3.4	7.9	2.9	2.4	4.4	5.6	6.7	2.3	6.8

This indicated that wheat straw and other substrates had attained full colonization by this time, although significant differences were observed at early stages of colonization. Wheat straw was ideal for increasing the colonization percentage of oyster mushrooms compared with others substrates. Grown mushrooms should be able to colonized in an area quickly before other parasitic fungi can cover a designated area (van Nieuwenhuijzen, 2007). The variation observed may be due to environmental differences, hygiene and the viability of oyster mushroom spawn.

Table. 3 Colonization (%) of *Pleurotus florida* for wheat, mustard, chickpea, soybean, black gram, sugarcane straw and saw dust from day 01 to day 21.

Substrates	First week	Second week	Third week
Wheat(Control)	16.6	41.9	77.4
Mustard	7.4	19.9	29.3
Chickpea	11.25	31.5	49.9
Soybean	11.28	30.8	45.4
Black gram	12	33.8	51.2
Sugarcane	13.2	37.3	50.65
Saw dust	6.2	15.9	25.9
LSD ($\alpha < 0.05$)	**Ns**	**ns**	**ns**
P-value	**1.4**	**3.4**	**2.6**

(b)Comparison between substrate drainage and rate of colonization.

The extent of drainage did not significantly affect rate of colonization from 1 to 3rd week. Un-drained wheat straw did not differ significantly to drained wheat straw in terms of rate of colonization from days 1 to 3rd week. Furthermore, un-drained wheat straw attained 78.1% colonization in 3rd week (21-days from inoculation), whereas drained wheat straw did too attain full colonization. Mane *et al.* (2007) reported a range of 12–14 days for full spawn running in various *Pleurotus* species on lingo-cellulosic substrates, although the present results concurred with the spawn running periods reported above for *Pleurotus florida*. Un-drained other substrates showed an increased rate of colonization compared with drained other substrates from days 1 to 3rd week. Un-drained other substrates attained 30.2, 51.2, 45.9, 51.8, 50.7 and 26.4 % colonization for mustard, chickpea, soybean, black gram, sugar cane and saw dust, respectively (Table 4), Indicating that the polyethylene bags were fully colonized not appeared out side in three weeks. There was no significant difference in percentage colonization between drained and un-drained saw dust. Mycelia growth area preliminary step that creates suitable internal conditions for fruiting and also was a vital factor in mushroom cultivation because at the end of the day, farmers were willing for better yield Pokhrel *et al*. (2009) and Mashudu *et al*. 2015.

Table. 4 Colonization (%) of *Pleurotus florida* for wheat, mustard, chickpea, soybean, black gram, sugarcane straw and saw dust from day 01 to day 21.

Substrates	Colonization rate (%) of *P. florida on different agricultural wastes substrates used*					
	Drained substrates			Un-drained substrates		
	First week	Second week	Third week	First week	Second week	Third week
Wheat(Control)	17.6	42.2	78.1	17.7	43.1	78.1
Mustard	7.4	19.9	29.3	7.6	21.3	30.2
Chickpea	11.25	31.5	49.9	12.3	32.1	51.2
Soybean	11.28	30.8	45.4	12.4	31.5	45.9
Black gram	12.00	33.8	51.2	12.9	33.8	51.8
Sugarcane	13.2	37.3	50.65	14.5	38.2	50.70
Saw dust	6.2	15.9	25.9	07.1	16.7	26.4
LSD (α < 0.05)	**Ns**	**ns**	**ns**	**ns**	ns	ns
P-value	**1.3**	**2.5**	**3.1**	**3.4**	2.6	2.5

(c) Amount of contamination

Percentage contamination of *Aspergillus spp. Penicillium spp. Trichoderma spp. and Rhizopus spp* exhibited no significance differences amongst the treatments during first week. Saw dust did not differ significantly from wheat straw in relation to amount of contamination in second week. However, saw dust showed higher percentage contamination (16.7 %) compared with other substrates as mustard (4.5%), chickpea (5.3%), soybean (4.3%), black gram (4.4%) and sugarcane (4.3%) in week-2, whereas wheat straw (0%) showed no contamination. Van Niewenhuijzen (2007) stated that a fast rate of colonization by mushrooms within the growing area can suppress the development of other fungi or bacteria. Saw dust were more susceptible to contamination compared with other substrates, whereas wheat straw did not show any contamination during the experiment (Table 5). In week- 3 saw dust showed significantly increased percentage contamination (28%) compared with other substrates as mustard (8.9%), chickpea (8.5%), soybean (9.1%), black gram (10.2%) and sugarcane (10.5%). This might be due to variation in moisture loss within the different substrates, thereby influencing development of *Aspergillus spp. Penicillium spp. Trichoderma spp. and Rhizopus spp*. On-farm hygiene can also contribute to contamination of both substrate and mushrooms (van Niewenhuijzen, 2007). In week-4, saw dust significantly differed from wheat straw in amount of contamination. Moreover, saw dust showed the highest percentage contamination (38.7%) compared with other substrates mustard (12.3%), chickpea (13.2%), soybean (13.6%), black gram (13.7%) and sugarcane (13.5%) and wheat straw (0%)

Table. 5 Colonization (%) of contamination (Aspergillus spp. Penicillium spp. Trichoderma spp. and Rhizopus spp.), on agriculture wastes substrates used for *P. florida* from 1st week to 4th week (28-days).

Substrates	First week	Second week	Third week	Fourth week
Wheat(Control)	0.0	0.0	0.0	0.0
Mustard	0.0	4.5	8.9	12.3
Chickpea	0.0	5.3	8.5	13.2
Soybean	0.0	4.3	9.1	13.6
Black gram	0.0	4.4	10.2	13.7
Sugarcane	0.0	4.3	10.5	13.5
Saw dust	0.0	16.7	30.5	38.8
LSD (α < 0.05)	**Ns**	**ns**	**ns**	**ns**
P-value	**0.0**	**2.2**	**2.7**	**2.2**

The results indicated that wheat straw significantly suppressed contamination throughout the production period. Clearly, both saw dust and other substrates were not effective in suppressing contamination. Sofi *et al.* (2014) indicated that nutrient poor substrates exhibited low mycelia densities, making them prone to contamination especially by green mould. According to Kumari and Achal (2008) and Mashudu *et al*. (2015) contamination can be caused by improper pasteurization of straw and the availability of contaminants in a substrate.

(d) Mineral composition of substrates

Soybean had higher N content (1.42%) and other substrates as chickpea (1.30%), black gram (1.27%), Sugarcane (1.25% and mustard (0.41%), than both wheat straw (0.56%) and saw dust (0.18%). Rajarathnam *et al*. (1988) and Mashudu *et al*. (2015) indicated that N-plays an important role in building biomass of *Pleurotus ostreatus*. Soybean had significantly higher available N-compared with both wheat straw and saw dust.

Table 6. Mineral analysis of different growing substrates within the same column, means followed by the same letter are not statistically different

Substrates	Element (%)					Element (mg kg−1)
	N	P	K	Ca	Mg	Fe
Wheat	0.56	0.54	0.90	0.34	0.10	845
Mustard	0.41	0.80	0.20	0.23	0.70	234
Chickpea	1.30	0.60	1.80	0.25	0.34	345
Soybean	1.42	0.90	0.53	0.49	0.28	282
Black gram	1.27	0.05	0.81	0.34	0.24	347
Sugarcane	1.25	0.42	1.50	0.35	0.14	254
Saw dust	0.18	0.00	0.03	0.06	0.02	235
LSD ($\alpha < 0.05$)	0.04	0.00	0.02	0.02	0.00	34.01
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

This finding was also supported by Yildiz *et al.* (2002), who reported that the natural substrates (*i.e.* woods) on which *Pleurotus* species grow were very poor in N-content, nevertheless fruit bodies were produced. Upadhyay *et al.* (2002) reported that *Pleurotus* species have the capability to fix atmospheric N. Soybean had a significantly higher P-content (0.90%) compared with both wheat straw (0.54%) and saw dust (0%). In contrast, wheat straw contained a higher amount of K (0.90%) compared with both soybean (0.53%) and saw (0.03%). In terms of Ca-levels, soybean, wheat straw and saw dust varied significantly (0.49%, 0.34% and 0.06%, respectively). Chiu *et al.* (1998) reported that agricultural wastes could be used to supply Ca for oyster mushroom growth and yield. In addition, application of poultry manure can be used to supplement and compensate for the lack of Ca, Cu, Mn and Fe in a nutrient-deficient substrate for oyster mushroom cultivation Bandara *et al.* **(**2006) and Mashudu *et al*. (2015). Available Mg content significantly differed for soybean(0.282%) compared with both wheat straw (0.10%) and saw dust (0.02%). Wheat straw contained a higher amount of Fe (845 mg kg−1) compared with both soybean (408.3 mg kg−1) and saw dust (235 mg kg−1) (Table 6). In general, saw dust had the lowest mineral (e.g. N, P, K, Ca, Mg and Fe) quantities, far below critical threshold levels required for oyster mushroom production, compared with the other substrates. The lower mineral content of saw dust was reflected in the production of fewer cumulative numbers of flushes and caps and lower fresh mass of oyster mushrooms.

(e) Nutritional composition of oyster mushrooms

There were no significant differences ($P < 0.05$) between treatments (wheat straw, wood chips and thatch grass) in terms of the chemical composition (i.e. ash, fat, protein and carbohydrates) of oyster mushrooms (Table 3). Other studies have reported protein contents ranging from 22.89% to 25.97%, which were far higher than the current results, when rice straw was used as a substrate. The fat and carbohydrates content ranged from 1.03% to 1.50% and 30.24% to 42.26%, respectively. These results indicate that carbohydrate and protein contents are dependent on the substrate used (Wang et al. 2001). However, in the present study, all mineral nutrients were available in harvested oyster mushrooms in lower percentages, regardless of the different substrates (Table 7).

Table 7: Nutritional value of oyster mushrooms harvested in different growing substrates media

Substrates	**Nutritional value (%)**						
	Fresh mass	**Dry matter**	**Moisture**	**Ash**	**Fat**	**Protein**	**Carbohydrates**
Wheat(Control)	**10.54**	**9.84**	**90.16**	**0.82**	**0.15**	**1.66**	**7.22**
Mustard	**10.53**	**9.78**	**89.46**	**0.85**	**0.16**	**1.67**	**7.23**
Chickpea	**10.32**	**9.87**	**88.99**	**0.89**	**0.17**	**1.68**	**7.32**
Soybean	**10.44**	**9.80**	**90.34**	**0.88**	**0.18**	**1.69**	**7.12**
Black gram	**10.56**	**9.58**	**90.18**	**0.89**	**0.18**	**1.67**	**7.22**
Sugarcane	**10.45**	**9.77**	**89.57**	**0.90**	**0.15**	**1.67**	**7.24**
Saw dust	**10.76**	**9.16**	**89.94**	**0.44**	**0.08**	**2.45**	**7.09**
LSD ($\alpha < 0.05$)	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**
P-value	**0.804**	**0.767**	**0.768**	**0.115**	**0.472**	**0.585**	**0.962**

The substrates in the present experiment had moisture contents ranging from 89.94% to 90.84%. This finding was similar to that of Dunkwal and Jood (2009), who reported that oyster mushrooms grown on wheat straw and brassica straw contained moisture contents of 89.68% and 88.98% on a fresh weight basis. Oyster mushrooms are soft in nature due to the high moisture content at a young stage but tend to lose moisture with maturity Prakash *et al.* (2011) and Mashudu *et al*. (2015). Mushroom fungi are regarded as a good source of protein, with high vitamins and lower calories, and free from cholesterol (Selvi *et al.* 2007). Generally, no growing medium was superior to the other substrates in relation to chemical composition.

(f) Harvesting periods

Oyster mushroom harvesting started at ±66 days after planting. At first harvest, Wheat straw (45) produced a higher number of flushes compared with mustard(14), chickpea(27),soybean(22),black gram(28),sugarcane(26), and saw dust(13)(Table 5). Wheat straw had a higher cumulative number of flushes, although each harvest differed in number of flushes and caps and fresh mass produced during the entire production. However, chickpea, soybean, black gram and mustard and saw dust had a similar number of flushes compared with wheat straw. Wheat straw produced a similar number of caps from the first harvest to the sixth harvest. Surprisingly, mustard and saw dust had three harvests only compared with wheat straw and other pluses straws (soybean, chickpea and black gram).

Table 8: Harvesting times with number of flushes (A), number of caps (B) and fresh mass (C) of oyster mushrooms produced from 15 October to 15 November, 2021

Substrates	Number of flushes	Number of pin heads	Fresh mass (g)
Wheat(Control)	45	395	4200
Mustard	14	131	1386
Chickpea	27	1324	2520
Soybean	22	1234	2100
Black gram	28	1124	2622
Sugarcane	26	1129	2620
Saw dust	13	214	1260
LSD ($\alpha < 0.05$)	Ns	ns	ns
P-value	0.804	0.767	0.768

This study was not inconsistent with the findings of Sharma et al. (2013), who harvested only two flushes of mushrooms for each treatment (rice straw, rice straw + wheat straw, rice straw + paper, sugarcane bagasse and saw dust). In general, All pulses straw (soybean, chickpea and black gram) produced a high numbers of pin head in small size due to high protein content but low fresh mass in compared to wheat straw because of small in size, which decreased the increased yield. This finding was not inconsistent with that of Sofi *et al.* (2014) and Mashudu , *et al*. (2015) who reported that wood chips in combination with wheat straw had the highest yield compared with single usage of wheat straw and waste paper substrates. It indicated that the high protein content straw must be used with half wheat straw in ration to obtain good size of pin head high.

(g) Yield of oyster mushrooms

Cumulative number of pin head produced on all substrates differed significantly compared with saw dust. Highest number of small pin head produced on pluses crops as chickpea (1324), soybean (1234) and black gram(1124) as compared to less number and larger size in sugar cane (1129), mustard(131), saw dust (214) and in wheat straw (395) differed significantly in terms of cumulative fresh mass of oyster mushrooms. Cumulative number of flushes produced was significantly different among all treatments from wheat straw to saw dust. Wheat straw (4200 g) had the highest fresh mass produced followed by black gram (2622 g), sugar cane (2620 g), chickpea (2520 g), soybean(2100 g), mustard (1386 g) and saw dust 1260 g) (Table 8). Kumari and Achal (2008) and Mashudu *et al*. (2015) cultivated *Pleurotus ostreatus* on different substrates and reported that the highest yield was achieved on wheat straw, followed by the combination of paddy straw and wheat straw. These authors' findings were similar in that the highest yield was on wheat straw, but the other substrates used were different to those of the present study. This indicated that both wheat straw and thatch grass produced greater yields. Thatch grass also showed potential as an alternative to wheat straw when considering the cumulative fresh mass produced

IV. Conclusions

Wheat straw accelerated the rate of colonization, which helped to avoid contamination with parasitic fungi (*Aspergillus spp. Penicillium spp, Rhizopus spp. and Trichoderma spp*.). However, with mustard soybean, chickpea, black gram, sugar cane and saw dust , the rate of colonization recovered at a later stage after contamination had occurred. This indicated that wheat straw and other agricultural wastes accelerated the rate of colonization, although at different stages. Wheat straw suppressed contamination due to quick coverage of mycelia in the culture bag. Saw dust had a high rate of contamination by parasitic fungi due to slow mycelial coverage of the culture bags. Although all substrates and saw dust had minimal contamination at an advanced stage of mycelia coverage, it was still advisable to be used as an alternative substrate only if wheat straw was not available pr with portion of 50% in ration. Mustard, soybean, chickpea, black gram and sugar cane were recommended because it contains three important nutrients (N, P and Mg) required by oyster mushrooms, whereas wheat straw contains only N and Mg in high quantities. Wheat straw and other substrates produced high cumulative numbers of flushes and caps and high fresh mass of oyster mushrooms. In general, other agricultural wastes could be used were showed to be useful as an alternative substrate to wheat straw or with half-half amount of ration because it produces a higher yield of oyster mushrooms.

V. Acknowledgements

Thanks to the Bundelkhand Mahila Mushroom Utpadak Swa-Sahita Samooh(*Women Self help group of Mushroom Production of local area*),Ambedakarngar,Tikamgarh (M.P.) and Soil Science and Food Technology Laboratories helped to analyzed the mineral and contains in substrates and mushroom during studies of KVK, Tikamgarh (M.P.). Highly acknowledged to the Principal Scientist and Head of KVK, Tikamgarh (M.P.)and Food Technologist Scientist of College of Agriculture, Tikamgarh (M.P.) for his cooperation for providing the facilities necessary to conduct this study. Thanks also to all my colleagues of KVK, Scientists and staff as well as farmers who participated in this work.

References

[1]. Bandara Wmms, Seneviratne G, Koolasooriya Sa. 2006. Interactions Among Endophytic Bacteria And Fungi: Effects And Potentials. Journal Of Biosciences 31: 645–650.
[2]. Bernardi E, Donini Lp, Minotto E. 2007. Cultivation Of Three Pleurotus (Jacq.: Fr.) P. Kummer Species On Pasteurized Elephant Grass (Pennisetum Purpureum) Substrate. International Journal Of Medicinal Mushrooms 9: 373–378.
[3]. Bughio I. 2001. Yield Performance Of Oyster Mushroom, Pleurotus Ostreatus (Jacq. Ex. Fr) Kummer On Combination Of Different Straws. Msc Thesis, Sindh Agriculture University, Tandojam, Pakistan.
[4]. Cohen R, Persy L, Hadar Y. 2002. Biotechnological Applications And Potential Of Wood-Degrading Mushrooms Of The Genus Pleurotus. Applied Microbiology And Biotechnology 58: 582–594.
[5]. Dunkwal V, Jood S. 2009. Effect Of Substrates On Nutrient Composition Of Oyster Mushroom (Pleurotus Sajor-Caju). Journal Of Dairying, Foods And Home Sciences 28: 132–136.
[6]. Greenfield H, Southgate Dat. 2003. Food Composition Data – Production, Management And Use (2nd Edn). Rome: Food And Agricultural Organization Of The United Nations.
[7]. Harris Le. 1970. Nutrition Research Techniques For Domestic And Wild Animals, Vol. 1. Logan, Ut: Animal Science Department, Utah State University.
[8]. Isaac Ra, Johnson Wc Jr. 1992. Determination Of P, K, Ca, Mg, Mn, Fe, Ai, B, Cu And Zn In Plant Tissue By Emission Spectroscopy. In: Plank Co (Ed.), Plant Analysis Reference Procedures For The Southern Region Of The United States. Southern Cooperative Series Bulletin 368. Athens, Ga: Georgia Agricultural Experiment Stations, University Of Georgia. Pp 41–43.
[9]. Khan Na. 2009. Studies On Cultivation Of Oyster Mushroom On Commonly Available Agricultural Wastes In Pleurotus. Phd Thesis, University Of Agriculture, Faisalabad, Pakistan.
[10]. Khan Sm, Nawaz A, Ali Ma, Ahmad T, Khan Na, Rehman Au. 2012. Response Of Oyster Mushroom On Different Agricultural Wastes Of Southern Punjab. Pakistan Journal Of Agricultural Science 49: 127–130.
[11]. Kumari D, Achal V. 2008. Effect Of Different Substrates On The Production And Non-Enzymatic Antioxidant Activity Of Pleurotus Ostreatus (Oyster Mushroom). Life Science Journal 5(3): 73–76.
[12]. Kwon H, Kim Bs. 2004. Bag Cultivation. In: Mushroom Growers' Handbook 1. Seoul: Mushworld. Pp 139–152.
[13]. Labuschagne Pm, Eiker A, Aveling T, De Meillon S, Smith Mf. 2000. Influence Of Wheat Cultivars On Straw Quality And P. Ostreatus Cultivation. Bioresource Technology 71: 71–75.
[14]. Mane Vj, Patil Ss, Syed Aa, Baig Mmv. 2007. Bioconversion Of Low Quality Lignocellulosic Agricultural Wastes Into Edible Protein Pleurotus Sajor-Caju (Fr.). Singer Journal Of Zhejiang University Science 8: 745–751.
[15]. Mashudu R Masevhe, Puffy Soundy And Nicolette J Taylor. 2015. Alternative Substrates For Cultivating Oyster Mushrooms (Pleurotus Ostreatus). South African Journal Of Plant And Soil 2016, 33(2): 97–103 Printed In South Africa.
[16]. Mertens Dr. 2002. Gravimetric Determination Of Amylase-Treated Neutral Detergent Fiber In Feeds With Refluxing In Beakers Or Crucibles. Journal Of Aoac International 85: 1217–1240.
[17]. Mondal Sr, Rehana Mj, Noman Ms, Adhikary Sk. 2010. Comparativestudy On Growth And Yield Performance Of Oyster Mushroom (Pleurotus Florida) On Different Substrates. Journal Of Bangladesh Agricultural University 8: 213–220.
[18]. Pokhrel Cp, Yadav Rkp, Ohga S. 2009. Effects Of Physical Factors And Synthetic Media On Mycelial Growth Of Lyophyllum Decastes. Journal Of Ecobiotechnology 1: 46–50.
[19]. Poppe J. 2004. Agricultural Wastes As Substrates For Oyster Mushroom. In: Mushroom Growers' Handbook 1. Seoul: Mushworld. Pp 75–85. Prakash P, Samundeeswari R, Vivek C, Chitra Devi A. 2011.The Influence Of Potassium Humate On Pleurotus Florida. World Journal Of Science And Technology 1: 28–31.
[20]. Prakash P, Samundeeswari R, Vivek C, Chitra Devi A. 2011. The Influence Of Potassium Humate On Pleurotus Florida. World Journal Of Science And Technology 1: 28–31.
[21]. Ragunathan R, Gurusamy R, Palaniswamy M, Swaminathan K. 1996. Cultivation Of Pleurotus Species On Various Agro-Residues. Food Chemistry 55: 139–144.
[22]. Rajapakse Jc, Rubasingha P, Dissanayake Nn. 2007. The Potential Of Using Cost-Effective Compost Mixtures For Oyster Mushroom (Pleurotus Species) Cultivation In Sri Lanka. Tropical Agricultural Research And Extension 10: 29–32.
[23]. Rajapakse Jc, Rubasingha P, Dissanayake Nn. 2007. The Potential Of Using Cost-Effective Compost Mixtures For Oyster Mushroom (Pleurotus Species) Cultivation In Sri Lanka. Tropical Agricultural Research And Extension 10: 29–32.
[24]. Rajarathnam S, Bano Z, Miles Pg. 1988. Pleurotus Mushrooms. Part Ib. Pathology, In Vitro And In Vivo Growth Requirements, And World Status. Critical Reviews In Food Science And Nutrition 26: 243–311.
[25]. Sanchez C. 2004. Modern Aspects Of Mushroom Culture Technology. Applied Microbiology And Biotechnology 64: 756–762.
[26]. Selvi S, Uma Dp, Suja S, Marugan S, Chinnaswamy P. 2007. Comparison Of Non-Enzymic Antioxidant Status Of Fresh And Dried Form Of Pleurotus Florida And Calocybe Indica. Pakistan Journal Of Nutrition 6: 468–471.

[27]. Shah Za, Ashraf M, Ishtiag Ch M. 2004. Comparative Study On Cultivation And Yield Performance Of Oyster Mushrooms (Pleurotus Ostreatus) On Different Substrates (Wheat Straw, Leaves, Sawdust). Pakistan Journal Of Nutrition 3: 158–160.
[28]. Sharma S, Yadav Rkp, Pokhrel Cp. 2013. Growth And Yield Of Oyster Mushroom (Pleurotus Ostreatus) On Different Substrates. Journal On New Biological Reports 2: 3–8.
[29]. Sofi B, Ahmad M, Khan M. 2014. Effect Of Different Grains And Alternate Substrates On Oyster Mushroom (Pleurotus Ostreatus) Production. African Journal Of Microbiology Research 8: 1474–1479.
[30]. Tan Kk. 1981. Cotton Waste Is A Fungus (Pleurotus) Good Substrate For Cultivation Of Pleurotus Ostreatus The Oyster Mushroom. Mushroom Science 11: 705–710.
[31]. Tesio L. 2003. Measuring Behaviours And Perceptions: Rasch Analysis As A Tool For Rehabilitation Research. Journal Of Rehabilitation And Medicine 35: 105–115.
[32]. Upadhay Rc, Verma Rn, Singh Sk, Yadav Mc. 2002. Effect Of Nitrogen Supplementation In Pleurotus Species. In: Sanchez Je, Huerta G, Montiel E (Eds), Mushroom Biology And Mushroom Products. Morelos: Universidad Autonoma Del Estado De Morelos. Pp 225–235.
[33]. Van Niewenhuijzen B. 2007. Small-Scale Mushroom Cultivation - 2. Agaricus And Volvariella. Agrodok 41. Wageningen: Agtromisa Foundation And Cta.
[34]. Wang D, Sakoda A, Suzuki M. 2001. Biological Efficiency And Nutritional Value Of P. Ostreatus Cultivated On Spent Beet Grain. Bioresource Technology 78: 293–300.
[35]. Wood Da, Hartley Rd. 1988. Conclusions And Recommendations. In: Zadrazil F, Reiniger P (Eds), Treatment Of Lignocellulosics With White Rot Fungi. London: Elsevier Applied Science. Pp 115–117.
[36]. Yadav, A. K. (2019) Agro-Climatic Regions Of India: Descriptive Study With Special Reference To The Bundelkhand Agro-Climatic Zone (Bacz).Journal Of Advances And Scholarly Researches In Allied Education 16(1) 2365 – 2369