Zagazig J. Agric. Res., Vol. 37 No. (2)2010 315 - 335

THE SUITABLE MEDIUM FOR IMPROVING THE PRODUCTIVITY AND QUALITY OF OYSTER MUSHROOM

Arisha, M.H.E., M.A.I. Khalil, E.A. El-Ghamriny and A. Bardisi

Hort. Dept., Fac. Agric., Zagazig Univ., Egypt

Accepted 28 /4 /2010

ABSTRACT: This study was conducted during the period from 2008-2009 in Mushroom Research Laboratory, Horticulture Department Faculty Of Agriculture, Zagazig University to determine the suitable media and their mixtures that enhance the yield and its components as well as fruit bodies quality of oyster mushroom. The organic substrate used for the cultivation of mushroom were rice straw, clover hay and sugarcane bagasse each was used alone or in binary mixtures; viz., 1:1, 3:1, 1:3 (w/w) as dry weight bases.

The obtained results showed that, the highest values of both average cluster weight (gm) total fresh mushroom yield/bag, and biological efficiency were obtained when mushroom cultivated on rice straw alone, rice straw +clover hay (3:1, w/w) and rice straw + sugarcane bagasse (3:1, w/w).Whereas, the maximum early yield/total yield percentage was obtained when mushroom was grown on clover hay medium alone.

On the contrary, cultivation of mushroom on sole clover hay medium produced the lowest number of clusters per bag followed by clover hay medium + sugarcane bagasse medium (3: 1,w/w) and rice straw + clover hay medium (1: 3,w/w).

On the other hand, the obtained results indicated that the highest protein and phosphorus percentages in fruit bodies of mushroom were recorded when it was grown on clover hay medium alone, clover hay + sugarcane bagasse medium (3: 1,w/w) and rice straw + clover hay (1: 3,w/w). Cultivation oyster mushroom on sole sugarcane bagasse medium and on rice straw+ sugarcane bagasse as medium gave the lowest value of potassium percentage in fruit bodies.

Key words: Cultivation, oyster mushroom, yield, fruit body protein percentage, substrate chemical constituents.

INTRODUCTION

There are at least 12,000 species of fungi that can be considered mushrooms, with at least 2000 species showing various degrees of edibility. Furthermore, over 200 species have been collected from the wild and used for various traditional medical purposes. About 35 mushroom species have been cultivated commercially, and of these, around 20 were cultivated on an industrial scale (DÜndar and Yildiz, 2009).

The genus *Pleurotus* (oyster mushroom) comprises about 40 species (Jose and Janardhanan, 2000) They are ubiquitous, being found in both temperate and tropical parts of the world, and are now considered to be the second most important cultivated mushroom in the world. Oyster mushroom belongs to class: *Basidiomycetes*, subclass: *Holobasidiomycetidae*, order: *polyporales*.

Cultivation of oyster mushroom is became more popular through the world and had many advantages comparing with other cultures because of their ability to grow in a wide range of temperature its highly labor intensive, short duration crop life cycle and land saving beside to using the agricultural wastes as a medium for it's growth (Moda *et al.*, 2005).

For both spawn running and fruit body development lignin and cellulose materials such as corncobs, all cereal straw, wood shaving, saw dust and vegetable wastes, as well as food industry wastes are sufficient (Yildiz and Ertekin, 1996). Moreover it has been reported that mushrooms can grow on cotton wastes, dried chopped maize straw, used tea leaves, rice straw, sugarcane bagasse new sprint and sawdust (Banjo *et al.*, 2004).

Cultivation of saprophytic edible mushrooms may be the only currently economical biotechnology for lignocelluloses organic wastes recycling that combine the production of protein rich food with the reduction of environmental pollution (Obodai *et al.*, 2003).

The use of different types of substrates by fungus could be depend on its capacity to secrete enzymes like cellulase,

hemicellulases and ligninase, releasing nutrients for its growth (Mata *et al.*, 2001).

According to Zanetti and Ronal (1997), if on the one hand the low content of nitrogen decreased productivity, on the other hand high content of this nutrient negatively affected the production of fruit bodies where there is an optimum concentration of nitrogen to mycelia phase and production.

Many investigators evaluated *Pleurotus* sp yield when grown on different substrate and its mixtures. In this connection Singh *et al.* (1995); Deka *et al.* (1994) and Khattab (2000) concluded that using rice straw recorded higher yield, higher biological efficiency more than to clover hay substrate. In addition Martinez-Carrera *et al.* (1990). Reported that growth and biological efficiency of oyster mushroom on sugarcane bagasse alone were low, but they increased when that medium was mixed with barley straw (1:1, W/W). Also, Kurt and buyukalaca (2010) found negative correlation between mushroom yield of *Pleurotus* and C/N ratio. The decrement in mushroom yield might be due to the excess of nitrogen in the initial substrate which affected degredation of lignin and may prevent the mycelium from developing (Donini *et al.*, 2009).

On the other hand, the highest protein and carbohydrate percentage in mushroom fruit bodies were recorded with clover hay and sugarcane bagasse, respectively (Khattab, 2000).

This study aimed to evaluate the cultivation of oyster mushroom on different substrates and their mixtures that enhance the yield and its components, fruit bodies quality of oyster mushroom and its relation to the raw media contents of the major nutrients especially nitrogen, protein, and C/N ratio.

MATERIALS AND METHODS

This work was carried out in Mushroom Research Laboratory (MRL), Horticulture Department, Faculty of Agriculture, Zagazig University, during the period from 2008 to 2009. To determine the suitable substrate and their mixtures that enhanced the yield and its components as well as fruit body's quality of oyster mushroom.

This experiment included twelve treatments as follows:

1. Rice straw
2. Clover hay
3. Sugarcane bagasse

4. Rice straw+ clover hay (1:1,w/w)
5. Rice straw + sugarcane bagasse (1:1, w/w)
6. Sugarcane bagasse+ clover hay (1:1, w/w)
7. Rice straw+ clover hay (3:1, w/w)
8. Rice straw+ sugarcane bagasse (3:1, w/w)
9. Sugarcane bagasse+ clover hay (3:1, w/w)
10. Rice straw + clover hay (1:3,w/w)
11. Rice straw + sugarcane bagasse (1:3, w/w)
12. Sugarcane bagasse + clover hay (1:3, w/w)

These treatments were arranged in a randomized complete block design system with three replicates and each replicate consists of two polyethylene bags.

Preparation of Organic substrates

All organic substrates (clover hay, sugarcane bagasse and rice straw) were chopped into pieces (15-20 cm) and one kg of dry substrates were picked in perforated bags and soaked in waterfor 3, 6 and 9 hours, respectively and left to drain the excess water.

The substrates and their mixtures were pasteurized in life steam system at 80 – 90 ^{O}C for 6-8 hours. The pasteurized substrates were left to reach the room temperature (Zadrazil, 1978).

Spawning

After complete pasteurization process, the substrates were packed in four layers into polyethylene bags (60 cm depth x 40 cm diameter). Every bag contains 1 kg dry substrate (about 3 kg wet substrate with 70-75% moisture content) and the spawn were distributed over each layer 10-15 cm thickness at the rate of 5% this equal to about 150 gm spawn/bag. *Pleurotus florida* (strain 238) was obtained from the Institute of Food Technology – Giza -Egypt.

Mycelial Growth

The polyethylene bags were transferred to incubation room at temperature 25°C±3 with less ventilation and darkness till full colonization (about two weeks). Polyethylene bags were then pinned and transferred to production room, where the temperature was 20°C ± 3 and a relative humidity was maintain to about 80-90% using a foggy system.

The polyethylene bags were perforated to have enough aeration

needed for fungal growth. The holes were mad by using sterilized glass bar with 1cm diameter and were distributed as 5 cm between each others (about 50 holes /bag).

Data Recorded

Growth characters

Two oyster mushroom clusters were taken from each treatment of the first flush (first 15 days) and the following data were recorded:

1. Cap weight (g)
2. Stipe weight (g)
3. Stipe diameter (cm)
4. Cap diameter (cm)

Yield and its components

At suitable harvesting stage, all clusters were harvested and the following data were recorded:

1. Number of clusters / bag
2. Early yield/total yield ratio (%)
3. Total fresh yield /bag (g)
4. Average of cluster weight (g)
5. Biological efficiency.

It was defined as percentage of the fresh weight of harvested mushroom over the dry weight of substrate as explained by Zervakis and Balis (1992).

6. Bioconversation ratio.

It was defined as the grams of dry mushrooms produced per 100 gm of dry substrate used (DÜndar and Yildiz, 2009).

7. Number of days from spawning to first harvest.

Chemical constituents

Sample of 100 gm fruit bodies from each replicate as well as samples of 200 gm from all studied substrates before spawning and after harvesting, were taken, then dried in oven at 70°C till constant weight. The dried materials were grinded to a fine powder for the following chemical analysis.

Minerals determination

N, P and K was determined in mushroom fruit bodies and the substrates before spawning and at the end of the experiment according to the methods advocated by Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Jackson (1970), respectively.

Crude protein (%)

It was determined in the dried fruit bodies as nitrogen content and multiplied by 4.38 to convert it to equivalent protein content (Fujihara *et al.*, 1995).

Total carbohydrates (%)

It was determined following the method described by (Dubois *et al.*, 1956).

Carbon (%)

It was determined in the substrates before spawning according to the method described by (Jackson, 1970).

Statistical analysis

The obtained data were subjected to statistical analysis of variance according to Snedecor and Cochran (1982), and means separation were done according to Duncan (1958).

RESULTS AND DISCUSSION

Effect of Some Organic substrates and their Mixtures on Growth Characters of Mushroom Fruit Bodies

The obtained results as shown in Table 1 exhibited the effect of different organic substrates and their mixtures on the growth characters of oyster mushroom in both seasons of study.

It is quite clear from such results that, the highest values of stipe diameter was more distinct by growing mushroom on rice straw + clover hay (1:1, w/w) followed by rice straw + clover hay (1:3, w/w), then rice straw + sugarcane bagasse (1:1,w/w), while the minimum stipe diameter of fruit bodies was produced with rice straw + sugarcane bagasse (1:3,w/w).

It is clear from data in Table 1 that the highest cap diameter was obtained when mushroom was grown on rice straw+ sugarcane bagasse (1:1,w/w) followed by rice straw + clover hay (1:1,w/w), clover hay + sugarcane bagasse (1:1,w/w) and clover hay + sugarcane bagasse (3:1,w/w) without significant differences between them on the same characters described above. Moreover, the least treatment was rice straw + sugarcane bagass (1:3,w/w).

Generally, it is evident from Table 1 that using rice straw + clover hay (1:1,w/w), and rice straw + sugarcane bagasse (1:1,w/w) being the most effective and favorable treatments that recorded the maximum values of cap diameter in the two growing seasons of study with regards to stipe weight, the obtained results in Table 1 also revealed the maximum values in this respect by using sole clover hay (6.83)

Table 1. Effect of some organic substrates and their mixtures on growth characters of mushroom fruit bodies

Treatments / Substrate (w/w)	Stipe diameter (cm)		Cap diameter (cm)		Cap weight (g)		Stipe weight (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
R.S.	1.48 cd	1.54 bc	7.51 cd	7.98 a	b	16.10 ab	4.14 b	6.47 ab
C.H.	1.48 cd	1.35 d	7.60 cd	8.15 a	8.23 c	8.33 d	6.58 a	7.08 a
S.B.	1.35 de	1.28 d	7.49 cd	7.76 a	13.79 b	14.51 bc	1.83 c	3.90 bcd
R.S. + C.H (1 : 1)	1.75 a	1.71 a	8.24 b	8.38 a	18.60 a	18.17 a	4.77 ab	5.14 abc
R.S. + S.B. (1 : 1)	1.62 abc	1.61 ab	8.94 a	8.61 a	18.17 a	15.34 abc	3.81 bc	6.40 ab
C.H.+ S.B. (1 : 1)	1.64 ab	1.58 ab	8.03 bc	8.35 a	14.85 b	16.08 ab	3.89 bc	2.99 cd
R.S.+C.H. (3 : 1)	1.57 bc	1.60 ab	7.53 cd	8.65 a	15.18 b	15.51 abc	3.61 bc	3.10 cd
R.S. + S.B. (3 : 1)	1.26 e	1.41 cd	7.29 d	8.06 a	13.18 b	15.53 abc	3.81 bc	2.06 d
C.H.+ S.B. (3 : 1)	1.57 bc	1.57 ab	8.01 bc	8.51 a	13.77 b	13.01 c	3.86 bc	6.86 a
R.S.+C.H. (1 : 3)	1.64 ab	1.70 a	7.81 bcd	8.01 a	13.07 b	14.85 bc	3.54 bc	5.70 abc
R.S. + S.B. (1:3)	1.28 e	1.27 d	7.49 cd	7.67 a	15.12 b	16.94 ab	2.99 bc	3.55 cd
C.H..+ S.B. (1: 3)	1.35 de	1.40 cd	7.20 d	8.08 a	13.14 b	15.35 abc	2.73 bc	3.62 cd

R.S.: Rice straw; C.H.: Clover Hay; S.B.: Sugarcane bagasses, w/w: weight/ weight.
Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

followed by clover hay + sugarcane bagasse (3:1,w/w), (5.36) respectively, (average of two seasons of study).

Similar results were found by Farrag (1993) who reportedd that, rice straw was the best substrate for increasing cluster weight of *pleurotus sp.* Hosni (1996) and Khattab (2000) came to similar results regarding fruit body weight and cap weight.

In this connection, Radwan (2005) reported that the highest stipe weight, cap diameter and cap weight of mushroom fruit bodies were obtained when mushroom cultivated on rice straw compared to other tested substrates, i.e., sugarcane bagasse and Bermuda grass.

Number of Days Till First Flush, Number of Clusters/bag and Average Cluster Weight

The period needed for fruit bodies formation of *Pleurotus florida* are given in Table 2. The most rapid fruit bodies formation took place (19.00 and 19.33 days) with the clover hay followed by 20.83 and 16 days for clover hay + sugarcane bagasse (1:1, w/w), but the most slow fruit body formation took place (31.75 and 27.17 days) with sugarcane bagasse compared to other used substrates. These results are true in the two seasons of study. It is interest to note that mixing of clover hay with any substrate accelerate fruit body formation. However, increasing the amount of sugarcane bagasse delayed fruit body formation

This means that mixing clover hay to other substrates increased early yield /total yield ratio because it contains hight nitrogene percent. While, sugarcane bagasse resulted in the lowest early yield/total yield. (Khattab, 2000) came to similar finding. In this connection Khattab, (2000) found that clover hay alone decreased and rice straw alone increased the number of days from spawning to the first flush, respectively.

The effect of different substrates on number of cluster/ bag and average clusters weight are shown in Table 2. The highest number of cluster/bag were achieved using all tested substrates and their mixtures except sole clover hay, rice straw + clover hay (1:1,w/w), clover hay + sugarcane bagasse (3:1,w/w) and rice straw + clover hay (1:3,w/w), which recorded the lowest values in this respect.

Table 2. Effect of some organic substrates and their mixtures on number of clusters, average cluster weight and number of days till first flush in fruit bodies of oyster mushroom

Treatments / Substrate (w/w)	Number of days till first flush		Number of clusters/ bag		Average cluster weight (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
R.S.	25.67 cd	20.17 cd	5.67 a	4.67 ab	221.53 a	244.36 a
C.H.	19.00 f	19.33 cde	1.50 d	1.00 d	86.58 e	98.45 f
S.B.	31.75 a	27.17 a	4.83 ab	4.33 ab	130.60 d	125.09 de
R.S. + C.H. (1 : 1)	23.00 de	21.00 bc	4.50 b	3.83 b	225.59 a	226.55 ab
R.S. + S.B. (1 : 1)	29.83 ab	25.67 a	4.67 ab	4.33 ab	215.46 a	210.58 b
C.H.+ S.B. (1 : 1)	20.83 cf	16.00 e	4.67 ab	4.67 ab	173.07 b	181.50 c
R.S. + C.H. (3 : 1)	21.83 def	19.30 cde	5.50 ab	5.00 a	228.02 a	231.78 ab
R.S. + S.B. (3 : 1)	29.67 ab	24.33 ab	5.50 ab	4.83 a	208.41 a	220.70 ab
C.H.+ S.B. (3 : 1)	22.33 def	17.83 cde	2.50 c	2.33 c	147.20 bcd	109.00 ef
R.S. + C.H. (1 : 3)	22.67 def	16.83 de	2.33 cd	2.67 c	139.79 cd	136.81 d
R.S. + S.B. (1 : 3)	27.67 bc	21.33 bc	4.67 ab	4.50 ab	167.79 bc	163.56 c
C.H.. + S.B. (1 : 3)	24.00 dc	17.00 de	4.67 ab	4.67 ab	153.22 bcd	183.16 c

R.S.: Rice straw; C.H.: Clover Hay; S.B.: Sugarcane bagasses, w/w: weight/ weight.

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

Among the different substrates sole rice straw, rice straw + clover hay (1:1,w/w), rice straw + clover hay (3:1,w/w) and rice straw+ sugarcane bagasse (3:1,w/w) proved to be the best substrates for increasing average cluster weight. On the other hand oyster mushroom grown on sole clover hay gave the lowest cluster weight compared to other substrates. Obtained results are in agreement with those reported by Farrag (1993) and Hosni (1996) on oyster mushroom. They concluded that the highest fruit body weight was produced when mushroom was cultivated on both rice straw and wheat straw compared to other tested substrates.

Yield and its Components of Fruit Bodies

Results in Table 3 showed the effect of some organic substrates on the yield and its components of oyster mushroom during the two seasons of study.

Data of early yield/total yield (%) of oyster mushroom are given in Table 3. Results indicated that using sole clover hay, rice straw + clover hay (1:1, w/w), clover hay + sugarcane bagasse (1:1,w/w), and clover hay + sugarcane bagasse (3:1), (86.83, 82.78, 68.95, 72.58) recorded the maximum values of early yield/total yield ratio (average two seasons) compared to other substrates. These results are consistent with those of Farrag, (1993) who concluded that using faba bean stalk as a substrate for growing oyster mushroom produced high ratio of the first flush as percentage of total yield. This means that mixing clover hay to other substrates increased early yield/total ratio. While, sugarcane bagasse resulted in the lowest early yield /total yield ratio. (Khattab, 2000) came also to similar finding

It is quite clear from such data that, the mushroom total yield per bag, biological efficiency and bioconversation ratio were obtained from cultivation of oyster mushroom on different studied substrates and their mixtures, are represented in Table 3. Sole rice straw, rice straw + clover hay (3:1)or rice straw + sugarcane bagasse (3:1, w/w) were the best substrates for increasing total yield of oyster mushroom compared to the other tested substrates sole or in mixtures. Also, the total yield obtained from growing mushroom on sole clover hay was the least effective medium in this concern compared to the other studied substrates. From the abovementioned

Table 3. Effect of some organic substrates and their mixtures on total yield, biological efficiency, and bioconversation ratio in fruit bodies of oyster mushroom

Treatments / Substrate (w/w)	Early Yield /total Yield (%)		Total yield/bag (g)		Biological efficiency (%)		Bioconversation ratio (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
R.S.	40.14 fg	56.05 bc	1251.95 a	1139.38a	125.20 a	113.94 a	7.20 ab	7.65 a
C.H.	79.58 ab	94.09 a	129.87 f	98.45 f	12.99 f	9.85 f	0.97 f	0.79 f
S.B.	33.79 g	56.16 bc	622.91 d	537.77 d	62.29 d	53.78 d	3.83 cd	3.77 d
R.S. + C.H. (1 :1)	81.01 ab	84.56 a	1015.17 b	867.73 bc	101.52 b	86.77 bc	7.08 ab	6.26 b
R.S. + S.B. (1 : 1)	56.34 def	43.46 c	997.30 b	911.02 b	99.73 b	91.10 b	6.22 b	6.33 b
C.H.+ S.B. (1 : 1)	78.04 abc	59.87 bc	810.35 c	838.78 bc	81.04 c	83.88 bc	4.73 c	5.84 bc
R.S. + C.H. (3 : 1)	45.47 efg	49.17 c	1247.82 a	1155.62a	124.78 a	115.56 a	8.20 a	8.19 a
R.S. + S.B. (3 : 1)	40.06 fg	55.51 bc	1146.23 a	1063.68a	114.62 a	106.37 a	7.24 ab	7.36 a
C.H.+ S.B. (3 : 1)	88.79 a	56.37 bc	368.00 e	256.70 e	36.80 e	25.67 e	2.76 de	1.90 e
R.S. + C.H. (1 : 3)	62.06 cde	68.21 b	329.93 e	367.57 e	32.99 e	36.76 e	2.61 e	2.79 de
R.S. + S.B. (1 : 3)	50.28 defg	47.23 c	776.47 c	736.78 c	77.65 c	73.68 c	4.34 c	4.91 c
C.H.. + S.B. (1 :3)	65.16 bcd	52.70 bc	713.37 cd	853.20 bc	71.34 cd	85.32 bc	4.44 c	5.97 b

R.S.: Rice straw; C.H.: Clover Hay; S.B.: Sugarcane bagasses, w/w: weight/ weight.

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

results it could be suggested that the superiority in total yield of mushroom fruit bodies may be due to the increase in average cluster weight by such treatments.

It is clear from the data in Table 3 that the substrate rice straw gave the best biological efficiency being 125.20% and 113.94% both seasons, respectively. Rice straw + clover hay (3:1, w/w) recorded 124.78% and 115.56% and rice straw + sugarcane bagasse (3:1,w/w) gave 114..62% and 106.37%. These results are in harmony with those reported by Thomas *et al.* (1998) who reported that sole rice straw is considered the best substrate for maximum yield of oyster mushroom and gave the highest biological efficiency. Thus the farmer must utilize the rice straw to convert the agricultural wastes to the form suitable for mushrooms.

It is also clear from the same data in Table 3 that there was nearly no mycelial growth. Thus very low yield when clover hay was used as sole substrate for cultivation of *Pleurotus florida* was obtained. This substrate recorded only 11.42% biological efficiency as average of the two seasons. This means that clover hay could not be good sole substrate for mushroom cultivation. Moreover, mixing it with other substrates significantly increased yield and biological efficiency compared with the other sole investigated substrates.

In this connection Deka *et al.* (1994) showed that paddy straw was the best substrate for high yield of three strains *(Pleurotus* spp.) under study. Singh *et al.* (1995) came to similar results with *Pleurotus florida* on total yield and biological efficiency (BE) and recorded the higher value of biological efficiency compared to other tested substrates.

Also, El-Bagori *et al.* (1996) reported that sugarcane bagasse was to be the least suitable substrate for *Pleurotus spp.* This could be attributed to its weak water holding capacity, poor compact structure, in addition abundance of soluble carbohydrates, especially sucrose which stimulated numerous saprophytic contaminants to grow which depressed growth and fructification. Moreover, Martinez-Carrera *et al.* (1990). Cultivated *P. ostereatus* (P-15) found that colonization and growth were poor on sugarcane bagasse alone due to its low N content and weak water holding capacity. The biological

efficiency was only 14.15%. On the other hand, the growth and yield on sugarcane bagasse mixtures with other substrates were dense and abundant. It is clear from the data in Table 3 that the bioconversation ratio gave the same trend as recorded with biological efficiency.

Chemical Constituents of Fruit Bodies

It is clear from the data in Table 4 that the heaviest values of nitrogen percent were recorded by growing mushroom fruit bodies on clover hay alone, clover hay + sugarcane bagasse (3:1,w/w) and rice straw + clover hay (1:3,w/w) with no significant differences among them. This means that production of mushroom on rice straw mixing with clover hay produced beneficial results regarding total nitrogen content. On the other hand, cultivation of *Pleurotus florida* on sugarcane bagasse alone and/or in mixtures especially with rice straw gave fruit bodies with the lowest nitrogen percentage. In this regard, Farrag (1993), Tshnyangu (1996), Yieldez *et al.* (1998) Khattab (2000), Radwan (2005) came to the similar results. They reported that mushroom fruit bodies obtained from growing mushroom on media containing high nitrogen percentage, i.e., clover hay or grass contained high percentage of nitrogen and crude protein in their tissues.

Obtained results in Table 4 show that production of oyster mushroom on clover hay alone significantly increased phosphorus. Percentage in fruit bodies over those produced from other tested substrates and its mixtures, while those produced on rice straw + sugarcane bagasse (1:1,w/w) and rice straw + sugarcane bagasse (3:1,w/w) gave the lowest phosphorus percentages in the fruiting bodies compared to other used substrates.

The same data in Table 4 clearly show that the most favorable substrates for increasing potassium percentages in fruit bodies were mushroom cultivated on rice straw alone and clover hay alone compared to other tested substrates.

Similar results are nearly in a good line with those reported by Khattab (2000) who found that the highest values of phosphorus percentage in mushroom fruit bodies was obtained with sugarcane bagasses. In this respect,

Table 4. Effect of some organic substrates and their mixtures on chemical constituents in fruit bodies of oyster mushroom

Treatments / Substrate (w/w)	N (%)		P (%)		K (%)		Total protein (%)		Total carbohydrates (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
R.S.	4.12 de	4.20 bcde	0.76 cd	0.61 d	3.64 a	3.33 a	18.05 de	18.40 bcde	53.04 ab	51.30 ab
C.H.	4.95 a	4.89 a	1.09 a	0.96 a	3.69 a	3.33 a	21.70 a	21.43 a	47.78 cd	50.18 ab
S.B.	3.87 e	4.05 cde	0.82 bc	0.80 abcd	2.66 c	2.62 bc	16.94 e	17.73 cde	56.03 a	52.65 a
R.S. + C.H. (1 : 1)	4.83 ab	4.62 ab	0.78 bcd	0.80 abcd	3.38 ab	3.38 a	21.14 ab	20.24 ab	52.85 ab	49.35 b
R.S. + S.B. (1 : 1)	3.96 de	3.80 e	0.64 d	0.59 d	3.02 bc	2.62 bc	17.35 de	16.64 e	54.80 ab	50.93 ab
C.H.+ S.B. (1 : 1)	4.83 ab	4.41 bc	0.86 bc	0.82 abc	3.34 ab	2.62 bc	21.17 ab	19.33 bc	53.63 ab	49.28 b
R.S. + C.H. (3 : 1)	4.25 cde	4.41 bc	0.72 cd	0.76 abcd	3.33 ab	3.20 ab	18.63 cde	19.33 bc	55.19 a	50.85 ab
R.S. + S.B. (3 : 1)	3.87 e	3.83 de	0.62 d	0.60 d	3.33 ab	3.29 a	16.93 e	16.79 de	52.46 abc	50.18 ab
C.H.+ S.B. (3 : 1)	4.70 abc	5.01 a	0.84 bc	0.76 abcd	3.02 bc	3.06 abc	20.59 abc	21.93 a	49.99 bcd	50.93 ab
R.S. + C.H. (1 : 3)	5.06 a	5.01 a	0.96 ab	0.90 ab	3.33 ab	3.51 a	22.16 a	21.93 a	46.61 d	50.93 ab
R.S. + S.B. (1 : 3)	3.94 de	3.83 de	0.83 bc	0.64 cd	3.02 bc	2.93 abc	17.26 de	16.79 de	52.46 abc	51.68 ab
C.H. + S.B. (1 : 3)	4.37 bcd	4.25 bcd	0.89 bc	0.73 bcd	2.73 c	2.48 c	19.13 bcd	18.63 bcd	54.80 ab	51.30 ab

R.S.: Rice straw; C.H.: Clover Hay; S.B.: Sugarcane bagasses, w/w: weight/ weight.
Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

Radwan (2005) found that growing mushroom on rice straw or sugarcane bagasse gave fruit bodies with high phosphorus and potassium percentages in their tissues compared to other used substrates.

It could be noted from the data in Table 4 that using sole clover hay, rice straw + clover hay (1:3,w/w), clover hay + sugarcane bagasse (3:1,w/w) and rice straw + clover hay (1:1,w/w) as substrates for cultivation of mushroom produced fruit bodies having the highest protein percent than those produced by using other substrates and even their mixtures .On the other hand, the lowest protein percentage in fruit bodies was obtained when *Pleurotus florida* was cultivated on sole sugarcane bagasse, rice straw + sugarcane bagasse (3:1,w/w), rice straw + sugarcane bagasse (1:3,w/w) and rice straw + sugarcane logasse (1:1,w/w).

It is of interest to note that using sugarcane bagasse alone or in mixtures with any tested substrate, except clover hay showed decrements in protein percent of mushroom fruit body because of both sugarcane bagasse and rice straw as substrates contain little nitrogen content in their tissues.

Thus, crude protein percent of the fruiting bodies varied with the different substrates. Using substrates with high protein content in its tissues resulting in production of fruit bodies of high protein percent. These results are in accordance with those reported by Qin *et al.* (1989) and Khattab, (2000).

A significant increase in carbohydrates percentage in the fruit bodies was observed when mushroom was cultivated on sole sugarcane bagasse, rice straw + sugarcane bagasse (1:1,w/w) and rice straw + clover hay (3:1,w/w) when compared to other tested substrates and their mixtures Table 4. The lowest carbohydrate percent in fruit bodies was obtained when sole clover hay was used as a substrate for growing *Pleurotus florida*. These results were true in the both seasons. In this connection, (Khattab, 2000)found that cultivation of oyster mushroom on sugarcane bagasse produced the highest carbohydrate percent, while using clover hay as substrate gave fruit bodies with the lowest carbohydrates percentages.

It could be mention that mixing rice straw with clover hay (3:1, w/w) increased total yield/bag and

biological efficiency Table 3 and protein percent in fruit bodies Table 4 over those produced on rice straw alone.

Chemical Constituents of Air Dried Media before Spawning

Organic carbon percentage, nitrogen percentage and C/N ratio of substrate just before spawning are presented in Table 5. There were significant differences among the tested substrates and their mixtures in carbon percent, nitrogen percent and C/N ratio, except those of the second season which didn't reach the level of significance.

Based on the results presented in Table 5, sugarcane bagasse alone, rice straw + sugarcane bagasse (1:3,w/w) and clover hay + sugarcane bagasse (1:3,w/w) recorded significant increase in organic carbon percent compared to other tested substrates and even their mixtures. The lowest carbon percentage was obtained in the case of clover hay. These results are true in both investigated seasons, while the differences didn't reach the level of significance in the second one.

Regarding nitrogen percent in the tested substrates, it is clear from Table 5 that clover hay alone is mostly contained high nitrogen percentage followed by clover hay + sugarcane bagasse (3:1,w/w) then rice straw + clover hay (1:3,w/w).

Table 5 presents the values of C/N ratio of different substrates used in this study. Results show that sugarcane bagasse recorded the highest C/N ratio in both seasons, followed by rice straw + sugarcane bagasse (1:3,w/w). The lowest C/N ratio value was observed with clover hay substrate.

Clover hay alone had the highest nitrogen percentage in this tissues compared with the other tested substrates. Growing oyster mushroom on clover hay produced lower yield. Mixing clover hay to other substrate significantly increased yield and biological efficiency of oyster mushroom. The reduction in yield after using clover hay may be attributed to its high content of tannins which may affect protein and carbohydrate digestibility (Giner - Chavez *et al.*, 1997). Also these results are in agreement with (Farrag, 1993) who found that the highest nitrogen content of the substrate negatively correlated with the used substrate.

It could be concluded that higher yields and biological efficiency as well as fruiting body

Table 5. Differences among the used organic substrates and their mixtures in their chemical analysis (Carbon%, Nitrogen% and C/N ratio) before spawning

Treatments / Substrate (w/w)	Organic carbon		N (%)		C/N ratio	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
R.S.	43.11 abc	43.86 a	0.69 e	0.64 f	63.92 c	68.38 c
C.H.	40.88 c	41.63 a	3.36 a	3.55 a	12.16 e	11.75 f
S.B.	44.60 a	43.11 a	0.49 g	0.54 f	90.94 a	79.84 ab
R.S. + C.H. (1 : 1)	40.88 c	43.11 a	1.99 c	2.02 d	20.58 e	21.34 e
R.S. + S.B. (1 : 1)	40.88 c	42.96 a	0.55 fg	0.58 f	75.15 b	74.09 b
C.H.+ S.B. (1 : 1)	41.63 bc	43.11 a	1.87 c	1.99 d	22.27 e	21.61 e
R.S. + C.H. (3 : 1)	41.63 bc	43.11 a	1.17 d	1.18 e	35.87 d	36.51 d
R.S. + S.B. (3 : 1)	41.63 bc	44.60 a	0.63 ef	0.59 f	66.19 bc	75.59 b
C.H.+ S.B. (3 : 1)	40.88 c	42.45 a	2.54 b	2.66 b	16.14 e	15.94 ef
R.S. + C.H. (1 : 3)	41.63 bc	43.11 a	2.57 b	2.55 c	16.18 e	16.95 ef
R.S. + S.B. (1 : 3)	43.86 ab	44.60 a	0.52 fg	0.54 f	85.15 a	82.64 a
C.H. + S.B. (1 : 3)	43.11 abc	44.60 a	1.17 d	1.27 e	36.98 d	35.11 d

R.S.: Rice straw; C.H.: Clover Hay; S.B.: Sugarcane bagasses, w/w: weight/ weight.
Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test.

protein content as rice straw is used alone or mixed with clover straw (3:1, w/w). These results are in accordance with those of Khattab, (2000).

Finally, it could be also concluded that using rice straw, rice straw + clover hay (3:1, w/w) in most cases as substrate were more effective on yield and biological efficiency of oyster mushroom in both seasons of study.

REFERENCES

Banjo, N.O., E.T. Abikoye and A.O. Kukoye. 2004. Comparison of three nutrient supplements used as additive to sawdust during the cultivation of oyster mushroom (*Pleurotus pulmonarius*). Niger. J. Microbiol, 18:335-336.

Bremner, J.M. and C.S. Mulvaney. 1982. Total nitrogen. In: Page, A. L., R. H. Miller, and D. R. Keeney (Eds). Methods of soil analysis . Part 2. Amer. Soc. Agron. Madison, W. I. USA. : 595-624.

Deka, H.K., A.P. Thapliyal, R.R. Sinha, S.N. Potty and M.R. Sethuraj. 1994. Prospects and feasibility of mushroom (*Pleurotus spp.*) cultivation in Garo hills of Meghalaya. Indian Journal of Natural Rubber Research, 7 (I): 6-71. (C.F. Hort. Abstr., 65: 9921).

Donini, L.P., E. Bernardi, E. Minott and J.S. Nascimente. 2009. Cultivation of shimejii on elephant grass substrate supplemented with different kinds of brann. Scientia Agraria, Curitiba, 10 (1): 67-74.

Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers and F. Smith. 1956. Colorimetric method for determination of sugars and related substances. Analytical Chemistry, 28:350-356.

Duncan, D.B. 1958. Multiple range and multiple F test. Biometrics 11: 1-42.

DÜndar, A. and A. Yildiz. 2009. A comparitve study on *Pleurotus ostreatus* (Jacq.) *P. Kumm.* cultivated on different agricultural lignocellulosic wastes, Turk. J. Biol. 33:171-179.

El-Bagori, M.H., Sh. El-Gremi and M.E.K. Ibrahim. 1996. Production of mushroom (*Pleurotus spp.*) on agricultural wastes in Kafr El-Sheikh, Egypt, 1st Egypt-Hung. Hort. Conf.I:72-83.

Farrag, Amel. M.A. 1993. Studies on the productivity of some oyster mushroom strains on

some agricultural wastes .Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt.

Fujihara, S.A., Y. Kasuga, Aoyagi and T. Sugahara. 1995. Nitrogen to protein conversion factors for some common edible mushrooms. Journal of Food Science, 60 (5): 1045-1047.

Giner-Chavez, B.I., P.J. Van Soest, J.B. Robertson, C. Lascano and A. N. Pell. 1997. Comparison of the Precipitation of Alfalfa Leaf Protein and Bovine Serum Albumin by Tannins in the Radial Diffusion Method. J. Sci., Food Agric. 74:513-523.

Hosni, F.A.A. 1996. Studies on the growth and production of mushroom. M.Sc. Thesis, Fac. Agric., Al-Azhar Univ., Egypt 97p.

Jackson, M.L. 1970. Soil chemical Analysis. Prentice Hall. Englewood Gilles, New Jersey.

Jose, N. and K.K. Janardhanan. 2000. Antioxidant and antitumour activity of *pleurotus florida*. Curr. Sci., 79 (7) 941-943.

Khattab, Entsar, A.K. 2000. Effect of some cultural practices on mushroom production. M.Sc. Thesis, Fac. Agric., Munufiya Univ., Egypt.

Kurt, S. and S. Buyukalaca. 2010. Yield performance and changes in enzyme activities of *Pleurotus spp.* (*P. ostreatus and P. sajor-caju*) cultivated on different agricultural wastes. Bioresources Technology, 101: 3164-3169.

.Martinez- Carrera, D., P. Morales and M. Sobal. 1990. Cultivation of *Pleurotus ostreatus* on sugarcane bagasse supplemented with coffee pulp or barley straw. Micologia Neotropical Aplicada, 3, 49 - 52. (C.F. Hort. Abstrs, 62: 5920).

Mata, G., P. Delpech, J.M. Savoie. 2001. Selection of strains of lentinula boryana adapted to efficient mycelial growth on wheat straw. Revista Iberoamericana de Micologia, 18. P 118-122.

Moda, E.M., J.H. ORII and M.H. F.SPOTO. 2005. Edible mushroom pleurotus sajor-caju production on washed and supplemented sugarcane bagasse. Scientia Agricola, 62 (2): 127-132.

Obodai M., J. Cleneand-Okine and K.A. Vowotor. 2003. Comparative study on the growth and yield of *Pleurotus ostreatus* mushroom on different lignocellulosic by-production. J. Ind. Microbiol. Biotechnol., 30:146-149.

Olsen, S.R. and L.E. Sommers. 1982. Phosphours. In: Page, A. L., H. Miller and D. R. Keeney (Eds). Methods of Soil Analysis. Part 2, Amer. Soc. Agron. Madison, W. I. USA pp 403-430.

Qin, S.X., H.L. Zhang, L.K. Ren and X.J. Yan. 1989. Effects of different cultivation materials on nutritive composition of *Pleurotus* fruiting bodies. Edible Fungi of China, 3: 12- 13.

Radwan, M.M. 2005. Studies on mushroom production. M. Sc. Thesis, Fac. Agric., Zagazig Univ., Egypt.

Singh, A.K., S.K. Awasthi, and Bharat Rai. 1995. Utilization of sugarcane trash (dried leaves) for production of oyster mushroom, *Pleurotus florida*. Mushroom Research, 4 (1): 35-38.

Snedecor, G.W. and W.G. Cochran. 1982. Statistical methods. 7th ed. The Iowa State Univ. Press, Amer. Iowa, USA.

Thomas, G.V., S.R. Prabhu, M.Z. Reeny and B.M. Bopaiah. 1998. Evaluation of lignocelluloses biomass from coconut palm as substrate for cultivation of *pleurotus sajur-cajo* (Fr.) Singer. World J. Microbiol. and Biotechnol., 14: 879-882.

Tshinyangu, K.K. 1996. Effect of grass hay substrate on nutritional value of Pleurotus ostreatus var. columbinus. Nahrung, 40 (2): 79 – 83.

Yildiz, A., M. Karakaplan and F. Aydin. 1998. Studies on *Pleurotus ostreatus* (Jacq. Ex. Fr.) Kum. var.salgnus (Pers ex. Fr.) Konr. et Maubl.: cultivation, proximate composition, organic and mineral composition of carpophores. Food Chemistry, 61 (1/2): 127- 130.

Zadrazil, F. 1978. Cultivation of Pleurotus. Pages 521 -557. In: Changm S.T. and Hayes. A.W. The Biology and cultivation of Edible mushrooms Academic Press, New York. 819 P.

Zanetti, A.L. and M.A. Ronal. 1997. Supplementation of sugarcane with cowpea as a substrate for cultivation of *Pleuotus florida*. Pesquisa Agropecaria Brasileira, 32 (9): 959- 964.

Zervakis G. and C. Balis. 1992. Comparative study on cultural characters of pleurotus species under the different substrates and fruiting temperature. Micol. Neotop. appl., 5:39.

البيئة المثلي لتحسين إنتاجية وجودة عيش الغراب المحاري

محمد حامد محمد الهادي عريشة – محمود عبد العزيز إبراهيم خليل
المتولي عبد السميع الغمريني – عبد الله برديسي أحمد
قسم البساتين – كلية الزراعة – جامعة الزقازيق – جمهورية مصر العربية

أجريت هذه الدراسة خلال الفترة من ٢٠٠٨– ٢٠٠٩ بمعمل أبحاث عيش الغراب، التابع لقسم البساتين، كلية الزراعة – جامعة الزقازيق وذلك لتحديد البيئية المناسبة ومخاليطها والتى تؤدى إلى زيادة المحصول ومكوناته، بالإضافة إلي تحسين صفات جودة الأجسام الثمرية لفطر عيش الغراب المحارى، وقد استخدمت البيئات العضوية التالية وهى قش الأرز، ودريس البرسيم ومصاصة قصب السكر، إما منفردة أو فى مخاليط بنسب ١:١، ١ : ٣ ، ٣: ١ من كل منهما على أساس الوزن الجاف.

وقد أوضحت النتائج المتحصل عليها أن اعلي القيم لكل من متوسط العنقود الثمري للأجسام الثمرية، والمحصول الكلي للأجسام الثمرية للكيس الواحد، والكفاءة البيولوجية قد سجلت عند زراعة فطر عيش الغراب المحارى على بيئة قش الأرز منفردة، وبيئة قش الارز + دريس البرسيم بنسبة (٣ : ١، وزن/وزن) وبيئة قش الأرز + مصاصة قصب السكر بنسبة (٣ : ١، وزن/وزن) علي أساس الوزن الجاف، وتم الحصول على أعلى نسبة محصول مبكر للمحصول الكلى من بيئة دريس البرسيم منفردة.

وعلي العكس من ذلك فقد أنتجت بيئة دريس البرسيم أقل عددا من العناقيد الثمرية للكيس الواحد، يليها بيئة دريس البرسيم + مصاصة قصب السكر (٣ : ١، وزن/وزن) ثم بيئة قش الأرز + بيئة دريس البرسيم (١: ٣، وزن/وزن)

ومن ناحية أخري فقد أظهرت النتائج أن اعلي نسبة بروتين ونسبة فوسفور فى الأجسام الثمرية لفطر عيش الغراب كانت عند زراعته على بيئة دريس البرسيم بمفردة، ودريس البرسيم + مصاصة قصب السكر بنسبة (٣ : ١، وزن/وزن)، ثم بيئة قش الأرز + دريس البرسيم بنسبة (١ : ٣، وزن/وزن)، بينما أدت زراعة فطر عيش الغراب المحارى على بيئة مصاصة قصب السكر إلي الحصول على أقل قيمة لمحتوى الأجسام الثمرية من عنصر البوتاسيوم.