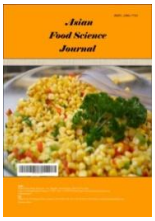

Asian Food Science Journal

19(3): 25-38, 2020; Article no.AFSJ.62668
ISSN: 2581-7752

Impact of Different Substrates and Mother Cultures on Yield and Yield Attributes of Oyster Mushroom (*Pleurotus ostreatus*)

M. Mubasshira[1], F. M. Aminuzzaman[1*], N. Sultana[1] and J. F. Tanni[1]

[1]Department of Plant Pathology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. Author MM performed the experiment. Author JFT prepared the manuscript. Author FMA conceived, designed, supervised the study and corrected and edited the manuscript. Author NS managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI:10.9734/AFSJ/2020/v19i330241
Editor(s):
(1) Dr. Surapong Pinitglang, University of the Thai Chamber of Commerce, Thailand.
Reviewers:
(1) M. K. Khokhar, ICAR - National Centre for Integrated Pest Management, India.
(2) Parveez Ahmad Sheikh, Sher-e-Kashmir University of Agricultural Science & Technology- Kashmir, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/62668

Original Research Article

Received 29 September 2020
Accepted 04 December 2020
Published 16 December 2020

ABSTRACT

Aim: This study was aimed to compare the performance of different substrates and mother culture materials on yield and yield parameters of oyster mushroom (*Pleurotus ostreatus*).
Study Design: This is an experimental study following Complete Randomized Design (CRD).
Place and Duration of Study: The experiments were conducted in the Laboratory, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka and Mushroom Development Institute, Savar, Dhaka from January 2019 to February 2020.
Methodology: Accordingly, three substrates (sawdust, rice straw, sawdust + rice straw (1:1)) and three mother cultures (rice, maize, sawdust) were used in oyster mushroom cultivation.
Results: Among the substrates and mother culture components, using rice straw and sawdust mother spawn, the maximum length of stipe was recorded (23.27 mm and 24.29 mm, respectively). Applying sawdust + rice straw (1:1) and maize mother spawn, the peak diameter of stipe was calculated (9.90 mm and 10.01 mm, respectively). The maximal diameter of pileus was observed in sawdust + rice straw (1:1) and rice mother spawn (72.90 mm and 67.57mm, respectively). With the

**Corresponding author: Email: aminsaupp@yahoo.com;*

application of rice straw and maize mother spawn, thickest pileus was viewed (5.60 mm and 5.47mm respectively). The sawdust and sawdust mother spawn delivered peak number of fruiting body (6.67 and 7.33, respectively). Among the substrates, rice straw gave the highest biological yield (44.40 g/packet) and sawdust gave the lowest (41.73 g/packet). Among the mother spawn, sawdust mother spawn presented the highest biological yield (45.47 g/packet) and maize mother spawn gave the lowest (39.16 g/packet). In the comparison of combined effect of substrates and mother spawn, sawdust mother spawn performed best in the biological yield (50.80 g/packet) with rice straw as substrate material and maize mother spawn showed comparatively lower biological yield (37.60 g/packet) with both sawdust and rice straw as substrate material.

Conclusion: Rice straw and sawdust mother spawn can be recommended for its suitability in oyster mushroom (*Pleurotus ostreatus*) cultivation.

Keywords: Substrate; mother culture; yield; spawn packet; oyster mushroom.

1. INTRODUCTION

Mushroom is a fruiting body of macro fungi. These are highly rich in characteristic flavor, potent nutritional properties and possess various types of dietary supplements. Its calory amount is less but is a strong package of vitamin, mineral and protein [1]. A macro fungus is a species whose basidiocarp is visible in naked eye. The number of recognized mushroom species has been reported to be 14,000, which is about 10% of the total estimated mushroom species on the earth [2]. Some of those are edible and some are toxic. We can easily manage our agro based remainder using mushroom production technology. It can play an important role in improving the nutritional status of the population. We can consider mushroom as an option for good quality protein [3]. People can take mushroom cultivation as an alternative to cope up with poverty and to upgrade social status [4]. Till now, above 2000 mushroom species under 31 genera were recorded [5]. In tropical and temperate regions, farmers cultivate 12 species for the sake of food and/or medicine. *Pleurotus ostreatus*, commonly known as oyster mushrooms, are edible fungi cultivated worldwide especially in South East Asia, India, Europe and Africa. Mushroom cultivation is treated as an eco-friendly and financially profitable path to alter agro waste into nutritious food. There are three mostly produced mushrooms: *Agaricus bisporus* (button mushroom), *P. ostreatus* (oyster mushroom) and *Lentinula edodes* (shiitake mushroom). Oyster mushroom is the second in the world production ranking of mushroom [6,7] next to *A. bisporus*. Oyster mushrooms need a few period to grow. By converting a high percentage of the substrates to fruiting bodies, it enhances benefit cost ratio (BCR) [8].

Oyster mushrooms consumption has a positive impact in reducing many fetal diseases like diabetes, heart disease, high blood cholesterol level, gastric cancer, hepatitis B, liver illness, kidney problems, hypertension, microbial infection, chronic fatigue syndrome and impaired immune response [9]. These mushrooms have therapeutic ingredients such as dietary fibers,phenolic compounds and various bioactive compounds. Oyster mushrooms are saprophytes and have the ability to use cellulose, hemicelluloses, and lignin materials [10]. Oyster mushroom can degrade lignocelluloses residues and can change into protein-rich biomass [11]. Species of oyster-mushroom have proper adaptability level and can tolerate extreme environmental condition [12,8]. The growth of Oyster mushroom (*P. ostreatus*) mycelia was relatively faster on a combination of sawdust + teff straw wastes as compared to the remaining three combinations [13]. Rambey et al. [14] carried out a research to estimate the effect of the composition of rice straw mixture on white oyster mushroom growing media on the growth and productivity of white oyster mushrooms (*Pleurotus ostreatus*) and get the best composition of planting media for the growth and productivity of white oyster mushrooms (*P. ostreatus*). It can be grown in a medium derived from wood dust or lignin, which has been weathered and wrapped in plastic. Oyster mushroom production can play a vital role in waste product recycling. It can also draw impact on advanced economy, healthy food habit and ecological balance.

This study was conducted to compare the impact of selected substrates, selected mother culture and to analyze the interaction effect of both on yield and yield parameters of oyster mushroom (*Pleurotus ostreatus*).

2. MATERIALS AND METHODS

2.1 Experimental Site and Experimental Period

The laboratory experiments were conducted in the Department of Plant Pathology laboratory, Sher-e-Bangla Agricultural University, Dhaka and Mushroom Development Institute, Savar, Dhaka from January 2019 to February 2020.

2.2 Experimental Materials

The fruiting body of oyster mushroom, sawdust and rice straw used in preparing spawn were collected from Mushroom Development Institute, Savar, Dhaka. Rice grain, maize grain and sawdust were used to prepare mother spawn.

2.3 Design Layout and Treatments of the Experiment

The experiment was laid out in a Factorial Completely Randomized Design (CRD). In this experiment, three mother spawn were prepared. Three substrates as treatments with five replications were considered under each mother spawn. The three mother spawn were produced by using rice grain, maize grain, and sawdust. The treatments were-

Factor A: Three mother spawn culture

M1: Rice mother spawn

M2: Maize mother spawn

M3: Sawdust mother spawn

Factor B: Three substrates

T1: Sawdust

T2: Rice straw

T3: Sawdust + Rice straw (1:1)

2.4 Varietal Characteristics of Oyster Mushroom

The oyster mushroom (*Pleurotus ostreatus*) was well known for its faster rooting hyphae, more decaying capacity on cellulosic substrates. It has many colorful strains like white, cream, pink, grey, yellow, light brown, etc. Its basidiocarps are shell or spatula-shaped. In this experiment, the strain PO2 was used, which is white color.

2.5 Production of Tissue Mother

To produce tissue mother, two steps were followed. For the culture of tissue of oyster mushroom, sterilized PDA (Potato dextrose agar) media was used. The mother culture of oyster mushroom (*Pleurotus ostreatus*) was produced from this tissue mother.

2.5.1 Preparation of PDA (Potato Dextrose Agar) media

To prepare 1L PDA media, 250 g washed, peeled, and sliced potatoes were weighted using electrical balance. The potatoes were boiled in water and extract was collected passing through cheesecloth. Twenty gram (20 g) dextrose and 20 g agar was added and additional distilled water was added to make volume up to 1L. The media was then sterilized in an autoclave for 15 minutes at 121°C under 15 PSI.

2.5.2 Tissue culture

A small portion of tissue from the basidiocarp was inoculated on PDA medium under controlled environment in a laminar air flow cabinet and the inoculated dishes were incubated for 10 days at 25°C for sufficient mycelia growth. These are mentioned as pure cultures of "*Pleurotus ostreatus"* and had been used in the entire experiment.

2.6 Production of Mother Culture

To produce the mother culture of oyster mushroom, different grains or substrates were used. First of all, the grains or substrates were sterilized and then the inoculation of mother tissue was done. The mother cultures were ready to use after running full mycelium and it turned into white color.

2.6.1 Preparation and sterilization of the substrates

Rice grain, maize grain, and sawdust were used as substrate with a view to producing mother culture of *P. ostreatus*. Two kg of each grain and 1.5 kg of sawdust was taken separately. The grains were thoroughly cleaned, washed, and soaked it in water for 4 to 6 hrs. 0.5 g Carbendazim was thoroughly mixed in the substrates. The grains were cooked until they become soft. The cooked grains were decanted on the sieve to remove excess water and evenly spread on muslin cloth for cooling. The cooled,

cooked grains were mixed with calcium carbonate (10 g/kg) to avoid clumping of grains and the pH level was fixed. The prepared substrates were weighted @ 250 g in each poly bags and plugged those with non-absorbent cotton and sterilized it in an autoclave for 1.5 hrs.

2.6.2 Inoculation of mother tissue and running of mycelia

Twelve (12) packets of each substrate i.e. a total of 36 packets were prepared. A 5.0 mm diameter mycelial disc of *P. ostreatus* was inoculated in each bag, covered by cotton plug and incubated at 25°C for mycelial growth until the substrate was fully covered by whitish mycelia. As soon as the mycelium spreading was finished, the mother cultures were ready to use in spawn packets preparation.

2.7 Production of Spawn Packets

Fifteen (15) spawn packets of rice mother, 15 of maize mother, and 15 of sawdust mothers were prepared. Each packet was 500 g in weight which contained 400 g substrate and 100 g mother culture. Mother culture was thoroughly mixed with the substrates for equal distribution of mother culture inocula in the substrates.

2.7.1 Preparation and sterilization of the substrates

Sawdust and rice straw was pasteurized in the pasteurization chamber for an hour. Then rice straw was chopped into small pieces. Adequate water and sawdust were added to make it moist and sticky. Then a total of 45 spawn packets were prepared. Each packet contains 500 g substrates for mushroom cultivation.

2.7.2 Grafting of young mother culture in the spawn packet and running of mycelia

The produced mother cultures were mixed with the substrate to prepare spawn packets. Each substrate's weight was 400g in which 100g stock cultures were added for the purpose of making 500 g spawn packet. The mouth of each packet was wrapped with the plastic neck, rubber and cotton. A total of 45 spawn packets comprising fifteen spawn packets for each mother were prepared. After that, the prepared spawn packets were put in the culture room for mycelium growth. Observations were recorded with three treatments and five replications.

Observation on days for mycelium initiation on substrate, days for complete colonization of mycelium on substrate were carried out. After completion of full mycelium running, the spawn packets become white color.

2.7.3 Cultivation of the spawn packets

The two ends, opposite each other of the plastic bag's upper position were cut in "D" shape using a blade and infiltrated by removing the plastic sheet. After that, the opened surface of the substrate was scraped a little bit with a teaspoon for the purpose of removal of thin whitish mycelia layer. Then the spawn packet was soaked in water for 15 minutes and dispelled extra water for 15 minutes. Afterwards, each type's packets were arranged by keeping apart on the floor of the culture room and covered with newspaper. There was a controlled environment in culture room where the moisture was 80-85% maintained by spraying water three times a day, the light was around 300-500 lux, the temperature was 22-25°C and the culture room was well ventilated. The first primordial was visible 3-5 days after removing the plastic sheet. The time range and harvesting time were varied due to the variation in type of substrate. The whole cultivation procedure of oyster mushroom was presented in Flow Chart (Fig. 1).

2.7.5 Harvesting and data recording on yield parameters of the oyster mushroom (*Pleurotus ostreatus*)

As soon as the primordial initiated, oyster mushrooms were also developed within 2-3 days. The cap's cural margin defined the matured fruiting body, as supported by [15]. The fruiting body was collected by twisting to uproot from the bottom for three times per packet. The packets were scrapped again after the first harvest at the place where the "D" shaped cut had been done and then placed in the culture house (Fig. 2). Water was sprayed regularly to keep the packets moist. The primordial developed 9-10 days after the first harvest and 7-8 days after the second harvest. Water was sprayed until the mushrooms were ready to be harvested. Then the harvested mushroom samples were subjected to growth and yield analysis. Data on the yield parameters viz. length of the stalk, diameter of the stalk, diameter of the pileus, thickness of pileus and number of fruiting body were recorded [16,17]. Biological yield per 500 g packet was measured by weighing the

whole fruiting body cluster without removing the lower hard and dirty portion.

2.8 Statistical analysis of data

All the data collected on different parameters were statistically analyzed by following the analysis of variance (ANOVA) technique, and mean differences were adjusted by Least Significant Difference Test (LSD) [18] using the MSTAT-C computer package program. The mean differences among the treatments were compared by the least significant difference (LSD) at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Comparison of Substrate Materials on Yield and Yield Attributes of Oyster Mushroom (*Pleurotus ostreatus*)

The highest average length of stipe was observed in rice straw (23.27 mm) and the lowest average length of stipe was observed in the mixture of sawdust + rice straw (22.33 mm). There was no statistical significant difference among the treatments in terms of average length of stipe (Table 1). The highest average diameter of stipe was observed in the mixture of sawdust + rice straw (1:1) (9.90 mm) and the lowest average diameter of stipe was recorded in sawdust (7.13 mm). The treatments differed significantly in terms of average diameter of stipe (Table 1). It was found that though maximum diameter of stipe was recorded in the mixture of sawdust + rice straw but the same treatment performed in lower stipe length yield.

The highest average diameter of pileus was observed in the combined treatment of sawdust+rice straw (1:1) (72.90 mm) and the lowest average diameter of pileus was in sawdust (56.27 mm). The treatments differed significantly in terms of average diameter of pileus (Table 1). The highest average thickness of pileus was observed in rice straw (5.60 mm) and the lowest average thickness of pileus was in sawdust (5.20 mm). There was no statistical significant difference among the treatments in terms of average thickness of pileus (Table 1).The highest average number of fruiting body was observed in sawdust (6.67) and the lowest average number of fruiting body was observed in rice straw (6.33). There was no statistical significant difference among the treatments in terms of number of fruiting body (Table 1). It was clearly visible that, the mixture of sawdust+rice straw (1:1) yielded the best diameter of pileus. At the same time, rice straw paid the highest thickness of pileus but the highest average number of fruiting body was counted in sawdust treatment.

3.2 Effect of Substrate Materials on Biological Yield (g/packet)

The following graph (Fig. 3) shows that, the highest average biological yield was observed in rice straw (44.40 g/packet) and the lowest average biological yield was observed in sawdust (41.73 g/packet).

3.3 Effect of Mother Spawn Materials on Yield and Yield Parameters of Oyster Mushroom (*Pleurotus ostreatus*)

The highest average length of stipe was observed in sawdust mother spawn (24.29 mm) and the lowest average length of stipe was found in maize mother spawn (20.00 mm). The treatments differed significantly in terms of average length of stipe (Table 2). The highest average diameter of stipe was observed in maize mother spawn (10.01 mm) and the lowest average diameter of stipe was measured from sawdust mother spawn (7.72 mm). There was no statistical significant difference among the treatments in terms of average diameter of stipe (Table 2). The highest average diameter of pileus was observed in rice mother spawn (67.57mm) and the lowest average diameter of pileus was in sawdust mother spawn (62.56 mm). There was no statistical significant difference among the treatments in terms of average diameter of pileus (Table 2).

The highest average thickness of pileus was observed in both rice mother and maize mother spawn (5.47mm) and the lowest average thickness of pileus was in sawdust mother spawn (5.20 mm). There was no statistical significant difference among the treatments in terms of average diameter of pileus (Table 2). The highest average number of fruiting body was observed in sawdust mother spawn (7.33) and the lowest average number of fruiting body was observed in maize mother spawn (5.67). There was no statistical significant difference among the treatments in terms of average number of fruiting body (Table 2). From the above result, it was implied that, sawdust mother spawn gave the highest average length of stipe and the greatest number of fruiting body. But maize

mother spawn yielded the maximum average diameter of stipe. At the same time, rice mother spawn delivered the most average diameter of pileus. Both rice mother and maize mother spawn paid the highest average thickness of pileus.

3.4 Effect of Mother Spawn Materials on Biological Yield (g/packet)

The highest average biological yield was observed in sawdust mother spawn (45.47 g/packet) and the lowest average biological yield (39.16 g/packet) was observed in maize mother spawn (Fig. 4).

3.5 Combined Effect of Substrate and Mother Spawn Materials on Yield and Yield Parameters of Oyster Mushroom (*Pleurotus ostreatus*)

The results on combined effect of substrate and mother spawn packet materials on yield and yield parameters of oyster mushroom are shown in Table 3.The highest average length of stipe was observed in T_1M_3 (26.80 mm) which was sawdust mother spawn packet and the substrate material was sawdust and the lowest average length of stipe was in T_1M_2 (17.40 mm) where maize was mother spawn packet and the substrate material was sawdust. The other treatments differed

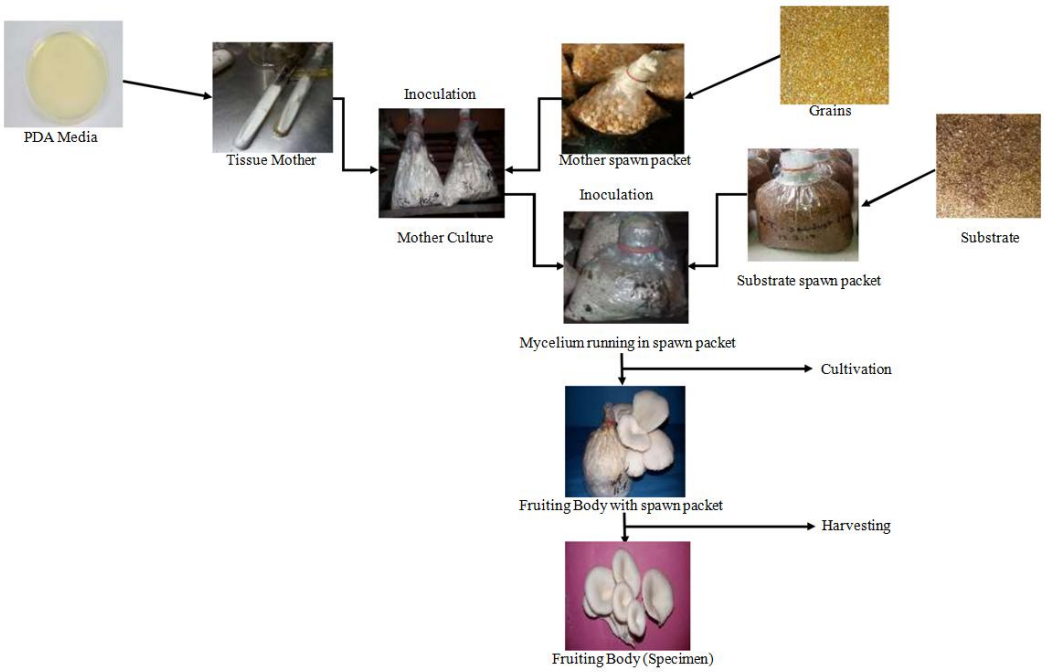

Fig. 1. Flow chart of oyster mushroom cultivation

Table 1. Effect of substrate materials on length and diameter of stipe, diameter and thickness of pileus and number of fruiting body of oyster mushroom (*Pleurotusostreatus*)

Treatments	Length of stipe (mm)	Diameter of stipe (mm)	Diameter of pileus (mm)	Thickness of pileus (mm)	Number of fruiting body/packet
Sawdust	22.40	7.13 b	56.27 b	5.20	6.67
Rice straw	23.27	9.33 a	67.13 a	5.60	6.33
Sawdust + Rice	22.33	9.90 a	72.90 a	5.33	6.60
Straw (1:1)					
*LSD	--	2.107	7.399	--	--
Level of Significance	NS	0.05	0.01	NS	NS
**CV(%)	16.18	32.38	15.27	17.75	30.27

**LSD = Least Significant Difference; **CV = Coefficient of Variation*

A

B

Fig. 2. Photograph of experiment set up for oyster mushroom production in mushroom culture room; A) Rice and wheat straw substrates ready for inoculation B) Oyster mushroom ready for harvest

Table 2.Effect of mother spawn materials on length and diameter of stalk, diameter and thickness of pileus and number of fruiting body of oyster mushroom (*Pleurotusostreatus*)

Treatments	Length of stipe (mm)	Diameter of stipe (mm)	Diameter of pileus (mm)	Thickness of pileus (mm)	Number of fruiting body/packet
Rice mother spawn	23.71 a	8.64	67.57	5.47	6.60
Maize mother spawn	20.00 b	10.01	66.17	5.47	5.67
Sawdust mother spawn	24.29 a	7.72	62.56	5.20	7.33
LSD(0.01)	2.716	NS	NS	NS	NS
CV(%)	16.18	32.38	15.27	17.75	30.27

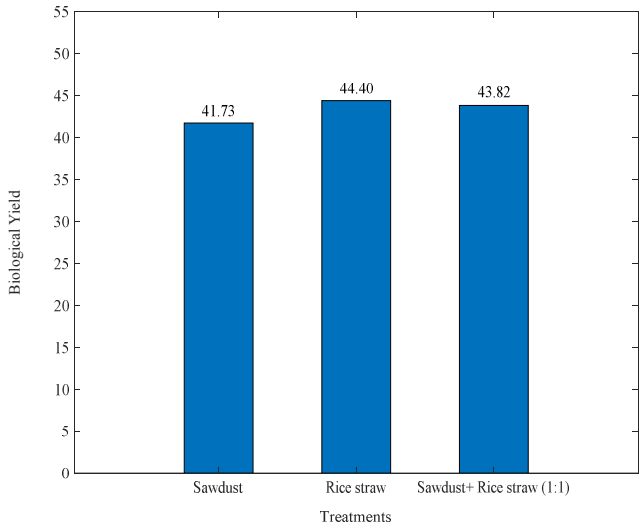

Fig. 3.Effect of substrate materials on biological yield (g/packet) of oyster mushroom (*Pleurotus ostreatus*)

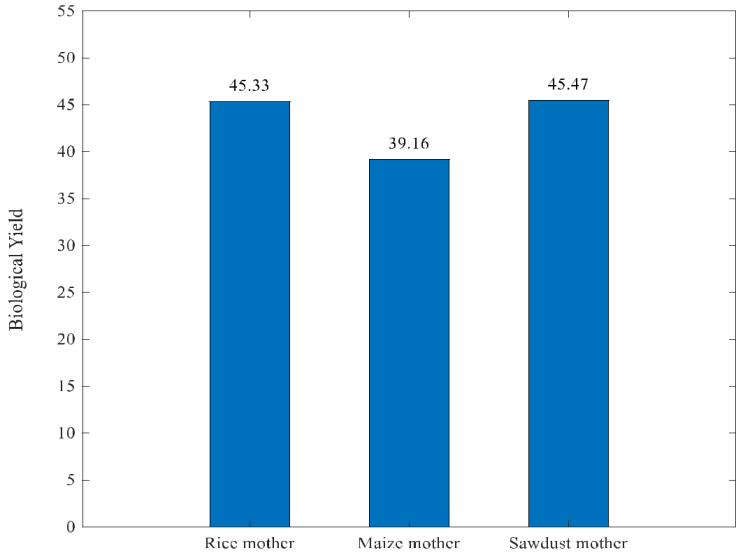

Fig. 4.Effect of mother spawn materials on biological yield (g/packet) of oyster mushroom (*Pleurotus ostreatus*)

significantly in terms of average length of stipe. The highest average diameter of stipe was observed in $\mathbf{T_3M_2}$ (11.62mm) which was maize mother spawn packet and the substrate material was sawdust + rice straw (1:1) and the lowest average diameter of stipe was in $\mathbf{T_1M_3}$ (6.40 mm) which was sawdust mother spawn packet and the substrate material was sawdust. There was no statistical significant difference among the treatments in terms of average diameter of stipe.The highest average diameter of pileus was observed in $\mathbf{T_3M_2}$ (74.90 mm) which was maize mother spawn packet and the substrate material was sawdust + rice straw (1:1) and the lowest average diameter of pileus was in $\mathbf{T_1M_3}$ (54.00 mm) which was sawdust mother spawn packet and the substrate material was sawdust. There was no statistical significant difference among the treatments in terms of average diameter of pileus. The highest average thickness of pileus was observed in both $\mathbf{T_3M_1}$ and $\mathbf{T_2M_2}$ (5.80 mm). The $\mathbf{T_3M_1}$ was rice mother spawn packet and the substrate material was sawdust + rice straw (1:1) and $\mathbf{T_2M_2}$ was maize mother spawn packet and

the substrate material was rice straw. The lowest average thickness of pileus was observed in **T_1M_1** (5.00 mm) which was rice mother spawn packet and the substrate material was sawdust. There was no statistical significant difference among the treatments in terms of average thickness of pileus. The highest average number of fruiting body was observed in **T_2M_3** (8.00) which was sawdust mother spawn packet and the substrate material was rice straw and the lowest average number of fruiting body was observed in **T_2M_2** (6.33) which was maize mother spawn packet and the substrate material was rice straw. There was no statistical significant difference among the treatments in terms of number of fruiting body.

3.6 Combined Effect of Substrates and Mother Spawn Materials on Biological Yield (g/packet)

In the following graph (Fig. 5) it is showed that, sawdust mother spawn gave the highest biological yield (50.80 g/packet) where rice straw was substrate and the lowest average biological yield was observed in maize mother spawn (37.60 g/packet) in which the substrate material was both sawdust and rice straw.

A number of studies were conducted on purpose of searching the way of using waste by product of agriculture via the mushroom. Hence, this study was conducted to select the best substrate materials for oyster mushroom cultivation. Oyster mushroom can be grown on various substrates including rice straw, maize stalks/cobs, vegetable plant residues, bagasses etc. This has been reported to influence its growth, yield, and composition [19]. Quimio [20] stated that cellulose rich organic substances are good substrates for mushroom cultivation. Substrates having high lignin and phenolic content minimize cellulose activity. On the contrary, substrates having less lignin increase enzyme dynamism and thus assure higher production of mushrooms [21].

In this experiment, sawdust, rice straw, and sawdust + rice straw (1:1) were used as substrate materials. The spawn packets were prepared by using three different mothers – Rice mother, Maize mother, and Sawdust mother. During this experiment, the effects of both substrate materials and mother spawn packets materials were observed on mushroom yields and yield contributing characters. The average length of stipe was observed highest in rice straw (23.27 mm) and lowest was in sawdust + rice straw (22.33 mm). The average diameter of stipe was observed in sawdust + rice straw (9.90 mm) and lowest in sawdust 7.13 mm). Sarker et al. [15] observed that, the mixture of sawdust + rice straw gave the highest average diameter of

Table 3. Combined effect of substrates and mother spawn materials on length and diameter of stipe, diameter of pileus, thickness of pileus and number of fruiting body of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Length of stipe (mm)	Diameter of stipe (mm)	Diameter of pileus (mm)	Thickness of pileus (mm)	Number of fruiting body/packet
T_1M_1	23.00ab	7.40	57.00	5.00	7.00
T_1M_2	17.40 c	7.60	57.80	5.40	6.00
T_1M_3	26.80 a	6.40	54.00	5.20	7.00
T_2M_1	24.20ab	8.40	71.40	5.60	6.00
T_2M_2	19.80bc	10.80	65.80	5.80	5.00
T_2M_3	25.80 a	8.80	64.20	5.40	8.00
T_3M_1	23.94ab	10.12	74.32	5.80	6.80
T_3M_2	22.80ab	11.62	74.90	5.20	6.00
T_3M_3	20.26bc	7.96	69.48	5.00	7.00
*LSD (P=0.01)	4.704	NS	NS	NS	NS
**CV(%)	16.18	32.38	15.27	17.75	30.27

T_1 = Sawdust, M_1 = Rice mother spawn, T_2 = Rice straw, M_2 = Maize mother spawn,
T_3= Sawdust + Rice straw (1:1), M_3 = Sawdust mother spawn
**LSD = Least Significant Difference*
***CV = Coefficient of Variation*

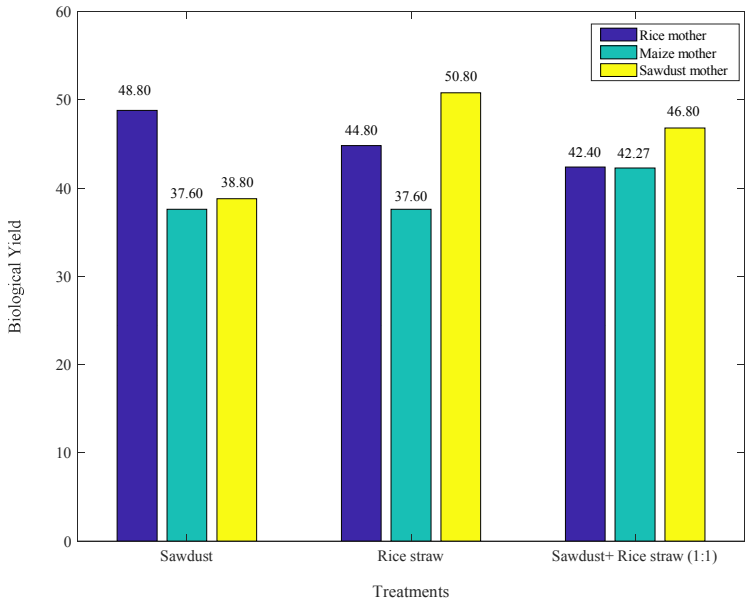

Fig. 5. Combined effect of substrates and mother spawn materials on biological yield (g/packet) of oyster mushroom (*Pleaurotus ostreatus*)

pileus (72.90 mm) and sawdust gave the lowest average diameter of pileus (56.27 mm). Deyet al. [22] carried out a study where he found that sugarcane bagasse gave the highest number of primordia and fruiting bodies and the amount of fresh weight with in all flushes whereas the lowest with mustard straw. Sonali [23] conducted a study where she observed that paddy straw and wheat straw delivered more production. Iqbal et al. [13] reported that, wheat straw and chickpea straw gave the highest flushes. Chick pea straw gave the maximum yield on a fresh basis followed by wheat straw. Rice straw paid the highest average thickness of pileus (5.60 mm) and sawdust gave the lowest average thickness of pileus(5.20 mm). Sarker et al. [24] found that, sawdust gave the highest average number of fruiting body (6.67) and rice straw delivered the lowest average number of fruiting body (6.33). The large sized fruit body is an indication of good quality and rated highly in mushroom production [25]. Maniruzzaman [26] conducted a study where wheat, maize, rice straw, and sawdust were used to produce oyster mushroom spawn and rice straw gave the best result for spawn production of oyster mushroom.

In case of biological yield, the current experiment monitored the performance of both substrate materials and mother spawn materials. Rice straw gave the highest average biological yield (44.40 g/packet) and sawdust gave the lowest average biological yield (41.73 g/packet). Tsegaye and Tefera [27] reported that the shortest time (14 days) was need for spawn production on sugarcane bagasse where other grains like sorghum and millet need 16 to 17 days. The findings of the present studies corroborate with the findings of Ranaet al. [28]. Bisaria et al. [29] reported that, the *Pleurotus ostreatus* yield with rice straw was 11.7% higher than wheat straw. Baysal et al. [8] observed in his study that the highest yield of oyster mushroom (*Pleurotus ostreatus*) was received with the substrate composed of 20% rice husk in weight. Khanna and Garcha [30] recorded cumulative yield of 32% in 104 days from rice straw. Dubey et al. [31] conducted an experiment where he grew *Pleurotus ostreatus* on paddy straw, wheat straw, sugarcane bagasse and banana leaves. Among all the treatments, rice straw was found most favorable for mushroom cultivation in terms of yield (1515 g) than other substrates. In this study it has been revealed that the rice straw mixture resulted in mycelium growth and the harvest age began to be longer. The composition of the best growing media for growth and productivity of white oyster mushrooms is a mixture of 30% rice straw (300-gram rice straw + sawdust 550 grams). Dubey et al. [31] revealed that rice straw delivered the highest yield (15.15 g) with the highest stipe length (4.86 cm) and cap diameter (5.14 cm) followed by other substrates. Sarker et al. [15] reported that waste paper delivered the highest

number of the fruiting body per packet (183.25) and water hyacinth gave the lowest number of the fruiting body (19.25). In their study, they used different cheap agricultural households' by-products, grasses, and weeds as substrate available in Bangladesh to monitor its performance on Oyster mushroom cultivation. Soniya et al. [32] conducted an experiment where they used rice straw, rice straw+ paper, rice straw + wheat straw, sawdust and sugarcane bagasse. The rice straw was found as the best substrates among all aspects with yield (381.85 gm) and BE (95.46%) to produce mushrooms, followed by paper waste and rice plus wheat straw. In another study Namdev et al. [33] found the highest yield from paddy straw (666 g/500 g) followed by wheat straw and mustard straw (427 and 400 g/500 g, respectively). Girmay et al. [34] carried out an experiment where they used four substrates viz. cotton seed, paper waste, wheat straw, and sawdust and they found that among the substrates, cotton seed gave the highest percentage of biological and economic yield of oyster mushrooms while the least was achieved from sawdust. Ashraf et al. [35] carried out a study where they found that among all the different agricultural wastes, cotton waste was most favourable on yield and growth of oyster mushroom. The findings of the present studies are in accordance with the findings of Deepika and Varenyam [36]. They used five different substrates viz. paddy straw, wheat straw, a mixture of wheat straw and paddy straw (in the ratio of 1:1), lawn grasses and bamboo leaves. Wheat straw and a mixture of paddy and wheat straw gave the earliest colonization of fungus. Wheat straw delivered the highest yield of *Pleurotus ostreatus* (29.27 g fresh weight/kg substrate) followed by the combination of wheat straw and paddy straw (27.96 g fresh weight/kg substrate). Fekadu Alemu [37] carried out another study where he found that, the best quality of media (substrate) was teff straw to produce oyster mushrooms. Like the running study another observation of Fatema et al. [38] with wheat straw, water hyacinth and their combinations proved that wheat straw only (3.1 kg) gave the best reply for formation of pinhead emergence and mushroom productivity. The mixture of several substrates in mushroom production was also reported from many authors [39,40].

Iqbal et al. [19] carried out a study which manifested that wheat straw and banana leaves, followed by cotton waste delivered the highest number of flushes. In case of formation of pin-heads and maturation of fruiting bodies, they came faster on sugarcane bagasse followed by cotton waste. Banana leaves followed by paddy and wheat straw gave the peak yield percentage on fresh and dry weight. Like the current study Kulsum et al. [41] also found the yield of 21.27 g due to sawdust substrate with the biological yield of 41.73 g/packet. The result of present study were supported by Khan et al. [42] where they found perfect spawn running in sawdust amended with different organic supplement like rice straw, wheat chaff, wheat bran, cotton waste etc. Sawdust + teff straw provided the highest mycelium colonization, primordial initiation, fruiting bodies formation, and fresh weight with a yield of 730 g/kg [13]. Adjapong et al. [43] revealed that on maize husk per crop, about 32.99 g of fruiting bodies of mushroom were obtained. Tsegaye and Tefera [27] conducted an exploration where they found that combination of cotton waste + coffee pulp delivered the maximum fresh yield of mushroom (790 g/kg).

In the running study, sawdust mother spawn packets paid the peak average length of stipe (24.29 mm)and maize mother spawn packets gave the minimum average length of stipe (20.00 mm).Maize mother spawn packets delivered the maximum average diameter of stipe (10.01 mm)and sawdust mother spawn packets offered the least average diameter of stipe (7.72 mm). Rice mother spawn packets (67.57 mm) gave the maximum average diameter of pileus and sawdust mother spawn packets paid the minimum average diameter of pileus (62.56 mm). Both rice mother and maize mother spawn packets gave the maximum average thickness of pileus (5.47 mm) and sawdust mother spawn packets paid the minimum average thickness of pileus (5.20 mm).The mixture of sawdust mother spawn packets delivered the toppest average number of fruiting body (7.33) and maize mother spawn packets gave the minimum average number of fruiting body (5.67). The large sized fruit bodies are treated as cherished attribute and rated highly in mushroom production [25]. Sawdust mother spawn supplied the maximum biological yield (45.47 g/packet) and maize mother spawn delivered the minimum (39.16 g/pack). Sawdust + teff straw and cotton seed + teff straw offered the maximum fresh weight 291.02 g and 279.90 g, respectively [13].

This research has been accomplished to analyze the combined effect of substrate materials and mother spawn materials on biological yield of

oyster mushroom. Sawdust mother spawn offered the maximum average biological yield (50.80 g/packet) where rice straw was the substrate material and maize mother spawn gave the minimum average biological yield (37.60 g/packet) where both sawdust and rice straw was treated as the substrate material. In another study, the highest mean value of growth and yield parameters were procured from the combination of sawdust and teff straw. While the lowest mean value of growth and yield parameters were observed from the combination of teff straw and onset waste [13]. The findings of our research were supported by Elattar et al. [44]. They reported that rice straw + wheat straw and single rice straw offered the maximum mushroom yield (7600 g and 6650 g, respectively). The mushrooms grown on a mixture of rice straw and wheat straw had the highest yield. It was revealed as a rich source of protein, minerals, and fibers. It could be established that oyster mushroom developed on a blend of rice straw and wheat straw is nutritious and rich in pharmaceutical-type products. Ibrahim et al. [45] conducted a research where they found that combination of sawdust and OPF with rice bran and calcium carbonate in 100:10:1 ratio was used as substrates to produce oyster mushroom. Their study revealed that sawdust offered better yield of oyster mushrooms. The present study was supported by Sarkeret al., [46] where growth and productivity improvement of milky mushroom (*Calocybeindica*) were reported by application of vermicompost-enriched rice or wheat substrates.

4. CONCLUSION

There are many substrate materials which are used in oyster mushroom cultivation. The purpose of this study was to find out the best substrates among the used three substrates. After conducting the study, the study disclosed that rice straw offered the best yield of Oyster mushroom as a substrate and sawdust gave the maximum yield as a mother spawn. As rice straw and sawdust are very common, low costly and most available, so farmers can easily cultivate Oyster mushroom using this cheaper materials and can update their social and economic standard.

DISCLAIMER

Authors have ensured that there is neither any personal interest present nor any advertisement exists in using the product and raw product used in this research activity. The products used in this experiment are only for research purpose.

ACKNOWLEDGEMENT

The Authors thank anonymous reviewers for their kind reviewing of this manuscript. This research work was supported by Sher-e-Bangla Agricultural University Research System (SAURES), No. SAU/SAURES/2017/1300, Dhaka, Bangladesh.

COMPETING INTERESTS

Authors have declared that, there is no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/62668