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Yield Potential and Quality of Some *Pleurotus* Species Grown in Substrates Containing Hazelnut Husk

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Abstract: This study was conducted to determine yield potential and quality of *Pleurotus ostreatus, P. sajor-caju* and *P. sapidus* grown in substrates containing hazelnut husk. Two different mixtures of hazelnut husk:wheat straw:wheat bran (1HH:2WS:1WB and 1.5HH:2WS:0.5WB) and wheat straw as a control (wheat straw+5% wheat bran) were used as substrates. It was determined that *Pleurotus* species differed ($P<0.01$) from each other in terms of total yield, while there were no significant differences among substrates for total yield. The highest mushroom yield was obtained from *P. sajor-caju* (27.00 kg per 100 kg substrate) and *P. ostreatus* (26.19 kg per 100 kg substrate). *P. ostreatus* and *P. sajor-caju* gave the highest biological efficiency (BE) rates (92.54 and 96.46%, respectively) when they cultivated in the wheat straw (control) substrate. BE of substrates prepared by hazelnut husk were lower than the control substrate, and it was found as 67.44% in 1HH:2WS:1WB for *P. ostreatus* and 70.96% in 1.5HH:2WS:0.5WB for *P. sajor-caju*. *P. sapidus* gave the lowest BE's in all substrates.

Key words: Biological efficiency, *Pleurotus,* plastic tunnel, substrate, yield

INTRODUCTION

Various wastes such as sawdust, all cereal straw, corn cobs, coffee pulp, cotton seed hulls, cotton waste from textile industry, paper, bean and cotton straw, coir, cocoa shell waste are used as substrates for *Pleurotus* cultivation[1,2]. Hazelnut is one of the most important agricultural crops of the Black Sea region in Turkey. Hazelnut trashing process produces large quantities of husk and shell waste. Uzun[3] studied the practicability of using hazelnut waste as substrate material for *Agaricus bisporus* cultivation, with promising results. The possibility of using hazelnut shell[4] and mixtures of hazelnut husk and sawdust[5] as substrate in *Pleurotus* cultivation have been investigated. Sivrikaya and Peker[6] studied the cultivation of *P. florida* on substrates prepared from leaves, sawdust, hazelnut husk and leaves, maize straw, tea waste, wheat straw and paper waste in 1:1, 1:3 and 3:1 ratios. Pekşen[7] determined the effects of different combinations of hazelnut husk with wheat straw and wheat bran on yield and quality of *P. sajor-caju.*

The aim of this study was to determine the effects of substrates containing hazelnut husk on the yield and quality traits of *P. ostreatus, P. sajor-caju* and *P. sapidus* grown during November 2001-April 2002 under an unheated high plastic tunnel.

MATERIALS AND METHODS

This study was carried out under an unheated high plastic tunnel and in the laboratory of the Faculty of Agriculture of Ondokuz Mayis University, Samsun in Turkey, during November 2001-April 2002. It was planned in Completely Randomized Design with 6 replications. Three *Pleurotus* species were used in the study. *Pleurotus ostreatus* (Jacq.: Fr.) Kummer and *P. sajor-caju* (Fr.) Sing. were obtained from a commercial firm and *P. sapidus* (Schulz. apud Kalchbr.) was provided from the Biology Department of the Kirikkale University.

The preparation of substrates was based on the dry weight of each components before mixing. Combinations of hazelnut husk (HH):wheat straw (WS):wheat bran (WB) in ratios of 1:2:1 and 1.5:2:0.5 were compared with the control substrate (wheat straw+5% wheat bran). Substrate components were wetted with water for 1-2 days. When the wetting was completed, plaster and lime mixture of 4:1 (on the basis of dry weight) was added to all of substrates. Prepared substrates were placed into heat-resistant gelatine bags of 15x30 cm size, with each containing 1 kg of substrate. Filled bags were plugged with cotton and then sterilized by autoclave at 121°C for 1.5 h. pH and moisture content of the substrates were determined. The sterilized substrates were spawned with

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8% mycelia grown on wheat grains, on the dry weight basis of substrate. Then, the inoculated bags were replugged and placed into the high plastic tunnel and covered with black plastic sheeting until the end of the spawn run (mycelia growth) period. When the spawn run was completed, black plastic sheeting on the bags were removed to promote mushroom formation. The tops of the bags were cutted open after primordia appearance. Bags were moistened and ventilated throughout the harvest period.

Spawn run period, days to first harvest and total mushroom yield were determined in the study. Biological efficiency (BE) was calculated according to Royse[8]. In the calculation of BE, differences in the % moisture content of each substrate after sterilization were taken into consideration. Mean mushroom weight, cap length and width, stem length and diameter[7] and dry matter content[9] were also determined.

RESULTS AND DISCUSSION

In this study, it was found that the pH of the sterilized substrates was between 5.40 and 6.20 and that moisture content was between 67.22 and 74.67% (Table 1). In a study carried out by Pekşen[7] the pH value of 1HH:2WS:1WB was found to be 6.5 and 6.8 for winter and summer periods, respectively.

Very significant differences ($P<0.01$) were found among *Pleurotus* species and substrates in terms of spawn run period and days to first harvest. A significant interaction between substrates and *Pleurotus* species ($P<0.01$) was also found. In general, spawn run period is 2-8 weeks depending on the structure of substrate and species[10]. *P. ostreatus* had the shortest spawn run period (38.72 days) and days to first harvest (72.28 days) in the present study (Table 2). This may be attributed to lower temperatures in the winter growing period and better growth of *P. ostreatus,* named *Pleurotus* of low temperatures, in the unheated plastic tunnel conditions when compared with the other *P.* species. Mushroom formation temperatures are 12-20°C for *P. ostreatus*, 18-30°C for *P. sajor-caju* and 15-25°C for *P. sapidus*[10]. In the present study, the number of days to first mushroom harvest after the completion of spawn run, ranged from 20.67 to 66.50 days (Table 2), due to low temperatures of around freezing point in the December and January. It is probable that the shock effect of low temperatures on *P. ostreatus* promoted earlier yield.

Substrates showed highly significant difference ($P<0.01$) for spawn run period and days to first harvest. The earliest spawn run (39.50 days) and shortest period to first harvest (63.50 days) was in wheat straw. This was followed by 1.5HH:2WS:0.5WB (Table 2). Increasing in the amount of wheat bran in the substrate results in substrate compaction, which prevents spawn run[7,11]. It was reported that the primordium formation period of *Pleurotus* species/strains grown in sugarcane leaves varied from 15 to 445 days after inoculation[12].

Total yield is expressed as total fresh weight of mushrooms obtained from 3 or 4 flushes in the harvest period. Harvest period ranged from 54.5 to 88.5 days depending on *Pleurotus* species and substrates. When total yields compared, it was shown that there was a significant difference ($P<0.01$) among *Pleurotus* species. The highest total yield was obtained from *P. sajor-caju* (27.00 kg per 100 kg substrate). This was followed by *P. ostreatus* (26.19 kg per 100 kg substrate). There was no significant difference between *P. ostreatus* and *P. sajor-caju*. Yield of *P. sapidus* (15.64 kg per 100 kg substrate) was highly significantly lower than the other species (Table 2). Low yield of *P. sapidus* was a result of low mean mushroom weight, small cap and stem (Table 3). Substrates were not statistically different from each other for total yield. Wheat straw, 1HH:2WS:1WB and 1.5HH:2WS:0.5WB substrates gave total yields of 22.34, 23.31 and 23.17 kg per 100 kg substrate, respectively. Erkel and Işik[13] reported that yield of *P. ostreatus* is 10.79-16.85 kg per 100 kg substrate and *P. florida* is 11.63-22.24 kg per 100 kg substrate. Pekşen[7] determined that the highest yield was obtained from 1HH:2WS:1WB (19.84 kg per 100 kg substrate) in the winter season. The combination of 2HH:2WS gave the lowest yield (11.18 kg per 100 kg substrate) in the same study.

Both substrates and *Pleurotus* species showed statistical differences ($P<0.01$) in terms of BE (Table 2). BE of *P. sapidus* (44.38%) was highly significantly lower than that of *P. ostreatus* (75.44%) and *P. sajor-caju* (77.91%) related to it's low yield. Although wheat straw had lower yield (22.34 kg per 100 kg substrate) than the other substrates, it gave the highest BE (78.96%). BE of wheat straw substrate for *P. ostreatus* and *P. sajor-caju* was 92.54 and 96.46%, respectively. 1HH:2WS:1WB and 1.5HH:2WS:0.5WB combinations gave higher yields than wheat straw, but their BE was lower because hazelnut husk does not absorb as much water as wheat straw. Determined BE's in the study were higher than the values of Mata and Gaitan-Hernandez[12], Ilbay and Okay[5], Pekşen[7], but lower than the values of Battick *et al.*[14].

Results of the study showed that *Pleurotus* species had significant differences ($P<0.01$) for the investigated morphological traits such as mean mushroom weight, cap length and width, stem length and diameter. The effects of substrates on the same traits were not significant. Except for stem length, *P. ostreatus* and *P. sajor-caju* were not

Table 1: pH values and moisture content of substrates used in the study

Properties	Substrates		
	WS (control)	1HH:2WS:1WB	1.5HH:2WS:0.5WB
pH	5.80	5.40	6.20
Moisture contents (%)	74.67	70.00	67.22

Table 2: The effects of the different substrates on spawn run, days to first harvest, total yield and BE of *Pleurotus* species

Properties	Substrates	*Pleurotus* species			
		P. ostreatus	*P. sajor-caju*	*P. sapidus*	Mean
Spawn run period (days)	WS (control)	39.67e**	40.50de	38.33e	39.50c**
	1HH:2WS:1WB	44.00cd	52.83a	49.83ab	48.89a
	1.5HH:2WS:0.5WB	32.50f	46.50bc	50.67ab	43.22b
	Mean	38.72b**	46.61a	46.28a	
Days to first harvest (days)	WS (control)	64.17de**(24.50)[1]	67.33de(26.83)	59.00e(20.67)	63.50c**(24.00)
	1HH:2WS:1WB	83.33cd(39.33)	119.33a(66.50)	107.83a(58.00)	103.50a(54.61)
	1.5HH:2WS:0.5WB	69.33de(36.83)	98.00bc(51.50)	97.83bc(47.16)	88.39b(45.17)
	Mean	72.28b**(33.56)	94.89a(48.28)	88.22a(41.94)	
Total yield (kg per	WS (control)	26.19	27.30	13.55	22.34
100 kg substrates)	1HH:2WS:1WB	26.98	26.53	16.43	23.31
	1.5HH:2WS:0.5WB	25.41	27.18	16.94	23.17
	Mean	26.19a**	27.00a	15.64b	
BE (%)	WS (control)	92.54	96.46	47.86	78.96a**
	1HH:2WS:1WB	67.44	66.31	41.06	58.27b
	1.5HH:2WS:0.5WB	66.33	70.96	44.23	60.51b
	Mean	75.44a**	77.91a	44.38b	

**:There are no significant differences (P<0.01) among means indicated by the same letter(s)

[1]: Number in brackets indicates days to first harvest after spawn run was completed

Table 3: The effects of different substrates on morphological characters and dry matter content of *Pleurotus* species

Properties	Substrates	*Pleurotus* species			
		P. ostreatus	*P. sajor-caju*	*P. sapidus*	Mean
Mean mushroom weight (g)	WS (control)	9.58	9.67	1.10	6.78
	1HH:2WS:1WB	8.60	10.35	1.11	6.69
	1.5HH:2WS:0.5WB	9.98	10.56	1.31	7.28
	Mean	9.39a**	10.19a	1.17b	
Cap length (cm)	WS (control)	6.89	6.40	3.23	5.51
	1HH:2WS:1WB	7.07	7.32	2.83	5.74
	1.5HH:2WS:0.5WB	7.10	6.72	3.14	5.65
	Mean	7.02a**	6.81a	3.06b	
Cap width (cm)	WS (control)	5.50ab*	5.10b	2.50c	4.37
	1HH:2WS:1WB	5.17b	5.75a	2.03c	4.32
	1.5HH:2WS:0.5WB	5.45ab	5.26ab	2.27c	4.33
	Mean	5.38a**	5.37a	2.26b	
Stem length (cm)	WS (control)	0.83bc**	1.01bc	0.39d	0.74
	1HH:2WS:1WB	0.73c	1.35a	0.18d	0.75
	1.5HH:2WS:0.5WB	0.81bc	1.08b	0.17d	0.69
	Mean	0.79b**	1.15a	0.25c	
Stem diameter (cm)	WS (control)	0.94	1.19	0.60	0.91
	1HH:2WS:1WB	0.94	1.21	0.56	0.90
	1.5HH:2WS:0.5WB	0.90	1.12	0.52	0.85
	Mean	0.93a**	1.17a	0.56b	
Dry matter content (%)	WS (control)	16.88	11.34	10.38	12.87
	1HH:2WS:1WB	15.39	16.42	17.27	16.36
	1.5HH:2WS:0.5WB	11.66	12.86	15.21	13.24
	Mean	14.64	13.54	14.29	

**: There are no significant differences (P<0.01) among means indicated by the same letter(s)

statistically different for all of the other morphological characters. *P. sapidus* differed from the other two species for all of characters. *P. sapidus* had very low mean mushroom weight (1.17 g) (Table 3). Cap sizes of *P. ostreatus* and *P. sajor-caju* were in agreement with the findings of Güler and Ağaoğlu[15], Ilbay and Okay[5], Pekşen[7], but stem sizes were lower than their findings.

It was found that dry matter content varied from 10.38 to 17.27% across substrate and species combinations. The effects of substrates, *Pleurotus* species and substrates x species interaction on dry matter content were not significant (Table 3). Dry matter contents

determined in the study were higher than the findings of Ilbay and Okay[5] and Güler and Ağaoğlu[15] were similar to the results of Pekşen[7].

The results of the study showed that substrates had no significant effect on yield and all investigated quality characters of *Pleurotus* species. Hazelnut husk can be provided at a low cost or free of charge. Increases in quantity of wheat bran in the substrate combinations increase substrate production cost. It was concluded that using of 1.5HH:2WS:0.5WB mixture in *Pleurotus* cultivation can be recommended for mushroom growers. It is likely that *P. sapidus* will not be preferred by growers and consumers because of its small cap and stem. In addition, low yield will deter growers from using *P. sapidus*. According to results of the present study, *P. ostreatus* and *P. sajor-caju* species can be recommended for cultivation under unheated, high plastic tunnels for the Black Sea region.

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