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Application of organic nitrogen supplementations increases the yield of oyster mushroom (*Pleurotus florida*)

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Oyster mushrooms *Pleurotus* spp. provides their nutritional requirement from a host substrate or from the agricultural wastes that are rich in lignin, cellulose and hemicelluloses. In order to investigate the effect of nutritional supplements in substrate on yield of oyster mushroom (*Pleurotus florida*) an experiment was carried out in Completely Randomized Design whit three replications. In present study three nutritional supplements, including alfalfa meal, soybean meal and vermicompost (2.5, 5 and 7.5%) and control were evaluated. Results indicated that all of traits significantly were affected by nutritional supplements ($P< 0.01$). Vermicompost at all levels led to early mycelium running (18.67 days) and application soybean meal (2.5%) increased fruiting body formation in comparison with other treatments. The length and diameter of stipe ranged from 3.86 to 5.86 cm and 0.95 to 1.71 cm respectively. Higher length (6.80 cm) and width of pileus (7.61 cm) were observed in substrate containing vermicompost (2.5%) and alfalfa meal (2.5 and 7.5%). The highest total mushroom yield (1231.40 g/kg wet substrate) and biological efficiency (117.10%) maximum were observed in the substrate with soybean meal 2.5% treatment.

Keywords: Growth characteristics, Nutritional supplement, Oyster mushroom, Yield, Biological efficiency.

The mushroom production is a global and expanding industry, its world production is 6535542 ton in 2009 (FAO, 2011). Oyster mushroom (*Pleurotus* spp.) is in the second position in the world and its cultivation has increased rapidly during the last decade (Royes, 2002; Shelly *et al*., 2009). Oyster mushroom accounted for Mushrooms are rich in proteins, vitamins, and minerals and popularly called as the vegetarian's meat. Mushroom proteins are considered to be intermediate between that of animals and vegetables (Kurtzman, 1976) as it contains all the nine essential amino acids required for human body (Hayes and Haddad, 1976). Cultivation of *Pleurotus* spp. as edible mushrooms is becoming important through the world because of their ability to grow at temperatures of 10- 35°C (Zadrazil, 1978; Yildiz *et al*., 1998) and on various lignocellulosic materials such as rotten wood, wood residues and most of agricultural wastes (Stamet, 2000; Straatsma *et al*., 2000).

Biswas *et al*., (2009) reported that oyster mushroom (*Pleurotus florida*) cultivation is popular due to low cost technology and easy availability of various substrates for its cultivation. In Asia, rice straw and in Europe, wheat straw is widely accepted as the main substrate to cultivate oyster mushroom (Mandeel *et al*., 2005). Oyster mushroom production requires good quality of substrate, sufficient amount of spawn, favorable environmental growth condition, mushroom straine, culture bed preparation and supplement usage (Royes, 2003; Royes *et al*., 2004; Banik and Nandi, 2004). Food supplements in substrate increase mushroom yield and quality (Royes, 2003). Gurjar and Doshi (1995) reported that application of 5 and 7.5% of soybean meal on substrate of *P. cornucopiae* had no positive effect on yield in wheat straw and assumed this could be due to a rise in temperature. Zadrazil and Kamara (1997) reported a 300% increase in the yield of *P. sajor-caju* from the addition of either 30% soybean or 40% alfalfa (*Medicago sativa)* meal. In the present studies three different organic supplement were evaluated to find out their effect on yield of *Pleurotus florida*.

Materials and Methods

The experiment was conducted in the Department of Horticulture, Faculty of Agriculture University of Tabriz during the period of September 2010 to December 2011. The substrate wheat straw was sun dried and chopped in to small bits, then was soaked for 24 hours and then boiled in water for 2 h and it is cold to ambient temperature and excess of water was dried out to moisture of 70% (Zadrazil, 1978). For enrichment of substrate three rates (2.5%, 5% and 7.5%) of nutritional supplements consist of alfalfa meal, soybean meal and vermicompost were used (Table 1). Supplements were mixed thoroughly at aforementioned reates in the substrate and 3 percent of grain spawn of *Pleurotus florida* were used. Substrate with different supplement (4 kg) was placed in polypropylene bags (16''×32''), and then the bags were closed. Bags were subsequently placed into a spawn running, room at 20-25°C under dark conditions. After completion of spawn running the bags were placed into a culture room at 18-25°C temperature and 70-80% relative humidity. The bags were cut D shaped (2"× 1") and water was sprayed for maintaining moisture up to the desired level in the form of fine mist with the help of a nozzle. After the maturation of fruit body the harvesting phase started. All environmental conditions in the culture were provided according to growth requirements of *P. florida* as indicated in Tables 2.

Table 1. Chemical composition of nutritional supplements (Dry weight based)

nutritional supplements	Components (%)		
	Nitrogen	Potassium	Phosphorus
Alfalfa meal	3.24	0.25	0.24
Soybean meal	7.98	0.33	0.60
Vermicompost	1.18	1.53	0.95

The yield data of three flushes in a period of 20 days from first flush were recorded in terms of average number and average weight of fruit body per experimental unit after harvesting of fruit bodies. Length and diameter of stipe, length and width of pileus were measured.

Biological efficiency is indicating the conversion of substrate mass to mushroom fruiting bodies which was calculated according to (Wasantha Kumara and Edirimanna, 2009).

Biological efficiency (%)= Total weight of fruit bodies / Total weight of substrate used (g) × 100.

Data collection and statistical analysis

The experiment was laid out in Completely Randomized Design (CRD) with three replications and ten treatments. Data were collected time required for completion of mycelium running, number of fruiting body, stipe length, stipe diameter pileus width, pileus length, total yield and biological efficiency. The data were analyzed statistically by SPSS 16.0 software. The means were compared by using of Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Table 2. Environmental conditions of oyster mushroom culture room.

Parameters	Spawn run head	Pin head stage	Fruiting body stage
Temperature (°C)	22± 2	12 ± 2	16- 20
Relative humidity (%)	85- 90	95- 100	85- 90
Air replacement per hour	1	5	5
Light (LUX/ day)	_	2000	2000

Results and Discussion

Mycelium running: Days required to completion of mycelium running in substrate was significantly affected by different supplements and it ranged from 18.66 to 23 days (Table 3). The minimum time (18.66 days) was recorded from soybean meal 7.5%, The maximum time (23 days) was recorded from vermicompost (2.5%). Bhatti *et al*. (1987) reported that the appreciable days to complete mycelium running of oyster mushroom in different substrates might be due to variations in their chemical composition and C: N ratio and the data of present study are in agreement with their findings.

Number of fruiting body: Nutritonal supplements significantly (P< 0.05) number of fruiting body obtained from 3 flushes (Table 3). The highest number of fruiting bodies was observed in soybean meal 2.5% treatment (74) and the lowest number of fruiting bodies was found in soybean meal 7.5% (31.3). Our results agree with finding Shelly *et al*., (2009) and Adamovic *et al.* (1996).

Lenght of stipe: The length of stipe differed significantly (p <0.05) between treatments and ranged from 3.86 to 5.86 cm (Table 3). The highest of stipe was recorded in vermicompost 2.5% (5.86 cm) and the lowest length of stipe was recorded in soybean meal 5% (3.86 cm). Similar results were reported by Biswas *et al*. (2009) and Shelly *et al*. (2009) in oyster mushroom.

Diameter of stipe: The diameter of stipe ranged from 0.95 to 1.20 cm on different treatment without any significant difference (Table 3). The highest diameter of stipe was found in soybean meal 2.5% (1.20 cm). The lowest diameter was found in soybean meal 7.5% (0.95 cm) followed by soybean meal 5% (1.00 cm). Shelly *et al*. (2009) was reported that the diameter of stipe was ranged from 0.65 to 0.83 cm and Sarker *et al*., (2007a) founded that diameter of stipe was ranged from 0.70 to 0.88 cm in oyster mushroom.

Pileus width: Pileus width of fruiting body ranged from 6.59 to 7.83 cm without any significant difference between treatments (Table 3). The similar result was reported by Shelly *et al*. (2009) who observed that the diameter of pileus ranged from 5.53 to 6.60 cm.

Pileus length: The highest length (6.80 cm) was observed in vermicompost 2.5% and the lowest (5.55 cm) was observed from soybean meal 5% without any significant difference with control (Table 3). Comparatively similar results were found by Peksen and Kucukomuzlu (2004) and Shukla and Jaity (2011).

Total yield: The effect of organic nitrogen supplementation in wheat straw on yield of *P. florida* was presented in Table 3. The yield of mushrooms was affected by different supplements. There was significant variability of total mushroom yield among different supplements. The total yield mushroom from 3 flushes ranged from 831.69 to 1231.4 (g/ kg) (Table 3). The highest total yield of mushrooms was recorded in soybean meal 2.5% (1231.4 g/ kg) and the lowest total yield was found in soybean meal 7.5% (831.69 g/kg) and control treatment (832.05 g/ kg). The yield of the mushroom is directly related to the spread of the mycelium into the substrates (Thomas *et al*., 1998). The fresh mushroom yield or biological efficiency of a species is directly related to strain, substrate nutrition and growth conditions (Upadhaya *et al*., 2002). Zadrazil and Kamara (1997) reported a 300% increase in the yield of *P. sajor-caju* from the addition of either 30% soybean or 40% alfalfa meal. Rinker (1989) found 37 and

42.6% more total yield in *P. ostreatus* from supplementation with barley straw with brewer's grain and 17, 27, 65 and 118% more yield by addition of alfalfa hay at 5, 10, 20 and 40% (dry wt. basis).

Table 3. Effect of different supplements on yield and yield contributing characters of *Pleurotus florida.*

Treatment	Mycelium running (days)	Number of fruiting body	Length of stipe (cm)	Diameter of stipe (cm)
Control	21.33[ab]	55.66[ab]	5.74[ab]	1.10[a]
WS+ A1	20.00[b]	52.00[abc]	5.45[ab]	1.05[a]
WS + A2	20.00[b]	60.00[ab]	4.14[bc]	1.13[a]
WS + A3	20.00[b]	63.30[ab]	4.91[abc]	1.16[a]
WS + S1	20.33[ab]	74.00[a]	4.40[abc]	1.20[a]
WS + S2	20.00[b]	46.33[bc]	3.86[c]	1.00[a]
WS + S3	23.00[a]	31.30[c]	5.36[abc]	0.95[a]
WS + V1	18.67[b]	59.30[ab]	5.86[a]	1.08[a]
WS + V2	19.33[b]	64.00[ab]	5.07[abc]	1.06[a]
WS + V3	19.33[b]	68.30[ab]	4.15[bc]	1.71[a]
CV (%)	5.99	22.37	16/87	15.31

Table 3. *Continued*

Treatment	Pileus length (cm)	Pileus width (cm)	Total yield (g/kg wet sbstrate)	Biological efficiency (%)
Control	6.10[a]	6.95[b]	832.95[bc]	81.90[bc]
WS+ A1	6.10[a]	7.68[b]	878.77[bc]	84.24[bc]
WS + A2	6.54[a]	7.00[b]	943.56[bc]	89.36[bc]
WS + A3	6.18[a]	7.61[b]	1115.80[ab]	104.21[ab]
WS + S1	5.92[a]	7.30[b]	1231.40[a]	117.10[a]
WS + S2	5.55[a]	6.59[b]	968.81[bc]	90.21[bc]
WS + S3	5.71[a]	7.13[b]	831.69[c]	75.86[c]
WS + V1	6.80[a]	7.20[b]	978.29[bc]	92.22[bc]
WS + V2	5.65[a]	6.79[b]	1103.4[ab]	101.01[ab]
WS + V3	5.97[a]	7.28[b]	983.79[bc]	87.35[bc]
CV(%)	13.04	12.44	9.57	9.70

In a column, means followed by a common letter are not significantly different at 1% level. A1= Alfalfa meal (2.5%), A2= Alfalfa meal (5%), A3= Alfalfa meal (7.5%), S1= Soybean meal (2.5%), S2= Soybean meal (5%), S3= Soybean meal (7.5%), V1= Vermicompost (2.5%), V2= Vermicompost (5%), V3= Vermicompost (7.5%).

Biological efficiency: The biological efficiency obtained from 3 flushes in different treatments varied significantly ($P< 0.01$). Addition of different levels of supplements in wheat straw substrate increased biological efficiency and yield. Highest biological efficiency was found in soybean meal 2.5% (117.10%) and the lowest biological efficiency was found in soybean meal 7.5% (75.86%). The result was approximately similar to the findings of Alam *et al.* (2007) who observed that the biological efficiency ranged from 45.21% to 125.70% in case of oyster mushroom.

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