Bioresearch Communications

Volume 02, issue 01, January 2016.

Journal Homepage: www.bioresearchcommunications.com

Original Article

Effect of different saw dust substrates on the growth and yield of Oyster Mushroom (*Pleurotus florida*)

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ABSTRACT: The present study was to analyze the effect of different saw dust substrates, namely *Ficus carica* (Fig tree, $\mathbf{T_2}$), *Albizia saman* (Rain Tree, $\mathbf{T_3}$), *Swietenia mahagoni* (Mahogany tree, $\mathbf{T_4}$), *Leucaena leucocephala* (Ipil ipil tree, $\mathbf{T_5}$), *Eucalyptus obliqua* (Indian gum tree, $\mathbf{T_6}$) and mixture of all five tree sawdusts ($\mathbf{T_1}$), supplemented with 30% wheat bran and 1% lime, on the growth and yield performance of *Pleurotus florida* (Oyster mushroom). The highest average number of effective fruiting body (48.36g) was obtained from T_4 sawdust substrate followed by T_1, T_5, T_2, T_3 and T_6 respectively. The highest average weight of individual fruiting body (4.31g) was found from T_3 sawdust substrate followed by T_5, T_2, T_1, T_6 and T_4 respectively. The highest amount of biological yield (356.6g), economic yield (354.3g) and dry yield (35.43g) were found from T_3 followed by T_5, T_6, T_4, T_1 and T_2. The highest biological efficiency (212.8%) was obtained from T_3 sawdust substrate followed by T_1, T_2, T_6, T_5 and T_4.

KEYWORDS: *Pleurotus florida*, Growth, Yield, Sawdust, Spawn, Wheat bran

CITATION: Rashid, M. H., Bhattacharjya, D. K., Paul, R. K., Rahaman, M. S. Rahaman, M. S., Miah, M. N., Ahmed, K. U. 2016. Effect of different saw dust substrates on the growth and yield of Oyster Mushroom (*Pleurotus florida*). *Biores Comm.* **2**(1), 193-199.

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INTRODUCTION

Lately, an increase in food prices due to high biofuel prices has caused food scarcity in many countries. Cultivation of mushrooms is a very reliable and profitable option to alleviate hunger and malnutrition in a world of rising food prices. Most of the Bangladeshi people have been suffering from malnutrition. Mushroom could substantiate the suffering from malnutrition to some extent. For this potential dish item, works on the growth and yield performance analysis are not available in the country.

Interests in cultivation of edible mushrooms (*Pleurotus spp.*) is thus gaining importance rapidly which can create working area, employment opportunity in urban and rural area[1] and also ensure the availability of it's at low price and for recycling of agricultural wastage[2-4]. With the acquisition of more knowledge about the edible and poisonous mushrooms and the development of cultivation methods of few mushrooms, the utilization of different fungi as food during the modern time has definitely increased.

Edible fungi, Oyster mushrooms belong to the genus *Pleurotus*, family-*Pleurotaceae*[5]. In different parts of the world *Pleurotus* species are delicacies because of their excellent flavor and taste[6-11]. Because of the well-known capability to convert crop residues to food proteins, oyster mushrooms are the easiest and least expensive commercial mushrooms to grow.

Mushroom substrates may be defined as a kind of lingo-cellulosic material which supports the growth, development and fruiting of mushroom[12]. However, supplementation of the substrates with various materials is recommended prior to spawning for enhancement of the yield of mushrooms. To improve growth and yield of mushroom, various supplements can be added to the substrates[13]. It is well known that, mycelium growth and mushroom production both are affected by cellulose, hemicelluloses and lignin proportions along with nitrogen content of the cultivating substrate[14].

Sawdust is produced in a large scale by the saw-mill industries as a byproduct. As a result, it is readily available and a possible alternative for solving the cultivation problem of mushrooms. On the other hand, wheat bran is rich in protein (~14%), carbohydrates (~27%), minerals (~5%), fat (~6%) and B vitamins[15]. Besides these nutritional values, it is cheap and readily available. Several attempts to incorporate bran from various sources into cereal products as a high protein and fiber sources are reported in the literature. Reports on the cultivation of mushrooms on solid substrates such as sawdust and different agricultural wastes such as rice bran, wheat bran, sugarcane bagasse, rice husks, coconut fiber, peanut hulls, banana leaves etc. can be found in the literature[8, 16-20].

Few works have been done on the performance of different species of oyster mushroom grown on the agricultural byproducts, wastes, grasses as substrates in mushroom cultivation is of recent history in Bangladesh. Cultivation of Oyster mushrooms (*Pleurotus.spp.*) has been provoked by the environmental conditions of Bangladesh[21-22]. Oyster mushroom requires high humidity (80-90%) and high temperature (25-30 °C) for the vegetative growth called spawn running and lower temperature (18-25 °C) for fruit body formation[23].

Thus, the objective of this work was to evaluate influence of locally available sawdust of different trees with wheat bran 30% and 1% lime on growth and yield so as to find out the suitable sawdust substrate for cultivation of *Pleurotus florida*.

MATERIALS AND METHODS

Experimental location and Materials

The experiment was carried out at the Mushroom Culture House (MCH), Biochemistry laboratory of the Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh and National Mushroom Development and Extension Center (NAMDEC) laboratory, Savar, Dhaka, Bangladesh. All the chemicals used were collected from Merck (Germany), Wako Pure Chemicals Industries Ltd. and JHD (China). The samples were weighted by electric balance (KEY: JY-2003; China) and heated in a muffle furnace (Nebertherm: Mod-L9/11/c6; Germany). Fruiting body of Oyster mushroom (*Pleurotus florida*) was collected from National Mushroom Development and Extension Center (NAMDEC), Saver, Dhaka, Bangladesh.

Cultivation and Harvesting of Pleurotus Florida Mushroom

Pleurotus florida mashroom was grown on different sawdust substrates, namely, fig tree (*Ficus carica*, $\mathbf{T_2}$), rain tree (*Albizia saman*, $\mathbf{T_3}$), mahogany tree (*Swietenia mahagoni*, $\mathbf{T_4}$), ipil ipil tree (*Leucaena leucocephala*, $\mathbf{T_5}$), Indian gum tree **(***Eucalyptus obliqua*, $\mathbf{T_6}$**)** and a control ($\mathbf{T_1}$), supplemented with 30% wheat bran and 1% lime in the spawn packets[24-26]. Study on the growth and yield of the mushroom were done after harvesting the mushroom samples.

Growth and Yield Performance Analysis

Mycelial Growth (%): Full packet as a full unit was fixed to determine the mycelial growth was counted and generally the data was taken at every two days intervals.

Mycelium Running Rate in Spawn Packet (cm): After the mycelium colony cross the shoulder of the packet the mycelium running rate for each type of substrate was measured. The linear length was determined at different places of packets described by *Sarker et al.* (2007)[27].

$$\mathbf{MRR=}\ \frac{L}{N}\ \mathbf{cm/day}$$

Where, L = Average length of mycelium running for different places (cm) and
N= Number of days

Days Required for Completing Mycelium Running: The required days from inoculation to completion of mycelium running were measured.

Average Number of Fruiting Body/Packet: Well-developed fruiting body number was recorded. Dry and pinheaded fruiting bodies were discarded but tiny fruiting bodies were included in counting.

Average Weight of Individual Fruiting Body/Packet: Average weight of individual fruiting body was estimated by the ratio of total weight of fruiting body per packet to the total number of fruiting body per packet.

Biological Yield (g): Biological yield per 500 g packet was estimated by weighing the whole cluster of fruiting body without removing the lower hard and dirty portion.

Economic Yield: Economic yield per 500 g packet was recorded by weighing all the fruiting bodies in a packet after removing the lower hard and dirty portion.

Dry Yield: About 50g of randomly selected mushroom sample was taken in a paper envelop and was weighed correctly. The mushroom was oven dried at 72 ºC temperature for 24 hours and weighed again. The weight of blank envelop was subtracted from both the weight. The dry yield was calculated using the formula described by *Sarker et al.* (2007)[27].

$$\textbf{Dry yield (g/500g packet) = Economic yield} \times \frac{\textbf{Oven dry weight of sample(g)}}{\textbf{Fresh weight of sample(g)}}$$

Biological Efficiency: Biological efficiency was determined by the formula described by Ahmed *et al.* (2013)[34].

$$\textbf{Biological efficiency} = \frac{\textbf{Total biological weight (g)}}{\textbf{Total weight substrate usesd (g)}} \times \mathbf{100.}$$

Cost Benefit Ratio: The benefit cost ratios for different low cost substrate were computed based on present market price of mushroom and cost of different inputs in the markets[27].

Statistical Data Analysis

Microsoft Office Excel 2013 was used to analyze various parameters by following standard statistical method by considering, 5 treatments with 3 replications and 1 spawn packets in each replication. The collected data were analyzed for partitioning the total variance using computer operated MSTAT-C programme. The data for the characters considered in the present experiments were statistically analyzed by the Complete Randomized Design (CRD) and Randomized Complete Block Design (RCBD) method. The analysis of variance was conducted and means were compared following least significant difference (LSD) test at 1% and 5% level of probability for interpretation of results were the formula found in the literature[28].

RESULTS AND DISCUSSION

Effect of Different Sawdust Supplemented with Wheat Bran on the Growth of *Pleurotus Florida*

Effect on Mycelium Running Rate (Days): Statistically similar mycelium running rates were found for different treatments but they varied from each other numerically. The highest mycelium running rate (0.63cm) was detected from $\mathbf{T_4}$ followed by those for $\mathbf{T_3}$, $\mathbf{T_2}$, $\mathbf{T_1}$ and $\mathbf{T_5}$ (Table 1). The lowest mycelium running rate (0.55cm) was observed from $\mathbf{T_6}$ (Table 1). The present findings corroborated with the findings of previous workers (Sarker *et al.,* 2007; Khan *et al.,* 1991; Kalita *et al.,* 2001)[27, 29-30]. Khan *et al.* (1991) reported that sawdust amended with different organic supplement like wheat chaff, wheat bran, paddy straw, cotton waste etc. provided suitable condition for spawn running[29]. Kalita *et al.* (2001) reported the completion of spawn running may require 17 days from 22 days depending on the use of different substrates[30]. Sarker *et al.* (2007) found that the mycelium running rate of Oyster mushroom greatly influenced with the supplement of wheat brans in different levels[27].

Effect on Time from Stimulation to Primordia Initiation (Days): Numerically highest time from stimulation to primordia initiation (8.67 days) was observed from $\mathbf{T_6}$ followed by $\mathbf{T_5}$, $\mathbf{T_3}$, $\mathbf{T_4}$ and $\mathbf{T_2}$ (Table 1). The lowest value (6.33 days) was shown by $\mathbf{T_1}$ substrate (Table 1). The present findings corroborated with the findings of previous researchers (Amin *et al.,* 2007; Sarker *et al.,* 2007)[25, 27]. Sarker *et al.* (2007) observed that duration from primordia initiation to first harvest of Oyster mushroom was significantly lower as compared to control where no supplement was used and the duration required for total harvesting of Oyster mushroom increased with the level of supplement used[27]. Amin *et al.* (2007) found significant differences among the level of supplements used for preparing the substrates[25]. In the present study, the time required for total harvest also decreased with the levels of supplements increased compared to rice straw alone.

Effect on Time from Primordia Initiation to Harvest (Days): Lowest time from primordia initiation to harvest (3.33) was observed from $\mathbf{T_2}$ and $\mathbf{T_5}$ followed by $\mathbf{T_1}$, which was also statistically similar to $\mathbf{T_6}$ (Table 1). The highest time from primordia initiation to harvest (4.00) was found from $\mathbf{T_3}$ followed by $\mathbf{T_4}$ (Table 1). The result of the present study matches the findings found in the literature (Shah *et al.,* 2004, Khan *et al.,* 2001; Dhoke *et al.,* 2001; Royse, 2002)[7, 31-33]. Shah *et al.* (2004) found that fruiting bodies of oyster mushroom became suitable for harvesting within 3-6 day of primordia initiation in the spawn packet[7]. Khan *et al.* (2001) reported that after spawn running pinhead formation took 7-8 days and fruiting body formed after 3-5 days, sporocarps may be harvested after 10-12 days[31]. Dhoke *et al.* (2001) found significant effect of different agro-wastes on the yield of oyster mushroom[32]. The days required for first picking varied from 11.25-12.00 and the final picking completed in 42.25 to 43.50 days depending on different substrates. According to Royse (2002) an increased spawn rate decreased the number of days to production[33].

Effect of Different Sawdust Supplemented with Wheat Bran on the Yield of *Pleurotus Florida*

Effect on Average Number of Primordia: Significantly highest average number of primordia (86.67) was noted from $\mathbf{T_4}$ followed by $\mathbf{T_1}$, $\mathrm{T_2}$, $\mathbf{T_5}$ and $\mathbf{T_3}$ (Table 1). The lowest average number of primordia (61.00) was shown by $\mathbf{T_6}$ (Table 1). The result of the present findings keeps in with the literature[34].

Effect on Average Number of Fruiting Body: Significantly highest average number of fruiting body (61.23) was found from $\mathbf{T_4}$ followed by $\mathbf{T_1}$, $\mathbf{T_2}$, $\mathbf{T_5}$ and $\mathbf{T_3}$ (Table 1). The lowest average number of fruiting body (45.63) was observed from of $\mathbf{T_6}$ (Table 1). The findings are in accordance with the findings of previous scientists (Amin *et al.,* 2007; Sarker *et al.,* 2007; Yoshida *et al.,* 1993)[25, 27, 35]. Yoshida *et al.* (1993) reported that the number of fruiting bodies was lower, but increased when the substrates was mixed with different supplements[35]. Sarker *et al.* (2007) found that the number of primordia increased with the levels of supplement and continued up to a certain range[27]. Amin *et al.* (2007) reported that the number of primordia grown on different substrates differed significantly[25].

Effect on Average Number of Effective Fruiting Body: Similar trend was found in the average number of effective fruiting body where significantly highest value was detected from $\mathbf{T_4}$ (48.62) followed by $\mathbf{T_1}$ which was statistically similar to $\mathbf{T_5}$ and $\mathbf{T_2}$. The lowest value (34.74) was found from $\mathbf{T_6}$ (Table 1). The result of the present findings keeps in with the results observed by many researchers (Amin *et al.,* 2007; Sarker *et al.,* 2007; Ahmed *et al.,* 2013; Yoshida *et al.,* 1993)[25, 27, 34, 35]. Yoshida *et al.* (1993) reported that the number of effective fruiting bodies was lower, but increased when the substrates was mixed with different supplements[35]. Sarker *et al.* (2007) found that the number of primordia increased with the levels of supplement and continued up to a certain range and decline thereafter[25]. In the present study the average number of effective fruiting body increased up to 10 % of wheat bran used as supplement and decreased thereafter. The comparative similar findings were also found by Amin *et al.* (2007) and Ahmed *et al.* (2013) in a similar type of experiment[25, 34].

Effect on Average Weight of Individual Fruiting Fody (g): Numerically highest value (4.31) was shown by $\mathbf{T_3}$ followed by $\mathbf{T_5}$ (4.18), $\mathbf{T_2}$ (4.07), $\mathbf{T_1}$ (3.62), $\mathbf{T_6}$ (3.22) and the lowest value (2.94) was shown by $\mathbf{T_4}$ (Table 1). Sarker *et al.* (2007) found similar results and reported that the individual weigh of fruiting body ranged from 1.33g-1.59g, which was more or less similar to this study[27].

Effect on Average Length of Stripe: Significantly highest value was shown by $\mathbf{T_4}$ (1.43) followed by $\mathbf{T_1}$, $\mathbf{T_2}$, $\mathbf{T_3}$, $\mathbf{T_5}$ and lowest by $\mathbf{T_6}$ (1.17) (Table 1). The result of the present study matches with the findings of previous scientists (Sarker *et al.,* 2007)[27]. Sarker *et al.,* (2007) reported that the stripe length of *Pleorotus spp*. on different substrate varied from 1.93-2.97 cm and the diameter ranged from 0.74-1.05 cm[27].

Effect on Average Thickness of Pileus: The highest average thickness of pileus was found under $\mathbf{T_2}$ (0.73) followed by $\mathbf{T_4}$, $\mathbf{T_3}$, $\mathbf{T_5}$, $\mathbf{T_1}$ and lowest average thickness of pileus was observed from $\mathbf{T_6}$ (0.57) (Table 1). The results of the present findings keep in with the findings of Sarker *et al.* (2007), who reported that the thickness of pileus ranged from 0.50-0.80 cm in case Oyster mushroom[27].

Effect of Different Sawdust Substrates on biological yield (g), economic yield (g), Dry Yield (g), Biological Efficiency and Benefit Cost Ratio

Effect on Biological Yield (g): The highest biological yield (356.6 g/packet) was counted under $\mathbf{T_3}$ and the lowest biological yield (314.3 g/packet) was counted under treatment $\mathbf{T_2}$ (Table 2). The result of this present study is supported by the result of Baysal *et al.* (2003), who found the highest yield of Oyster mushroom (*Pleurotus ostreatus*) with the substrate composed of 20% rice husk in weigh[20].

Table1. Effect of sawdust substrates on mycelial growth and yield contributing character of Oyster mushroom (*Pleurotus florida*)

Treatments	Mycelium running rate in spawn packet (cm)	Time from stimulation to primordia initiation (days)	Time from primordia initiation to harvest (days)	Average number of primordia /packet	Average number of fruiting body /packet	Average number of effective fruiting body /packet	Average weight of individual fruiting body(g)	Average length of stripe (cm)	Average thickness of pileus (cm)
T_1	0.58ab	6.33c	3.67b	79.23ab	53.42ab	42.32ab	3.62ab	1.37ab	0.60c
T_2	0.60ab	6.42bc	3.33c	74.36b	50.25b	39.24b	4.07ab	1.30ab	0.73a
T_3	0.62a	6.67b	4.00a	68.36c	48.36c	36.25c	4.31a	1.33ab	0.67b
T_4	0.63a	6.66b	3.87a	86.67a	61.23a	48.62a	2.94b	1.43a	0.70a
T_5	0.58ab	7.33ab	3.33c	72.54b	49.21b	39.54b	4.18a	1.33ab	0.67b
T_6	0.55b	8.67a	3.67b	61.00d	45.63d	34.74d	3.22ab	1.17b	0.57c
CV (%)	6.08%	16.04%	19.36%	7.32%	27.82%	23.10%	17.23%	8.91%	20.02%
LSD (0.05)	0.058	3.24	1.272	34.49	9.727	4.786	1.168	0.2153	0.2372

Means followed by same letter significantly different at 1% or 5% level of significance

Effect on Economic Yield (g): Numerically the highest economic yield (354.3 g/ packet) was counted under $\mathbf{T_3}$ and the lowest economic yield (311.8 g/packet) was counted under $\mathbf{T_2}$ (Table 2). Sarker *et al.* (2007) found appreciable variations in economic yield under different substrate-supplement combinations[27].

Effect on Dry Yield (g): The highest dry yield (35.43g/packet) of mushroom was found from $\mathbf{T_3}$ treatment and the lowest dry yield (31.18 g/ packet) was found from $\mathbf{T_2}$ (Table 2). The result of the present study is supported by Ahmed *et al.* (2013) who observed significant effects of various substrates on diameter and length of stalk also diameter and thickness of pileus[34]. He also found that lower diameter of pileus produced the lowest yield and concluded that the diameter of pileus increased the quality and yield of mushroom and highest dry yield from mango sawdust. Sarker *et al.* (2007) found the range of dry yield from 4.28 to 29.98, which is more or less similar to this study[27].

Effect on Biological Efficiency: The highest biological efficiency (212.8%) was calculated from the $\mathbf{T_3}$ and the lowest biological efficiency (189.9%) was calculated from $\mathbf{T_4}$ (Table 2). The present findings are supported by previous workers (Kalita *et al.*, 1997; Shen and Royse, 2001; Obodai *et al.*, 2003)[36-38]. Kalita *et al.* (1997) observed biological efficiency for different substrates ranged from 35.2 to 60.9 %[36]. Shen and Royse (2001) found supplements combined with basal ingredient result better mushroom quality as well as biological efficiency[37]. Obodai *et al.* (2003) found biological efficiency (BE) followed a pattern and ranged from 61.0% to 80.0%[38].

Effect on Cost Benefit Ratio: The highest cost benefit ratio (5.08) was calculated for $\mathbf{T_5}$ treatment and the lowest cost benefit ratio (3.25) was found for $\mathbf{T_1}$ (Table 2). Results supporting the present study were found in the literature (Ahmed *et al.*, 2013; Sarker *et al.*, 2007; Lim *et al.*, 1997)[25, 27, 39]. Lim *et al.* (1997) analyzed the cost and return of *Volvariella* and *Pleurotus* mushroom production and found the ROI of 8.9 and 5.1, respectively[39]. Ahmed *et al.* (2013) also observed the benefit cost ratio of 73.2, 23.78 and 16.23 in case of *Pleurotus sajor*-caju[34]. The cause of these variations between the results of this study might be due to consideration of other costs involved in the production of Oyster mushroom or might be due to measuring system. Sarker *et al.* (2007) mentioned the performances of substrates were significantly differed based on benefit cost ratio[27]. They reported the highest cost benefit ratio of 6.50 with wheat straw.

Table2. Effect of sawdust substrates on yield, biological efficiency and benefit cost ratio of oyster mushroom (*Pleurotus florida*)

Treatments	Biological Yield (g)	Economic Yield (g)	Dry Yield (g)	Biological Efficiency (%)	Cost Benefit Ratio
T_1	319.2d	317.0d	31.70b	205.2b	3.25c
T_2	314.3d	311.8d	31.18b	202.4b	4.81b
T_3	356.6a	354.3a	35.43a	212.8a	4.65b
T_4	336.9c	334.7c	33.47ab	189.9d	4.57b
T_5	354.9b	352.7b	35.27a	195.7c	5.08ab
T_6	339.9c	337.7c	33.77ab	198.7c	4.92ab
CV (%)	7.21%	7.29%	7.50%	7.21%	7.44%
LSD $_{(0.05)}$	49.3	49.5	5.43	29.62	0.562

Means followed by same letter significantly different at 1% or 5% level of significance

CORRELATION STUDY

A highly significant correlation between average number of fruiting body and biological yield was observed when saw dust was supplemented with wheat bran (Fig. 1). The relationship showed a quadratic equation as $y = -1.0565x^2 + 100.13x - 2151.5$ ($R^2 = 0.8155$**). Where y = biological yield and x = average number of fruiting body. The majority of total variation in biological yield of the Oyster mushroom can be explained by this equation. The R^2 value indicated that 81.55% of biological yield of Oyster mushroom (*Pleurotus florida*) was attributed to the average number of fruiting body.

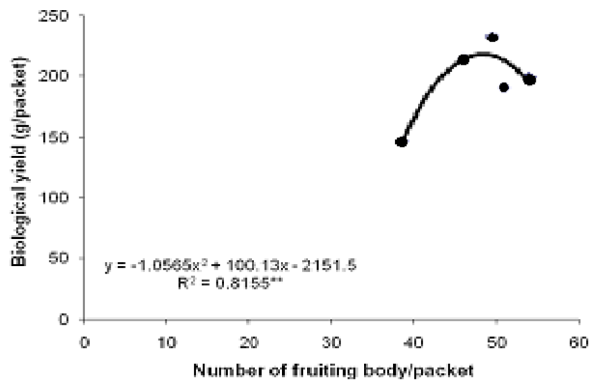

Fig.1: Functional relationship between average numbers of fruiting body with biological yield as influenced by different sawdust with wheat bran.

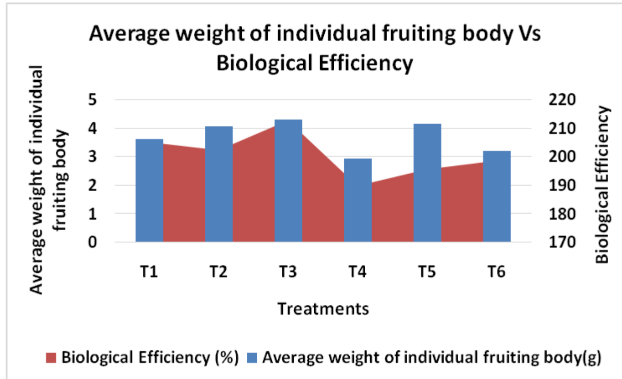

Fig. 2. Effect of different sawdust on relationship between average weight of individual fruiting body with biological yield

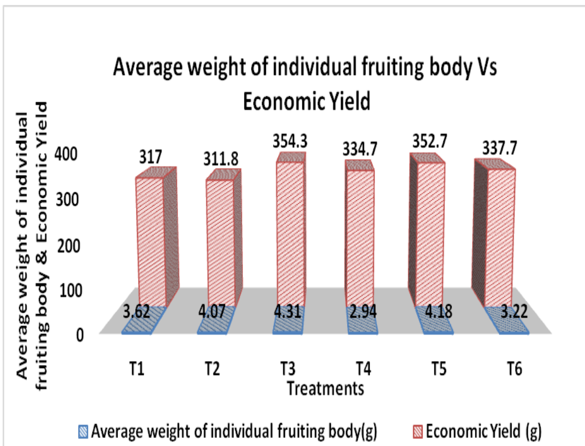

Fig. 4. Effect of different sawdust on relationship between average weight of individual fruiting body with economical yield

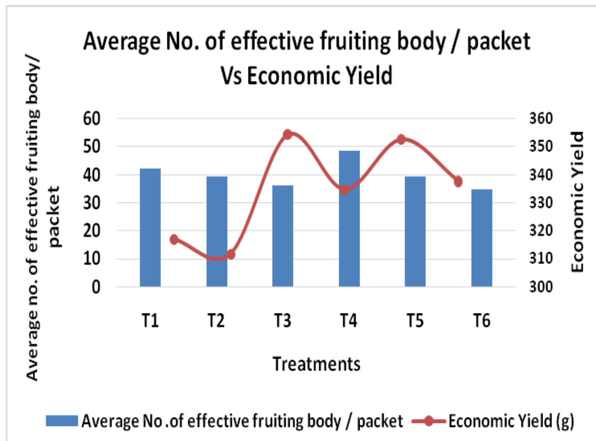

Fig. 3. Effect of different sawdust on relationship between average numbers of effecting fruiting body with economical yield

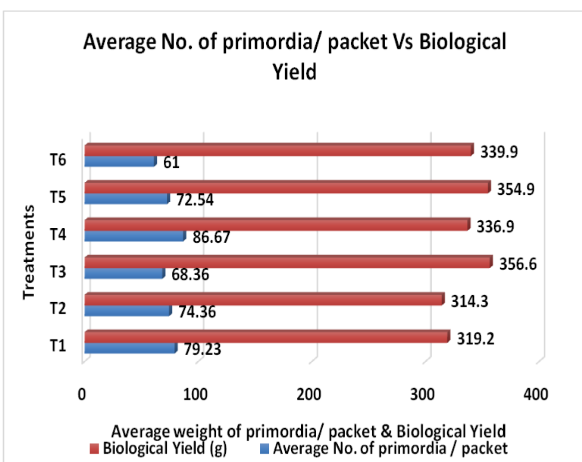

Fig. 5. Effect of different sawdust on relationship between average number of primordia with biological yield

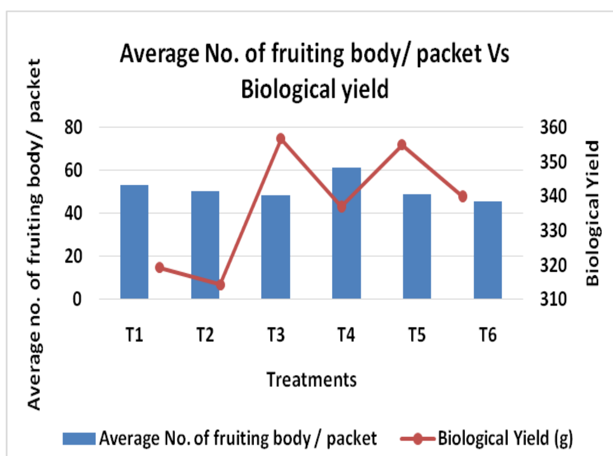

Fig. 6. Effect of different sawdust on relationship between average numbers of fruiting body with biological yield

CONCLUSION

Effect of different sawdust substrates on the growth and yield of *Plerotus florida* was observed. It may offer economic incentives for agribusiness to examine these residues as valuable resources and develop new enterprises to use them to produce nutritious mushroom products. Therefore, the mushroom cultivation may become one of the most profitable agribusiness that could produce food products from different substrates and help to dispose them in an environment friendly manner. The highest average number of effective fruiting body was obtained from T_4 sawdust substrate. Amongst all the treatment, T_3 was found as a best substrate in terms of the highest average weight of individual fruiting body, biological yield, economic yield and dry yield, biological efficiency.

ACKNOWLEDGEMENT
National Mushroom Development and Extension Center laboratory Savar, Dhaka, Bangladesh is gratefully acknowledged for their kind cooperation regarding the supply the fruiting body of Oyster mushroom and recorded the atomic absorption data. I would like to gratefully acknowledged Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for financial support my M.Sc. research work.

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