EFFECT OF SUBSTRATES ON OYSTER MUSHROOM PRODUCTION

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF SUBSTRATES ON OYSTER MUSHROOM PRODUCTION"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **HORTICULTURE**, embodies the result of a piece of bonafide research work carried out by **ISMOTARA ASHA**, Registration No. **18-09280** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

DECEMBER, 2020
Dhaka, Bangladesh

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Dedicated to
My
Beloved Parents

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The Author

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ABSTRACT

The experiment was conducted at the Mushroom Development Institute (MDI), Savar, Dhaka, during the period from October 2019 to February 2020 to find out the effect of substrates on oyster mushroom production. The experiment consisted of two substrates *viz*. S_1 (Straw substrate) and S_2 (Sawdust substrate) and seven varieties, *viz*. V_1 (PO2), V_2 (POP), V_3 (WS), V_4 (PO10), V_5 (Oyster big), V_6 (PSC) and V_7 (HK-51). The experiment was laid out in Completely Randomized Design (CRD) with three replications. In case of substrate performance, the highest number of fruiting body packet^{-1} (4.91), effective fruiting body packet^{-1} (2.89), total biological yield (146.63 g), economic yield (142.40) and biological efficiency (73.31) were observed from S_1 (Straw substrate) compared to S_2 (Sawdust substrate). Similarly, in case of variety, V_1 (PO2) gave the highest number of fruiting body packet^{-1} (9.00), effective fruiting body packet^{-1} (4.30), total biological yield (212.00 g), economic yield (206.60) and biological efficiency (106.00) compared to other varieties. Regarding combined effect of substrate and variety, S_1V_1 gave the highest total number of fruiting body packet^{-1} (10.00), number of effective fruiting body packet^{-1} (5.20), total biological yield (215.60 g), economic yield (209.80) and biological efficiency (107.80) compared to other treatment combinations. So, this treatment combination (S_1V_1) can be considered as best compared to other treatment combinations and can be considered for commercial cultivation.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Oyster mushroom (*Pleurotus spp*.) is an edible mushroom that belongs to the family Pleurotaceae (Randive, 2012). The term mushroom applies mostly to those fungi that have stem (stipe), cap (pileus), hymenium (lamellae) and spores on the underside of the cap (Masarirambi *et al*., 2011). Oyster mushroom can be grown at temperature ranging from 20 to 30°C and relative humidity 55%-70%. It can also be cultivated by providing the extra humidity required for its growth in hilly areas above 900 (masl), the best growing season is during March/April to September/October and in the lower regions from September/October to March/April.

The importance of mushroom in the agrarian economy of the world needs no emphasis because of its nutritional and medicinal value. Mushrooms contain about 85-95% water, 3% protein, 4% carbohydrates, 0.1% fats, 1% minerals and vitamins (Tewari 1986). It contains 19-35% protein on dry weight basis as compared to 7.3% in rice. 13.2% in wheat and 25.2% in milk (Chang and Miles, 1988). It is rich in essential minerals and trace elements (Chandha and Sharma, 1995). However, Oyster mushroom (*Pleurotus oystreatus*) is an edible mushroom having excellent fragrant and taste. *Pleurotus spp.* are rich source of proteins, carbohydrates, minerals & vitamins. Mushroom contains digestible proteins (10%-40%), carbohydrates (3%-21%), dietary fiber (3%-35%), on dry weight basis which is higher than those of vegetables and fruits and is of superior quality (Mallavadhani *et al*., 2006).

High potassium to sodium ratio contain in Pleurotus species helps to cure patients suffering from hypertension & heart diseases. Mushroom as an excellent food source to alleviate malnutrition in developing countries due to their flavor, texture, nutritional value and high productivity per unit area (Eswaran and Ramabadran, 2000). Today mushrooms are being considered as alternative food source to provide adequate nutrition to world's increasing population. Mushroom are useful against diabetes, ulcer and lungs diseases (Quimio, 1976). Mushroom are the good source of protein, vitamins and minerals (Khan *et al*, 1981). Therefore the significant impact of mushroom cultivation and mushroom derivatives and product on human welfare in the 21st century can be considered as a 'nongreen' revolution (Singh and Mishra, 2006). Wide spread malnutrition with ever increasing protein gap in our country has necessitated the search for alternative source of protein because the production of pulses has not kept pace with our requirement due to high population growth. Animal protein is beyond the reach of the most people in this country because most of the people live beyond poverty level (World Bank 1992). Edible mushrooms are recommended by the FAO as food, contributing to the protein nutrition of developing countries dependent largely on cereals. Cultivation of Mushroom is eco-friendly and profitable agribusiness but labour-intensive. (Chanda and Sharma, 1995). Mushroom cultivation represents the only current economically viable biotechnology process for the conversion of waste plant residues from forests and agriculture (Wood and Smith, 1987).

For successful mushroom cultivation, three factors must be considered, namely reliable spawn, good substrate and a conducive environment (Rajapakse *et al*. 2007). Substrates in mushroom cultivation have the same function as soil in plant production (Kwon and Kim 2004). Many species of Pleurotus are commonly grown on a wide range of lignocellulosic materials (Sanchez 2004). Different substrates can be recommended per region due to local availability of agricultural wastes (Cohen *et al*. 2002). The ideal medium for cultivation of edible fungi must be sterile and rich in essential nutrients (Wood and Hartley 1988; Kwon and Kim 2004), such as nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and iron (Fe). Most commonly used substrates include cereal straw, sawdust, cottonseed straw, corncob, sugar cane straw and other plant fibres with high cellulose content (Ragunathan *et al*. 1996; Kwon and Kim 2004, Yang *et.al*., 2013; Rezania *et.al*., 2017). According to Labuschagne *et al*. (2000), wheat straw has been the main substrate used for cultivating

Pleurotus ostreatus. However, Bughio (2001) successfully planted *Pleurotus ostreatus* on a combination of wheat straw, cotton boll straw, paddy straw, sugarcane and sorghum leaves. Additives such as gypsum, limestone and chalk can function as pH buffers in a substrate (Kwon and Kim 2004). Different substrates can, therefore, be recommended for different region depending on local availability of agricultural wastes (Cohen *et al*. 2002). Gunde and Cinerman (1995) reported that Oyster mushroom at maturity has a cap spanning diameter of 5 to 25 cm. The fruiting body of Oyster mushroom differs with respect to stipe length and girth, and pileus width when grown in different farm substrates (Shah *et al*., 2004).

Different species of Oyster can play a significant role on growth and yield. Mushroom cultivation represents the only current economically viable biotechnology process for the conversion of waste plant residues from forests and agriculture (Wood and Smith, 1987). The species of these genera show much diversity in their adaptation varying the agro-climatic condition which makes more cultivated species than other mushrooms (Zadrazil and Dube, 1992). The different species of *pleurotus* grow within a temperature range from 15-25°C and it can be grown on various agricultural waste materials as substrate (Block *et al*. 1958). Recently, it has been revealed that mushroom mycelia can play a significant role in the restoration of damaged environments (myco-restoration) through myco-filtration (using mycelia to filter water), myco-forestry (using mycelia to restore forests), mycoremediation (using mycelia to eliminate toxic waste), and myco-pesticides (using mycelia to control insect pests) (Stamets 2005). These methods represent the potential to create clean ecosystem, where no damage will be left after fungal implementation.

The Mushroom Development Institute (MDI), Savar, grows Oyster mushroom using sawdust. Bhuyan (2008) in his study observed that the proximate composition of Oyster mushroom is greatly changed due to different supplement used in sawdust based substrates. But, sawdust in our country has been becoming scarce due to its use in huge amount in developing poultry industries and its price is also increasing day by day. Therefore, it is necessary to identify the alternative suitable substrate for mushroom production that will be easily available with low cost and more yielding. Rice straw may be used in this aspect. A huge amount of rice straw is produced in Bangladesh annually. If we use a small part of this for Oyster mushroom production, then we can produce notable amount of mushroom. The present study was designed to evaluate the performance of Oyster mushroom (*Pleuratus spp*.) species in the winter of Bangladesh on different substrates with the following objectives:

1. To find out a suitable substrate to produce higher yield of Oyster mushroom
2. To identify best variety for better growth and yield of Oyster mushroom
3. To find out the best treatment combination of substrate and variety for higher yield performance of Oyster mushroom

CHAPTER II

REVIEW OF LITERATURE

A number of literatures relating to the performance of different substrates on mushroom cultivation were available but performances with different varieties were less available. The review of literature given below was based on the present information regarding the performance of Oyster mushroom *(Pleurotus ostreatus)* varieties and the effect of different substrates on the growth and yield of Oyster mushroom. The review includes reports of several investigators regarding mushroom cultivation with different substrates with or without different varieties are presented as follows:

Mushrooms constitute one of the most promising resources for promoting rapid socioeconomic development (Martinez-Ibarra *et al*., 2019). Cultivation of mushroom is a source of national income as well as a means of poverty alleviation. The production of mushroom creates a large number of direct and indirect employment opportunities in cultivation as well as in marketing activities as a labor-intensive management and offering opportunities for processing enterprises (Marshall and Nair, 2009 and Islam *et al*., 2013). Mushroom farming needs low capital, low technical knowledge and even in an indoor setting it is possible to cultivate mushroom in a small scale and one can easily get high return with low investment; Women can cultivate mushroom in their homes like rearing poultry with a little capital (Easin *et al*., 2017, Islam *et al*., 2013 and Sarker, 2019).

Ferdousi *et al.* (2019) compacted information on mushroom cultivation in relation to production, performance, problems and prospects is very important for developing this sector. The aim of the review paper is to compile information on mushroom cultivation in Bangladesh. Mushroom production is increasing due to high demand of domestic market and export potentiality. In Bangladesh 40000 MT mushrooms are produced during 2018-19. Oyster, Reishi, Milky, Button, Straw and Shiitake mushrooms are most preferable species and cultivated by the farmers; but the maximum cultivation is confined to Oyster mushroom (*Pleurotus spp*.) which are grown throughout the year. Mostly young aged educated people and rural women are adopting mushroom farming as commercial basis in Bangladesh. The study revealed that mushroom production is easy work because it requires only a little technical efficiency and a highly profitable agribusiness as evident for its lucrative benefit cost ratio (BCR 1.55-4.25). Although mushrooms production increased, there are some problems confronting by the mushroom growers during cultivation and marketing including lack of cultivation house, unavailability of good spawn, capital shortage, lack of equipment's, lack of available market and promotion in local level, lack of storage facilities etc. which are needed to be addressed for further development of this sector. There is enormous opportunity of expanding mushroom farming throughout the country. Considering the country's limited land, over and unemployed population, strengthening the production of mushroom could be one of the sustainable options for the development of rural economy. Development of this sector would also improve the diversified business and employment opportunities both in the rural and semi-urban areas.

Ferdousi *et al*. (2019) reported on emergence and number of primordia, number and weight of fully developed fruiting bodies, total yield, and biological efficiency of some Oyster mushrooms. They found that all the strains of *Pleurotus* mushroom produced first primordia after 7-10 days of scraping. The fastest primordia induction (IT) was recorded in the strains PHK and PO2, whereas the strains PG1 and PG3 showed the slowest primordia emergence. The highest number of primordia per bag (500 g) was produced in PHK and the lowest number was found in PO2 strain. The strain PHK produced the highest number of mature fruiting bodies, while the lowest was found in the strain PG3. The heaviest single fruiting body was found in PG1 strain followed by the strain PG3. Among the tested strains, both the highest biological and economic yields were reflected in PG1 strain and the lowest were recorded in PO3. The highest (95.8%) biological efficiency (BE) was recorded in PG1, whereas the lowest (56.4%) in PO3 strain.

Akter *et al*. (2019) carried out a research to study the effect of different spawn seed on different variety show significant effect on mycelia running rate of Oyster mushroom that reduced the required days to complete mycelium running in the spawn packet compared to the sawdust alone. Effect of different spawn seed on different variety found to be significant in yield contributing characters and yield of Oyster mushroom with some extent. The highest biological yield, economic yield, dry yield, biological efficiency (BE) and benefit cost ratio (BCR) 264.9g, 259.3g, 25.17g, 86.90, 9.11% respectively was observed in maize based spawn seed on the *Pleurotus florida* variety. Effect of different spawn seed on different variety has a profound effect on chemical composition of Oyster mushroom. Considering all the parameters in this experiment, maize based spawn seed on the *Pleurotus florida* variety is found promising for lowering the cost of production as well as increasing the yield and quality of fruiting body. Wheat based spawn seed on the *Pleuorotus ostreatus* variety may be the fair choice.

Rawte and Diwan (2019) reported that mushroom cultivation is a profitable agribusiness. Incorporation of non conventional crops in existing agricultural system can improve the economic status of protein, vitamins and minerals. Mushrooms are the source of extra ordinary power and have medicinal properties too. Five isolates of spp. *viz*. *P. florida* (PF), *P. sajor-caju* (PSC), *P. eous* (PE), *P. flabellatus* (PFl), *P. sp.* were selected to estimate their potential biological efficiency during the summer season. The experiment was carried out for the cultivation of Oyster mushroom. 2.5 kg paddy straw substrate was taken in polyproplene bags which produced highest yield and biological efficiency and can be recommended as a best substrate. The crop of Oyster mushroom was harvested in three flushes under proper humidity and temperature condition. The spawn running, pin head formation and fruiting body formation are the three important phases in the cultivation of species of *Pleurotus*. The final data was recorded after 42 days in five replicates. *P. sajor-caju* emerged out as the most potential isolate as it exhibited maxium yield and its biological efficiency was 65.20% on the basis of dry weight of substrate. It was followed by 65% in *P. sp*., 62.40% in *P. flabellatus*, 62% in P.florida and 60% in *P. eous*. The production capacity and hence the biological efficiency can be equated as PSC> PSp > PFl > PF.> PE.

Dubey *et al*. (2019) carried out a research at Mushroom house, Institute of Agriculture and Animal Science (IAAS), Paklihawa, Bhairahawa during January to March 2015. The objective of the study was to determine the effect of different substrates on the performance of Oyster Mushroom (*Pleurotus sajorcaju*). Various substrates as treatment, selected for the cultivation of Oyster mushroom were rice straw (T_1), wheat straw (T_2), banana leaves (T_3) and sugarcane bagasse (T_4) each of 4.5 kg and replicated for 4 times. The experimental design used was single factor Completely Randomized Design (CRD). The highest yield (1515 gm) with highest stipe length (4.86 cm) and cap diameter (5.14 cm) was obtained from the rice straw followed by other substrates. The colonization duration (19 days) was lower for wheat straw and banana leaves while fruiting duration (20.5 days) was lower in case of wheat straw. The analysis showed that mushroom production was best suitable in terms of economic return from the rice straw than other agricultural residues with B-C ratio of 3.498.

Masevhe *et al*. (2016) reported that wheat straw has generally been used as the main substrate for cultivating Oyster mushrooms (*Pleurotus ostreatus*); however, in South Africa it is becoming expensive for small-scale farmers to utilise. Therefore, the main objective of the study was to investigate the use of alternative, but suitable substrates for planting Oyster mushrooms. Wheat straw (control), wood chips and thatch grass, selected on account of their year-round availability and low cost, were tested with two drainage treatments (drained or not drained) and replicated four times. Wheat straw showed no contamination, whereas there was contamination in thatch grass and wood chips from weeks 1 to 4. At harvest, a significantly higher cumulative number of flushes, caps and fresh mass of Oyster mushrooms was observed in wheat straw and thatch grass compared with wood chips. The results demonstrated that thatch grass could be used as a viable alternative to the commonly used wheat straw.

Girmay and Gorems (2016) reported that mushroom cultivation is an economically viable bio-technology process for conversion of various lignocellulosic wastes. Given the lack of technology know-how on the cultivation of mushroom, this study was conducted in Wondo Genet College of Forestry and Natural Resource, with the aim to assess the suitability of selected substrates (agricultural and/or forest wastes) for Oyster mushroom cultivation. Accordingly, four substrates (cotton seed, paper waste, wheat straw, and sawdust) were tested for their efficacy in Oyster mushroom production. Pure culture of Oyster mushroom was obtained from Mycology laboratory, Department of Plant Biology and Biodiversity Management, Addis Ababa University. The pure culture was inoculated on potato dextrose agar for spawn preparation. Then, the spawn containing sorghum was inoculated with the fungal culture for the formation of fruiting bodies on the agricultural wastes. The Oyster mushroom cultivation was undertaken under aseptic conditions, and the growth and development of mushroom were monitored daily. Results of the study revealed that Oyster mushroom can grow on cotton seed, paper waste, sawdust and wheat straw, with varying growth performances. The highest biological and economic yield, as well as the highest percentage of biological efficiency of Oyster mushroom was obtained from cotton seed, while the least was from sawdust. The study recommends cotton seed, followed by paper waste as suitable substrates for the cultivation of Oyster mushroom. It also suggests that there is a need for further investigation on various aspects of Oyster mushroom cultivation in Ethiopia to promote the industry.

Ashrafi *et al.* (2014) carried out an experiment to reuse of SMS of Oyster mushroom for the production of Oyster mushroom at Bangladesh Agricultural University (BAU), Mymensingh. Two mushroom species *(Pleurotus ostreatus* and *P. florida)* were grown on SMS supplemented with sawdust and wheat bran at different proportions. The results showed that SMS supplement with 60% sawdust + 20% wheat bran demonstrated the highest biological yield, economic yield and biological efficiency for both *P. ostreatus* and *P. florida.* Yield parameters were increased with increasing C/N ratio where as 36:1 C/N ratio exhibited the highest yield. The C/N ratio below or above 36:1 decreased yield of both species of Oyster mushroom. The optimum C/N ratio for economic yield varied between the two Oyster mushroom species and found to be 35.2 for *P. ostreatus* against C/N ratio of 40.1 for *P. florida.* Concerning biological yield and biological efficiency the optimum C/N ratio was found 35.7 for *P. ostreatus* and 40.6 for *P. florida.* The study emphatically indicated that reuse of spent mushroom substrate with supplementation can be a good solution to address the disposal problem where as supplemented SMS can be a good substrate for further mushroom production.

Bhattacharjya *et al.* (2014) reported the cultivation 0f *Pleurotus ostreatus* on different sawdust substrates such as *Ficus carica* (Fig tree, T_2), *Albizia saman* (Rain Tree, T_3), *Swietenia mahagoni* (Mahogany tree, T_4), *Leucaena leucocephala* (Ipilipil tree, *T_5)*, *Eucalyptus globulus* (Eucalyptus tree, T_6) and mixture of all five tree sawdust (T_1) supplemented with 30% wheat bran and 1% lime as basal substrates. The effects of various sawdust substrates on growth and yield of performance of Oyster mushroom were analyzed. The highest mycelium running rate (0.70 cm/day) and the lowest time from primordial initiation to harvest (3.33 days), were obtained in T_4. The highest time from stimulation to primordial initiation (8.00 days were found in T_1. The highest biological yield (373.4 g/packet), economic yield (371.8 g/packet), dry yield (37.16 g/packet), biological efficiency (213.2%), benefit cost ratio (5.62), the highest average number of primordia/packet (226.3), the highest average number of fruiting body/packet (122.3), the highest average weight of individual fruiting body (4.45 g) and the highest average number of effective fruiting body/packet (21.33) was obtained in T_3. Among all aspects, T_3 was found as a best substrate with biological yield 373.4 g/packet) and biological efficiency (213.2%) followed by Ti, T_4, T_6 T_5, T_2 for the production of mushroom.

Sharma *et al.* (2013) observed the cultivation of *Pleurotus ostreatus* on different substrates such as rice straw, rice straw + wheat straw, rice straw + paper, sugarcane bagasse and sawdust of alder. All the substrates except rice straw were supplemented with 10% rice bran. The substrate without supplement was considered as control. The effects of various substrates on mycelial growth, colonization time, primordial appearance time, mushroom yield, biological efficiency (BE), size of the mushroom and chemical composition were analyzed. Among all aspects, rice straw (control) was found as a best substrate with yield (381.85g) and BE (95.46%) followed by rice plus wheat straw, rice straw plus paper waste for the production of mushroom. The nutritional composition was also better from mushroom fruit grown on rice straw.

Uddin *et al.* (2011) investigated the production of four species of Oyster mushroom: *Pleurotus ostreatus, P. florida, P. sajor-caju and P. high king* cultivated in every season (January to December) in Bangladesh. The temperature (in °C) and relative humidity (%) of culture house in each month, and parameters of mushroom production were recorded. In all of the selected species of this study, the minimum days required for primordial initiation, and the maximum number of fruiting bodies, biological yield and biological efficiency were found during December to February (14-27°C, 70-80% RH). The production was found minimum during the cultivated time August to October. They suggested the cultivation of selected *Pleurotus spp.* in winter (temperature zone 14-27^{o}C with relative humidity 70-80%) for better production and biological efficiency.

Mandol *et al*. (2010) carried out in the mushroom cultivation laboratory, Horticulture Center, Khairtala, Jessore to evaluate the better performance of Oyster mushroom *Pleurotus florida* in different substrate compositions as well as to find out the better substrate for mushroom cultivation. They reported the highest mycelium running rate in banana leaves and rice straw (1:1) but the lowest in control. Completion of mycelium running time was lowest in banana leaves and rice straw (1:3 and 3:1). Number of total primordia and effective primordia, found highest in control but the maximum pileus thickness was measured from rice straw. Highest biological yield and economic yield (164.4 g and 151.1 g) was obtained from rice straw which was much higher than control. From the graphical view, both positive and negative relationships were found between economic yield and different yield contributing attributes.

Hasan *et al*. (2010) conducted an experiment during April 20 to June 28, 2010 at Microbial Biotechnology Laboratory of Genetic Engineering and Biotechnology Department, Khulna University, Khulna, Bangladesh. Twelve different treatments with lime were evaluated to find out the growth and yield of mushroom. The mycelium running time and days required completion of full running of mycelium. Time required for the initiation of premordia to harvesting and number of premordia and number of effective premordia, Biological yield of mushroom were greatly influenced by different pretreated substrates. The highest yield (119gm) and return (12.85Tk) were obtained from the treatment of rice straw + 10% poultry litter + 1% lime. The highest mycelium running rate was observed in the treatment of banana leaf mid ribs + 10% horse dung + 1% lime. The minimum duration of mushroom production found in banana leaf mid ribs + 10% cow dung + 1% lime. However, the rice straw + 10% poultry litter + 1% lime and rice straw + 10% horse dung + 1% lime were the best treatments for the growing of Oyster (*Pleurotus ostreatus*) mushroom and they are economically viable.

Islam *et al.* (2009) conducted an experiment at the laboratory of Food Microbiology, Institute of Food Science and Technology, BCSIR, Dhanmondi, Dhaka-1205 during July 2000 to May 2001 to find out the suitable sawdust as substrate for growing mushroom. Seven different type of substrates viz. Mango, Jackfruit, Coconut, Jam, Kadom, Mahogony, Shiris sawdust with wheat bran and CaCO3 were evaluated to find their growth and yield of Mushroom. The maximum biological yield per packet was obtained with Mango sawdust (150 g) followed by Mahogony (148 g), Shiris (146 g), Kadom (136 g), Jam (114 g), Jackfruit (97 g) and Coconut sawdust (83 g). The lowest yield was observed in Coconut sawdust (83 g). However, highest return was obtained with Mango sawdust (Tk 24.86) while the lowest with Jackfruit sawdust (Tk11.68). Cost benefit analysis revealed that the Mango sawdust and Shiris sawdust were promising substrates for the growing of Oyster Mushroom *(Pleurotus flabellatus).*

Ashrafuzzaman *et al.* (2009) conducted an experiment on *Lentinus edodes* (Berk.), the shiitake mushroom, one of the most widely cultivated mushrooms in the word. They reported that sawdust is the most popular basal ingredient used in synthetic substrate formulations for producing shiitake spawn. However, the best sawdust for this uses needs to be determined. Shiitake mushroom was cultivated on sawdust from the woody plants Babla *(Acacia nilotica L.),* Champa *(Michelia champaca* L.), Garzon *(Dipterocarpus alatus Roxb.),* Ipil-ipil *[Leucaena glauca (Linn)* Benth], Jackfruit *(Artocarpus heterophyllus Lam),* Mango *(Mangifera indica* L.), Raintree *[Albizia saman* (Jacq.) F Mull], Segun *(Tectona grandis* L), Shimul *(Bombax ceiba* L), Shisoo *(Dalbergia sissoo Roxb)* or mixtures of sawdust from all of the trees with equal ratio or rice straw to determine growth and fruiting characteristics. Cultivation on Jackfruit resulted in significantly faster mycelial growth compared to other substrates. With respect to fructification, culture on Jackfruit produced the first pinhead (primordium) earlier compared to other substrates. Numbers of primordial and effective fruiting bodies was highest on Jackfruit sawdust. Rice straw, surprisingly, did not produce any fruiting bodies as well as showing no yield attributes. Yield attributes including stalk length, stalk diameter and diameter and thickness of the pileus were significantly higher on Jackfruit. The lowest biological and economic yields were found when culture was on Champa. Biological efficiency and biological yield, economic yield and dry yield at the first and final harvests were highest with culture on Jackfruit and its use is recommended in the production of shiitake mushroom in the tropics.

Kulsum *et al.* (2009) conducted an experiment to determine the effect of five different levels of cow dung (T_1=0%, T_2= 5%, T_3= 10%, T_4=15% and T_1=20%) as supplement with sawdust on the performance of Oyster mushroom. All the treatments performed better over control. The mycelium running rate in spawn packet and the highest number of primordia/packet were found to be differed due to different levels of supplements used. The highest weight of individual fruiting body was observed in sawdust supplemented with cow dung @ 10% (3.69 g). The supplementation of sawdust with cow dung had remarkable effect on biological yield, economic yield, the dry yield, biological efficiency and cost benefit ratio. The highest biological yield (217.7 g), economic yield (213g), dry yield (21.27 g) biological efficiency (75.06%) and cost benefit ratio (8.41) was counted under sawdust supplemented with cow dung @ 10%. Among the chemical characteristics highest content of protein (31.30%), ash (8.41%), crude fiber (24.07%) was found under treatment T3 (10%) and the lowest lipid (3.44%) and carbohydrate (32.85%) was counted also under treatment T3 (10%). Among the minerals the highest amount of nitrogen (5.01%), potassium (1.39%), calcium (22.15%), magnesium (20.21%), sulfur (0.043%), iron (43.4%) and the lowest phosphorus (0.92) were counted under sawdust supplemented with cow dung @ 10% (T3).

Ali (2009) conducted an experiment to investigate the performance of different levels of wheat bran as supplement with sugarcane bagasse on the production of Oyster mushroom and analysis of their proximate composition. The highest mycelium running rate (0.96 cm) was observed due to sugarcane bagasse supplemented with wheat bran @ 40%. The lowest time (3.23 days) from primordia initiation to harvest, the highest average weight (3.69 g) of individual fruiting body, the highest biological yield (254.7 g), economic yield (243.3 g), dry matter (23.40 g), biological efficiency (87.82%) and cost benefit ratio (8.29) were observed due to sugarcane bagasse supplemented with wheat bran @ 30%. The highest average number of primordia/packet (70.67), average number of fruiting body/packet (61.00) and the highest moisture content (90.45%) were observed due to sugarcane bagasse supplemented with wheat bran @ 40%. The highest content protein (30.31 %), ash (9.15 %), crude fiber (24.07 %), the lowest lipid (3.90 %) and carbohydrate (32.57 %) were observed due to sugarcane bagasse supplemented with wheat bran @ 30%. The highest percentage of nitrogen (4.85), potassium (1.39g/mg), calcium (22.08mg), magnesium (20.21mg), sulfur (0.042g/mg), iron (43.11mg) were observed due to sugarcane bagasse supplemented with wheat bran @ 30% but the highest percentage (0.92) of phosphorus was observed in control condition (sugarcane bagasse alone).

Dey and Nasiruddin (2008) conducted an experiments at the Mushroom and Tissue Culture Laboratory, Horticulture Demonstration and Training Center (HDTC), DAE, Keyotkhali, Mymensingh during the period from February to May 2006. Oyster mushroom was cultivated on different substrates viz. paddy straw, sugarcane bagasse and mustard straw using cylindrical block system to find out suitable substrate. Different substrates significantly affected the number of primordia and fruiting bodies, and the amount of fresh weight or yield of Oyster mushroom in cylindrical block system. The highest number of primordia and fruiting bodies, and the amount of fresh weight was obtained with sugarcane bagasse in all flushes whereas, the lowest with mustard straw.

Sarker *et al.* (2007a) found remarkable difference in nutrient content of Oyster mushroom in respect of different substrates. Wide variation was recorded in the protein content of fruiting body. On dry weight basis, the highest protein content (11.63%) was observed in fruiting body grown on sugarcane bagasse. The 2nd highest protein content (11.0%) was observed in that grown on wheat straw and water hyacinth. The lowest protein (7.81%) was observed in that grown on rice straw. Mushrooms are the good source of minerals also. Maximum of 18400 ppm calcium was found in mushroom which was grown on wheat straw. On other substrates its content varied from 1600 ppm to 18400 ppm. The content of iron in the mushroom grown on different substrates varied from 92.09 ppm to 118.40 ppm. The highest iron content was found in waste paper cultured Oyster mushroom and lowest on water hyacinth.

Sarker *et al.* (2007b) carried out an experiment to find out the performance of different cheap agricultural household byproducts, grasses and weeds as substrate available in Bangladesh. Mycelium growth rate and time required to complete mycelium running in spawn packet varied significantly in different substrates. The minimum duration to complete mycelium running was 17.75 days in waste paper, which differed significantly from that in all other substrates. Significant variation was found in duration from stimulation to primordial initiation, primordial initiation to first harvest and stimulation to first harvest in different substrates. The minimum duration required from stimulation to first harvest was observed in sugarcane bagasse (6.75 days), which was statistically similar to that in waste paper, wheat straw and sawdust (7.00 days). The number of fruiting body was positively correlated with biological efficiency, biological yield and economic yield of Oyster mushroom. The number of fruiting body grown on different substrates differed significantly and the highest number of fruiting body per packet (183.25) was recorded on waste paper, which was significantly higher as compared to all other substrates. The lowest number of fruiting body (19.25) was observed in water hyacinth. Significant variation in biological efficiency, biological yield and economic yield of Oyster mushroom were observed in different substrates. The highest economic yield (225.43 g/packet) was estimated from the waste paper followed by wheat straw (215.72 g/packet). The economic yield on sugarcane bagasse was 191.98 g/packet, which was statistically similar to that grown on rice straw (183.28 g/packet), kash (182.93 g/packet) and ulu (175.15 g/packet).The economic yield on sawdust was 160.40 g/packet, which was statistically similar to that on ulu. The lowest economic yield was observed in water hyacinth (33.59 g/packet). No fruiting body and economic yield were obtained from para and napier grasses. Performances of the substrates were compared based on benefit cost ratio (BCR). The highest BCR (6.50) was estimated when wheat straw was used as substrate followed by sugarcane bagasse (5.90), waste paper (5.65), rice straw (5.58) and kash (5.25) The lowest BCR was obtained from water hyacinth (1.05) followed by ulu (4.74) and sawdust (4.90).

Amin *et al*. (2007) carried out an experiment to find out the primordia and fruiting body formation and yield of Oyster mushroom *(Pleurotus ostreatus)* on paddy straw supplemented with wheat bran (WB), wheat flour (WF), maize powder (MP), rice bran (RB) and their three combinations (WB+MP, 1:1), (WB+MP+RB, 1:1:1) and wheat broken (WBr) at six different levels namely 0, 10, 20, 30, 40 and 50% were studied. The minimum time (4.5 days) for primordial initiation was observed in the MP at 20% level and the highest number of effective fruiting bodies (60.75) was obtained in WF at 50% level. The highest biological yield (247.3 g/packet) was recorded at 10% level of (WBr).

Bhatti *et al.* (2007) studied on the mushroom, *Pleurotus ostreatus* (Jacq. ex. Fr.) Kummer cultivated on wheat straw in polythene bags (containing 500 g wheat straw on dry weight basis per bag) using sorghum grain spawn at different rates. The spawning was done followed by boiling of substrate and sterilization of bags. The bags were kept in mushroom growing room at 25 to 35°C with 80 to 100% relative humidity under regular white fluorescent light arranged by the tube lights in mushroom growing room (10 × 14 × 14). The pinheads first appeared 32.33 days after spawning by using 70 g spawn rate per kg on substrate dry weight basis. The minimum period of 4.66 days after pinhead formation for maturation of fruiting bodies was recorded by using 60, 70, 80, 90 and 100 g spawn rate. The minimum period between flushes (6.33 days) was taken by using 20 g spawn rate. The maximum flushes (4.00) were harvested by using 70 g spawn rate. The maximum number of bunches per bag (7.66) were obtained by using 100 g spawn rate. The maximum number of fruiting bodies per bunch (7.30) was observed by using 70 g spawn rate. The maximum yield on fresh weight basis (45.4%) as well as on dry weight basis (4.63%) was also obtained by using 70 g of spawn rate per bag. The results were highly significant from each other. It is concluded that spawning at 70 g per kg on substrate dry weight basis found to be the best dose for obtaining early and high yielding crop of Oyster mushroom, with minimum period for maturation of fruiting bodies, maximum number of flushes and fruiting bodies per bag.

Zape et al. (2006) conducted a study to determine the spawn run, days taken to pin head initiation, yield and biological efficiency of three Oyster mushroom species *viz*. *Pleurotus florida*, *P. eous* and *P. flabellatus* were grown on wheat straw substrate. Time required for spawn run and pinning was significantly less in *Pleurotus eous* followed by *P. florida.* However, the yield and biological efficiency did not differ significantly but was higher in *P. florida* than *P. flabellatus* and *P. eous.* In analyzing the physico-chemical composition of dehydrated fruit bodies of *Pleurotus* species revealed that among different species *P. eous* was rich in protein (33.89%), moderate in fat (3.10%), carbohydrate (32.60%) and ash (8%) followed by *P. florida.* However, *P. flabellatus* was rich in crude fibre, carbohydrate and ash but low in protein and fat content as compare to *P. eous* and *P. florida.*

Sainos *et al.* (2006) conducted a study to determine the mycelial growth, intracellular activity of proteases, laccases and beta-1,3-glucanases, and cytoplasmic protein were evaluated in the vegetative phase of *Pleurotus ostreatus* grown on wheat straw and in wheat-grain-based media in petridishes and in bottles. The productivity of the wheat straw and wheat-grain-based spawn in cylindrical polyethylene bags containing 5 kg of chopped straw was also determined. We observed high activity of proteases and high content of intracellular protein in cultures grown on wheat straw. This suggests that the proteases are not secreted into the medium and that the protein is an important cellular reserve. On the contrary, cultures grown on wheat straw secreted laccases into the medium, which could be induced by this substrate. *P. ostreatus* grown on media prepared with a combination of wheat straw and wheat grain showed a high radial growth rate in petridishes and a high level of mycelial growth in bottles.

Namdev *et al.* (2006) conducted a study to determine the effect of different straw substrates on spawn growth and yield of Oyster mushroom. The number of days required for spawn run was significantly less (14 days) in case of gram straw, parthenium straw, sugarcane straw and wheat straw, compared with 20 days for sunflower stalk, mustard straw and paddy straw. Yield was very poor on parthenium straw (95 g/500 g dry substrates) and it was highest on paddy straw (666 g/500 g), followed by wheat straw and mustard straw (427 and 400 g/500 g respectively).

Khlood and Ahmad (2005) conducted an experiment to study the ability of Oyster mushroom *(Pleurotus ostreatus)* PO15 strain to grow on live cake mixed with wheat straw. The treatments comprised : 90% straw + 5% wheat bran + 5% gypsum (control); 80% straw + 10% olive cake + 5% wheat bran + 5% gypsum (T_1); 70% straw + 20% olive cake 5% wheat bran + 5% gypsum (T_2); 60% straw + 30% olive cake + 5% wheat bran + 5% gypsum (T_3); 50% straw + 40% olive cake + 5% wheat bran +.5% gypsum (T_4); and 90% olive cake + wheat bran + 5% gypsum (T_5). After inoculation and incubation, transparent plastic bags were used for cultivation. The pinheads appeared after

3 days and the basidiomata approached maturity 3-7 days after pinhead appearance. Several growth parameters including primordial induction and fructification period, earliness, average weight of individual basidiomata, average yield for each treatment, diameter of the pileus and biological efficiency percentage (BE%) were examined and proximate analyses for protein, crude fat, crude fiber, ash, carbohydrates, mineral and moisture contents were performed. The addition of 30% olive cake to the basal growing medium gave the highest yield (400 g/500 g dry substrate), average weight (21.5 g/cap) and average cap diameter (7.05 cm/cap) and BE% (80%). Carbohydrate, protein and fiber contents were high in the *P. ostreatus* basidiomete. Ash contents were moderate, while fat content was low. For mineral contents in the mushrooms the trend was the same in all treatments. The K and P contents were high compared to the other minerals in all treatments, sodium was moderate while both Mg and Ca were found at low concentrations (Mg was relatively higher than Ca). Fe and Zn were relatively high compared to Cu and Mn which had very low concentrations.

Iqbal and Rauf (2005) conducted investigations on the cultivation of Oyster mushroom, *Pleurotus ostreatus* (local and exotic strains) and *P. sajarcaju* were conducted to find out the growth and yield performance on different substrates. Results regarding the time required for completion of spawn running, formation of pin-heads and maturation of fruiting bodies on different substrates showed that in all the three cases, they appeared earlier on sugarcane bagasse followed by cotton waste and the maximum number of flushes were obtained from wheat straw and banana leaves followed by cotton boll locules and cotton waste. Furthermore, the results revealed that the minimum flush to flush interval was obtained on millet followed by wheat straw and sugarcane leaves and the maximum yield percentage on fresh and dry weight basis was obtained from banana leaves followed by paddy and wheat straw.

Habib (2005) tested different substrates such as sawdust, sugarcane bagasse, rice straw, wheat straw and waste paper for the production of Oyster mushroom in polypropylene bag. Different substrates significantly affected the number of primordia, number of fruiting bodies and amount of fresh weight or yield. This experiment revealed that the highest number of primordia and fruiting bodies were found in waste paper 43.75 and 31.00 respectively. The highest amount of fresh weight was also found in waste paper 94.25 g.

Ancona-Mendex *et al.* (2005) conducted an experiment to grow Oyster mushroom *(Pleurotus ostreatus* (Jacq.: Fr.) Kummer in either maize or pumpkin straw. Samples were taken for each one of the three harvests and analyzed for total nitrogen (N) content and amino acids profile. The substrate had no effect ($P>0.05$) on N content and amino acid profile of the fruits. However, N (g/100 g DM) increased ($P<0.05$) from 4.13 g in the first harvest to 5.74 g in the third harvest. In general, the amino acids tended to be higher on the first harvest samples, but no changes were found ($P>0.05$) in the amino acid profile due to substrate or harvest, except for valine decreasing ($P<0.05$) from 3.96 to 3.15 g/16 g N. Changes in the N content of the fruit could be explained by changes in the stipe and pileus proportions as they had different N content (3.15 and 5.48 + or 0.031 g N/100 g DM, respectively). The amino acid profile of the mushroom was adequate according to the FAO/WHO adult human amino acid requirements.

Shah *et al.* (2004) carried out an experiment to investigate the performance of Oyster mushroom on the following substrates: 50 % sawdust + 50 % wheat straw, 75 % sawdust + 25 % leaves, 50 % wheat straw + 50 % leaves, 100 % sawdust, 100 % wheat straw and 100 % leaves. The temperature was kept at 25°C for spawn running and 17-20°C for fruiting body formation. The time for the completion of mycelial growth, appearance of pinheads and maturation of fruiting bodies on different substrates were recorded. The number of fruiting bodies and the biological efficiency of substrates were observed. The results show that spawn running took 2-3 weeks after inoculation, while small pinhead-like structures formed 6-7 days after spawn running. The fruiting bodies appeared 3-6 weeks after pinhead formation and took 27-34 days later after spawn inoculation. Sawdust at 100 % produced the highest yield (646.9 g), biological efficiency (64.69%) and the number of fruiting bodies (22.11). Therefore, sawdust is recommended as the best substrate for Oyster mushroom cultivation.

Moni *et al.* (2004) cultivated the Oyster mushroom *(Pleurotus sajor-caju)* on paddy straw, banana leaves, sugarcane baggase, water hyacinth and beetle nut husk. The fruiting bodies were sun-dried and analyzed for various nutritional parameters. Considerable variation in the composition of fruit bodies grown on different substrates was observed. Moisture content varied from 88.15 to 91.64%. On dry matter basis, the percentage of nitrogen and crude protein varied from 4.22 to 5.59 and 18.46 to 27.78%, respectively and carbohydrate from 40.54 to 47.68%. The variation in content of crude fat and crude fiber ranged from 1.49 to 1.90 and 11.72 to 14.49% respectively.

Maniruzzaman (2004) in his study used wheat, maize, rice and sawdust for the production of spawn in Oyster mushroom and found that substrate rice was the best for spawn production of Oyster mushroom.

Banik and Nandi (2004) carried out an experiment on Oyster mushroom for its ease of cultivation, high yield potential as well as its high nutritional value. Laboratory experimentation followed by farm trial with a typical Oyster mushroom *Pleurotus sajor- caju* revealed that the yield potential of these mushrooms can be increased significantly when grown on a lignocellulose crop residue - rice straw supplemented with biogas residual slurry manure in 1:1 ratio as substrate. Residual slurry manures obtained from biogas plants utilising cattle dung or poultry litter, jute caddis or municipal solid waste as substrates for biogas production were all effective in increasing the yield of *Pleurotus sajor-caju* significantly although to different extents. Disinfection of straw and manure by means of 0.1% KMnO< sub>4</ sub> plus 2% formalin solution in hot water caused 42.6% increase in yield of *Pleurotus sajor-caju* over control, i.e., when disinfection done with hot water. In addition to increased yield, the above treatments caused significant increase in protein content, reduction in carbohydrate and increase in essential mineral nutrients in mushroom sporophores. Thus, it is concluded from the study that supplementation of rice straw with biogas residual slurry manure has strong impact in improving the yield potential, protein and mineral nutrient contents of *Pleurotus sajorcaju* mushroom in Indian subcontinent or similar climatic conditions.

Baysal *et al.* (2003) conducted an experiment to spawn running, pin head and fruit body formation and mushroom yield of Oyster mushroom (*Pleurotus ostreatus*) on waste paper supplemented with peat, chicken manure and rice husk (90+10; 80 + 20 W:W). The fastest spawn running (mycelia development) (15.8 days), pin head formation (21.4 days) and fruit body formation (25.6 days) and the highest yield (350.2 g) were realized with the substrate composed of 20% rice husk in weight. In general, increasing the ratio of rice husk within the substrate accelerated spawn running, pin head and fruit body formation and resulted increased mushroom yields, while more peat and chicken manure had a negative effect on growing.

Manzi *et al.* (2001) analyzed fresh and processed mushrooms *(Agaricus bisporus, Pleurotus ostreatus* and Boletus group). Results showed that botanical variety, processing and cooking are all effective determinants of mushroom proximate composition. Dried mushrooms (Boletus group) after cooking show the highest nutritional value, essentially due to insufficient dehydration. Dietary fiber, chitin and beta glucans, all functional constituents of mushrooms are present in variable amounts. Chitin level ranges from 0.3 to 3.9 g/100 g, while beta glucans which are negligible in *Agaricus,* range from 139 to 666 mg/100 g in *Pleurotus ostreatus* and Boletus group. On an average, a serving (100 g) of mushroom will supply 9 to 40% of the recommended of dietary fiber.

Dhoke *et al.* (2001) studied the effect of different agro-wastes on cropping period and yield of *Pleurotus sajor-caju* the experiments carried out in Prabhani and Maharashtra in India, during 1998-99. Various plant materials, i.e. soybean, paddy, cotton, wheat and jowar *(Sorghum bicolor)* were used. Cropping period on different substrates was recorded for first, second and third picking. The cropping period for third picking varied from 42.25 to 43.50 days in different substrates. The days required for first picking indicated that soybean straw took 22.00 days to produce first crop of harvestable mushroom while a minimum of 21.25 days were required for paddy and wheat straw. For second picking, jowar and cotton waste took the maximum days of 32.75 days while soybean took the minimum of 31.50 days. The final and third picking was completed in 43.50 days in case of soybean straw which was statistically higher compared to paddy and wheat straw (42.25) and cotton and jowar straw (42.75). The highest yield of 993.00 g/kg was obtained from cotton, followed by soybean straw (935.25 g/kg) and paddy straw (816.0 g/kg). The lowest yield of 445.50 g/kg was recorded in jowar straw.

Upamanya and Rathaiah (2000) conducted an experiment to test the effect of fortification of rice straw with rice bran on the yield and quality of Oyster mushroom (*Plelrrotus ostrentus*) in Jorhat, Assam, India. Treatments comprised: (i) addition of rice bran at 5% w/w (weight of rice bran/weight of dry substrate) at the time of spawning and (ii) control (without rice bran). Rice straw fortified with rice bran exhibited a higher yield compared to the control. Rice bran application had no effect on the crude protein content of mushroom but increased the yield by 44% over the control.

Ayyappan *et al.* (2000) used sugarcane trash and coir waste alone and in combination with paddy straw (3:1, 1:1 and 1:3 w/w) for sporophore production of two species of *Pleurotus*. The highest yields of *P. florida* (1395 g) and *P. citrinopileatus* (1365 g) were recorded in a mixture of sugarcane.

Rathaiah and Shill (1999) in their experiment found that parboiled paddy was as good as wheat for spawn production of Oyster mushroom. The spawn prepared from parboiled paddy was also compared with conventionally prepared paddy spawn. The suitability of parboiled paddy for spawn of paddy straw mushroom *(Volvariella volvacea)* was also confirmed.

Patil and Jadhav (1999) reported that *Pleurotus sajor-caju* was cultivated on cotton, wheat, paddy, sorghum and soyabean straws in Marathwada, India. Cotton stalks + leaves was the best substrate for production (yield of 1039 g/kg dry straw), followed by soyabean straw (1019 g/kg). Paddy and wheat straw yielded 650 and 701g/kg. The lowest yield (475 g/kg) was obtained on sorghum straw. Pileus size and stipe length of *P. sajor-caju* were greatest on sorghum straw.

Zhang-Ruihong *et al.* (1998) cultivated Oyster mushroom *(P. sajor-caju)* on rice and wheat straw without nutrient supplementation. The effects of straw size reduction methods and particle sizes spawn inoculation level and types of substrate (rice straw vs. wheat straw) on mushroom yield, biological efficiency and substrate degradation were determined. The protein content of mushrooms produced was 27.2% on an average. The dry matter loss of the substrate after mushroom growth varied from 30.1 to 44.3%. Yields were higher from substrates which had been ground-up to 2.5 cm lengths; further size reductions lowered yields. Mushroom cultivation is a highly efficient method for disposing of agricultural residues as well as producing nutritious human food.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out to find out the performance of Oyster mushroom (*Pleuratus spp*.) species in the winter of Bangladesh. This chapter deals with a brief description on location and design of experiment, experimental treatments, preparation of substrates, preparation of packets, cultivation of spawn packet, production procedure and collection of produced mushrooms, data recording and their analysis under the following headings and sub-headings:

3.1 Location of experiment

The experiment was carried out at the Mushroom Development Institute (MDI), Savar, Dhaka under the Department of Agricultural Extension (DAE), during the period from October 2019 to February 2020. The environmental condition of the experimental location was given in Appendix I.

3.2 Experimental materials

Substrates: Two substrate *viz*. (i) Straw and (ii) Sawdust were used

Variety: Seven varieties *viz*. (i) *Pleurotus ostreatus* (PO2), (ii) *Pleurotus ostreatus* (POP), (iii) *Pleurotus ostreatus var. White Snow* (WS), (iv) *Pleurotus ostreatus* (PO10), (v) *Pleurotus ostreatus var*. *Oyster Big*, (vii) *Pleuratus sajorcaju* (PSC) and (vii) *Pleurotus ostreatus var*. *high king* (HK-51) were used

3.3 Varietal characteristics of Oyster Mushroom

Oyster mushrooms *(Pleurotus* spp) are characterized by the rapidity of the mycelial growth and high saprophytic colonization activity on cellulosic substrates. Their fruiting bodies are shell or spatula shaped with different colors *viz*. white, cream, pink, grey, yellow, light brown etc. If the temperature increases above 32°C, its production markedly decreases.

3.4 Treatments of the experiments

Two factor experiments were as follows:

3.4.1 Factor A: Substrates – 2

1. S_1 = Straw substrate
2. S_2 = Sawdust substrate

3.4.2 Factor B: Variety - 7

1. V_1 = PO2 (*Pleurotus ostreatus*)
2. V_2 = POP (*Pleurotus ostreatus*)
3. V_3 = WS (*Pleurotus ostreatus var. White Snow*)
4. V_4 = PO10 (*Pleurotus ostreatus*)
5. V_5 = Oyster big (*Pleurotus ostreatus var. Oyster big*)
6. V_6 = PSC (*Pleuratus sajorcaju*)
7. V_7 = HK-51 (*Pleurotus ostreatus var*. *high king*)

Treatment combinations: S_1V_1, S_1V_2, S_1V_3, S_1V_4, S_1V_5, S_1V_6, S_1V_7, S_2V_1, S_2V_2, S_2V_3, S_2V_4, S_2V_5, S_2V_6 and S_2V_7.

3.5 Design and layout of the experiment

The experiment was laid out in two factors Completely Randomized Design (CRD) with five replications. The experiment considered fourteen treatment combinations one spawn packet was in each replication (Appendix II).

3.6 Preparation of substrates

4.6.1 Straw substrate

Rice straw substrate was prepared by pasteurization method. At first 4 kg weight of dry straw was taken. The straw was chopped to 4-5 cm length and soaked in 3 liters of water and then poured into cribriform nylon bag. The bag was submerged in water for sometimes and then drained out the excess water. After that the bag containing rice straw was kept in a pasteurization chamber at 60-70°C for 1-1½ hour. The bag was kept in same place for 18-20 hours to get cool slowly. After 20 hours the prepared rice straw was spread over polythene sheet in open place to reduce moisture at 60%. This substrate of rice straw was ready for spawn packet preparation.

4.6.2 Sawdust substrate

Sawdust substrate was prepared by pasteurization method. Four (4) kg sawdust was mixed with 3 liters of water and the mixture was poured into cribriform nylon bag. The bags were submerged in water for sometimes and then drained out the excess water. After that the bags containing SD were kept in a pasteurization chamber at 60-70°C for 1-1½ hour. The bag was kept in same place for 18-20 hours to get cool slowly. After 20 hours the prepared sawdust was spread over polythene sheet in open place to reduce moisture at 60%. This sawdust substrate was ready for spawn packet preparation.

3.7 Preparation of spawn packets

The mixed substrates were filled into 9 × 12 inch polypropylene bag @ 500 g. The filled polypropylene bags were prepared by using plastic neck and plugged the neck with cotton and covered with brown paper placing rubber band to hold it tightly in place.

3.8 Sterilization, inoculation and mycelium running in spawn packets

The packets were sterilized about 2 hour and then these were kept for cooling. After cooling, 5 g mother spawn was inoculated into the packets in the laminar airflow cabinet and the packets were kept at 20-22°C temperature until the packets become white with the mushroom mycelium. After completion of the mycelium running the rubber band, brown paper, cotton plug and plastic neck of the mouth of spawn packet were removed and the mouth was wrapped tightly with rubber band. Then these spawn packets were transferred to the culture house.

3.9 Cultivation of spawn packet

Two ends, opposite to each other of the upper position of plastic bag were cut in 'D' shape with a blade and opened by removing the plastic sheet after which the opened surface of substrate was scraped slightly with a tea spoon for removing the thin whitish mycelial layer. Then the spawn packets were soaked in water for 15 minutes and invested to remove excess water for another 15 minutes. The packets of each type were placed separately on the floor of culture room and covered with newspaper. The moisture of the culture room was maintained 80-85% relative humidity by spraying water 3 times a day. The light around 300-500 lux and ventilation of culture house was maintained uniformly. The temperature of culture house was maintained 22°C to 25°C. The first primordia appeared 2-4 days after scribing depending upon the type of substrate and variety. The harvesting time also varied depending upon the type of substrate and variety.

3.10 Collection of produced mushrooms (Harvesting)

Oyster mushrooms matured within 2-3 days after primordia initiation. The matured fruiting body was identified by curial margin of the cap, as described by Amin (2002). Mushrooms were harvested by twisting to uproot from the base.

3.11 Cultural operations for subsequent flushes

After completing the first harvest again the packets were scraped at the place where the 'D' shaped cut had been done and were soaked in a bucket for five minutes and then placed in the culture house and water was sprayed regularly. The primordia appeared 9-10 days after first harvest and 7-8 days after second harvest. Water spraying was continued until the mushrooms were ready to be harvested.

3.12 Data collection

Data were collected on the following parameters

1. Days required from pin head initiation to 1st harvest
2. Total cropping duration (days)
3. Length of stalk (cm)
4. Diameter of stalk (cm)
5. Length of pileus (cm)
6. Diameter of pileus (cm)
7. Thickness of pileus (cm)
8. Total number of fruiting body packet^{-1}
9. Number of effective fruiting body packet^{-1}
10. Biological yield of 1st harvest (g)
11. Total biological yield (g)
12. Economic yield (g)
13. Biological efficiency (%)

3.13 Procedure of recording data

3.13.1 Days required from pin head initiation to 1st harvest

Firstly 1st pin head initiation was observed and days to pin head initiation to 1st harvest was recorded.

3.13.2 Total cropping duration (days)

Total cropping duration was measured in days and it was counted from the inoculation of mycelium in spawn packets to final harvest of primordial.

3.13.3 Length of stalk (cm)

Length of stalk was measured in cm with the help of meter scale from base to top of the sock.

3.13.4 Diameter of stalk (cm)

Diameter of stalk was measured with the help of slide calipers and was expressed in cm.

3.13.5 Length of pileus (cm)

Length of pileus was measured in cm with the help of meter scale from base to tip of the pileus .

3.13.6 Diameter of pileus (cm)

Diameter of pileus was measured with the help of slide calipers and was expressed in cm.

3.13.7 Thickness of pileus (cm)

Thickness of pileus was measured by slide calipers and was expressed in cm.

3.13.8 Total number of fruiting body packet^{-1}

Number of well-developed fruiting body was recorded. Dry and pinheaded fruiting bodies were discarded but tiny fruiting bodies were included in counting.

3.13.9 Number of effective fruiting body packet^{-1}

Number of well-developed fruiting bodies was recorded which were suitable to consume excluding rejected fruiting bodies that were unable to consume.

3.13.10 Biological yield of 1st harvest (g)

Biological yield of 1st harvest per 500 g packet was measured by weighing the whole cluster of fruiting body at 1st harvest without removing the lower hard and dirty portion.

3.13.11 Total biological yield (g)

Total biological yield was calculated from all biological yield of 1st harvest to last harvest.

3.13.12 Economic yield (g)

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.

3.13.13 Biological efficiency (%)

Biological efficiency was determined by the following formula:

$$\text{Biological efficiency} = \frac{\text{Total biological weight (g)}}{\text{Total dry weight of substrate used (g)}} \times 100$$

3.14 Statistical analysis of data

All the data collected on different parameters were statistically analyzed using MSTAT-C computer package program following the analysis of variance (ANOVA) technique and mean differences were adjusted by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) u. The mean differences among the treatments were compared by least significant difference (LSD) test at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the effect of substrates on oyster mushroom production. Data on different parameters analyzed statistically and the results have been presented through different Tables and Figures. The results of the present study have been presented and discussed in this chapter under the following headings.

4.1 Growth parameters

4.1.1 Days required from pin head initiation to 1st harvest

Significant variation was found in days required from pinhead initiation to 1st harvest due to the effect of different substrates (Figure 1 and Appendix II). However, the highest days required from pin head initiation to 1st harvest (10.11 days) was observed in the substrate S_1 (Straw substrate) whereas the lowest days required from pin head initiation to 1st harvest (9.09 days) was in the substrate S_2 (Sawdust substrate). Similar result was also observed by Khan *et al*. (2001), Dhoke *et al*., (2001), Kulsum *et al*. (2009) and Uddin *et al.* (2011). 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. Dhoke *et al*. (2001) found significant effect of different agro-wastes on yield of Oyster mushroom.

Fig. Straw and Sawdust substrates

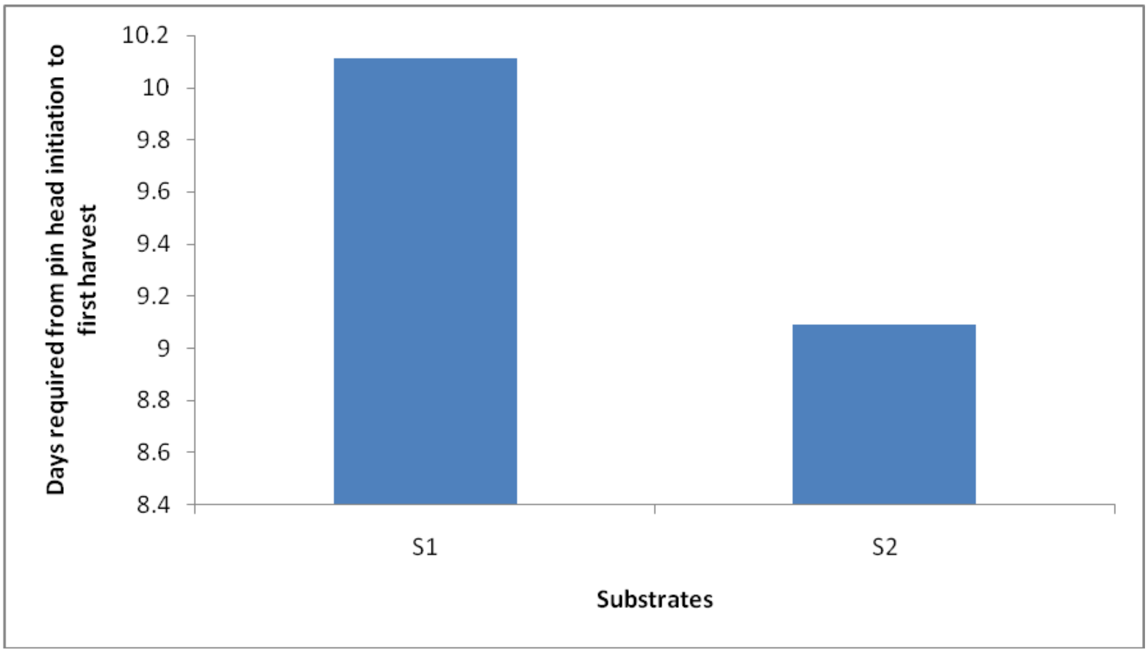

Figure 1. Days required from pin head initiation to 1st harvest of mushroom as influenced by different substrates

S_1 = Straw substrate, S_2 = Sawdust substrate

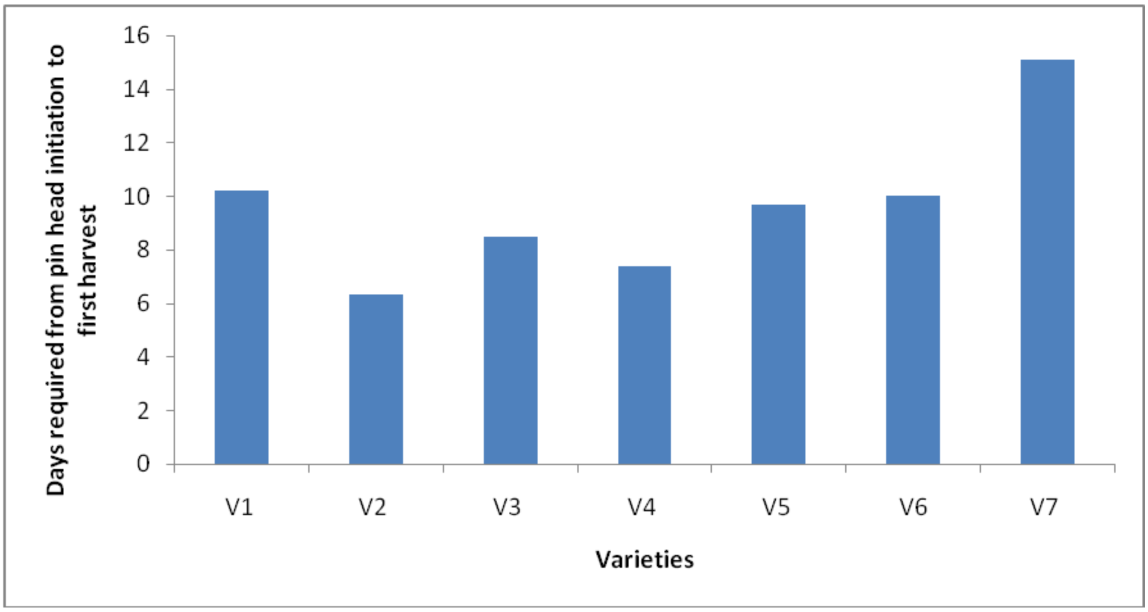

Figure 2. Days required from pin head initiation to 1st harvest of mushroom as influenced by different varieties

V_1 = PO2, V_2 = POP, V_3 = WS, V_4 = PO10, V_5 = Oyster big, V_6 = PSC, V_7 = HK-51

Different varieties of mushroom showed significant influence on days required from pinhead initiation to 1^{st} harvest (Figure 2 and Appendix II). Results revealed that the highest days required from pin head initiation to 1^{st} harvest was taken 15.10 days from the variety V_7 (HK-51) and this was significantly different from other treatments followed by V_1 (PO2), V_5 (Oyster big) and V_6 (PSC). The lowest days required 6.30 days from pin head initiation to 1^{st} harvest was found from the variety V_2 (POP) which was significantly different from other treatments.

Treatment combination of different substrates and varieties showed significant variation on days required from pin head initiation to 1^{st} harvest (Table 1 and Appendix II). Results indicated that the highest days (15.60 days) required from pin head initiation to 1^{st} harvest was recorded from the treatment combination of S_1V_7 that was significantly different from other treatment combinations followed by S_1V_1 and S_2V_7. The lowest days (5.80 days) required from pin head initiation to 1^{st} harvest was recorded from the treatment combination of S_2V_2 and this treatment combination was statistically similar to S_2V_1.

4.1.2 Total cropping duration (days)

Different substrates used in the present study had insignificant influence on total cropping duration (Figure 3 and Appendix II). However, the highest total cropping duration (81.74 days) was observed in the substrate S_2 (Sawdust substrate) whereas the lowest total cropping duration (80.46 days) was in S_1 (Straw substrate) treatment. Hasan *et al*. (2010) also found non-similar result with the present study who reported that cropping duration varied significantly due to the types of substrate.

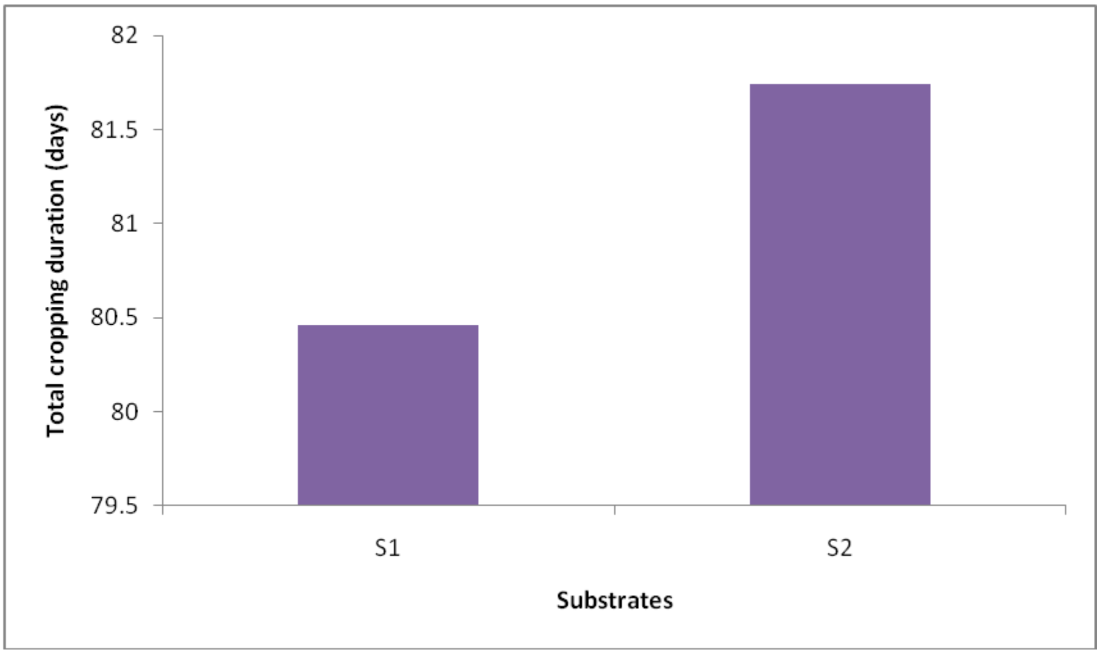

Figure 3. Total cropping duration of mushroom as influenced by different substrates

S_1 = Straw substrate, S_2 = Sawdust substrate

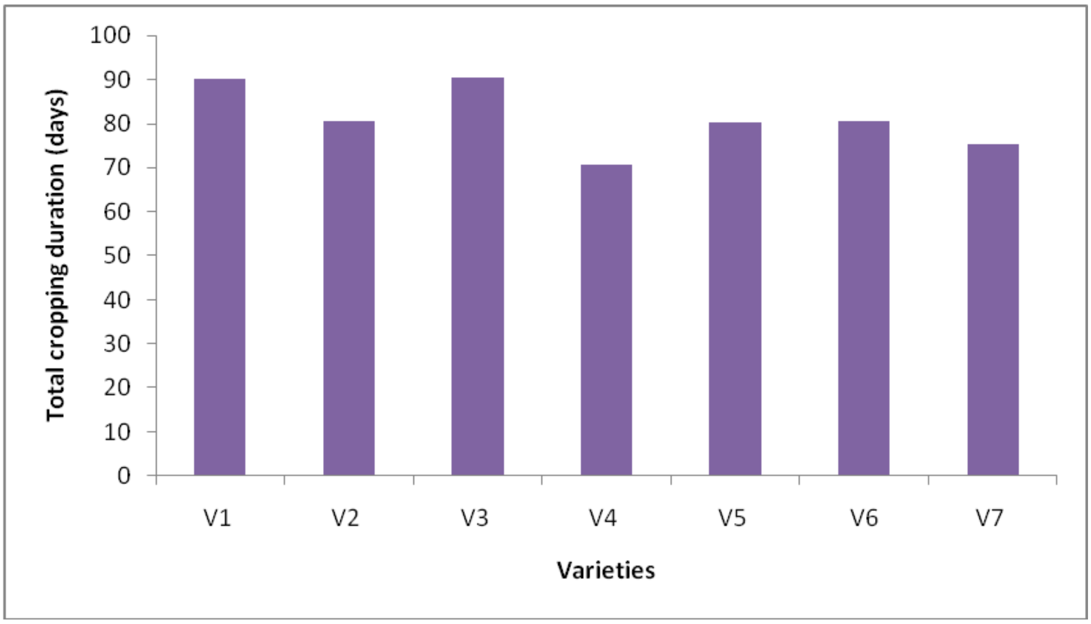

Figure 4. Total cropping duration of mushroom as influenced by different varieties

V_1 = PO2, V_2 = POP, V_3 = WS, V_4 = PO10, V_5 = Oyster big, V_6 = PSC, V_7 = HK-51

There was a significant variation on total cropping duration influenced by different varieties of mushroom (Figure 4 and Appendix II). The highest total cropping duration (90.40 days) was found from the variety V_3 (WS) which was statistically identical with V_1 (PO2). The lowest total cropping duration (70.60 days) was found from the variety V_4 (PO10) which was significantly different from other varieties. Similar result was also observed by Ferdousi *et al*. (2019) and Akter *et al*. (2019).

Table 1. Performance of different substrates and Oyster mushroom varieties on growth parameters.

Treatments	Growth parameters	
	Days required from pin head initiation to 1st harvest	Total cropping duration (days)
S_1V_1	13.80 b	89.80 a
S_1V_2	6.80 f	79.80 b
S_1V_3	8.40 e	89.60 a
S_1V_4	7.40 f	70.20 d
S_1V_5	9.00 de	79.40 b
S_1V_6	9.80 cd	79.40 b
S_1V_7	15.60 a	75.00 c
S_2V_1	6.60 fg	90.60 a
S_2V_2	5.800 g	81.20 b
S_2V_3	8.60 e	91.20 a
S_2V_4	7.40 f	71.00 d
S_2V_5	10.40 c	81.20 b
S_2V_6	10.20 c	81.60 b
S_2V_7	14.60 b	75.40 c
$LSD_{0.05}$	0.914	2.204
CV (%)	7.80	6.76

In a column means having similar letters) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_1 = Straw substrate, S_2 = Sawdust substrate

V_1 = PO2, V_2 = POP, V_3 = WS, V_4 = PO10, V_5 = Oyster big, V_6 = PSC, V_7 = HK-51

Total cropping duration was significantly influenced by different treatment combination of substrates varieties of mushroom (Table 1 and Appendix II). The highest total cropping duration (91.20 days) was recorded from the treatment combination of S_2V_3 which was statistically identical with the treatment combination of S_1V_1, S_1V_3 and S_2V_1. The lowest total cropping duration (70.20 days) was recorded from the treatment combination of S_1V_4 which was statistically same with the treatment combination of S_2V_4.

4.2 Yield contributing parameters

4.2.1 Length of stalk (cm)

Significant variation was not found on length of stalk influenced by different substrates used in the present study (Figure 5 and Appendix III). However, the highest length of stalk (3.98 cm) was observed in the substrate S_1 (Straw substrate) whereas the lowest length of stalk (3.95 cm) was in the substrate S_2 (Sawdust substrate). The result obtained from the present study was similar with the findings of Dubey *et al*. (2019) who obtained highest stalk length with rice straw substrate compared to wheat straw, banana leaves and sugarcane bagasse substrates. Similar result was also observed by Ashrafuzzaman *et al.* (2009) and Patil and Jadhav (1999).

Length of stalk was significantly varied due to different varieties (Figure 6 and Appendix III). The highest length of stalk (4.55 cm) was found from the variety V_1 (PO2) which was significantly different from other treatments followed by V_2 (POP), V_4 (PO10) V_5 (Oyster big). The lowest length of stalk (3.26 cm) was found from the variety V_6 (PSC) and that was also significantly different from other treatments. This result obtained from the present study was might be due to cause of genetical character of different mushroom strains.

Significant influence was noted on length of stalk as influenced by treatment combination of different substrates and varieties (Table 2 and Appendix III). The highest length of stalk (5.12 cm) was recorded from the treatment combination of S_1V_1 and this was significantly different from other treatment combinations. The lowest length of stalk (3.18 cm) was recorded from the treatment combination of S_2V_6 which was statistically similar with the treatment combination of S_1V_6.

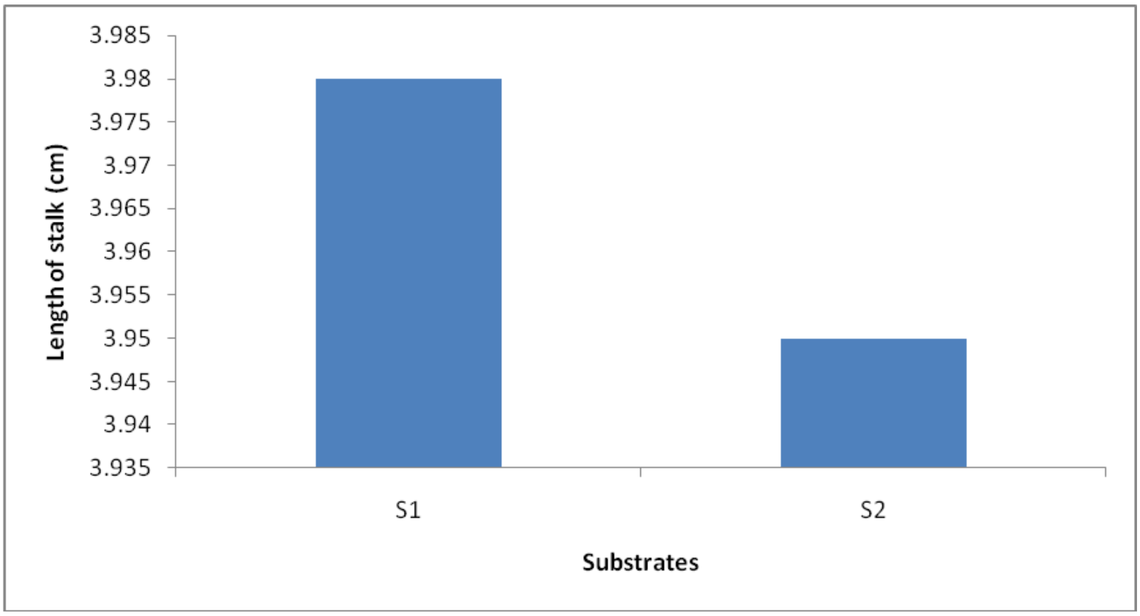

Figure 5. Length of stalk of mushroom as influenced by different substrates

S_1 = Straw substrate, S_2 = Sawdust substrate

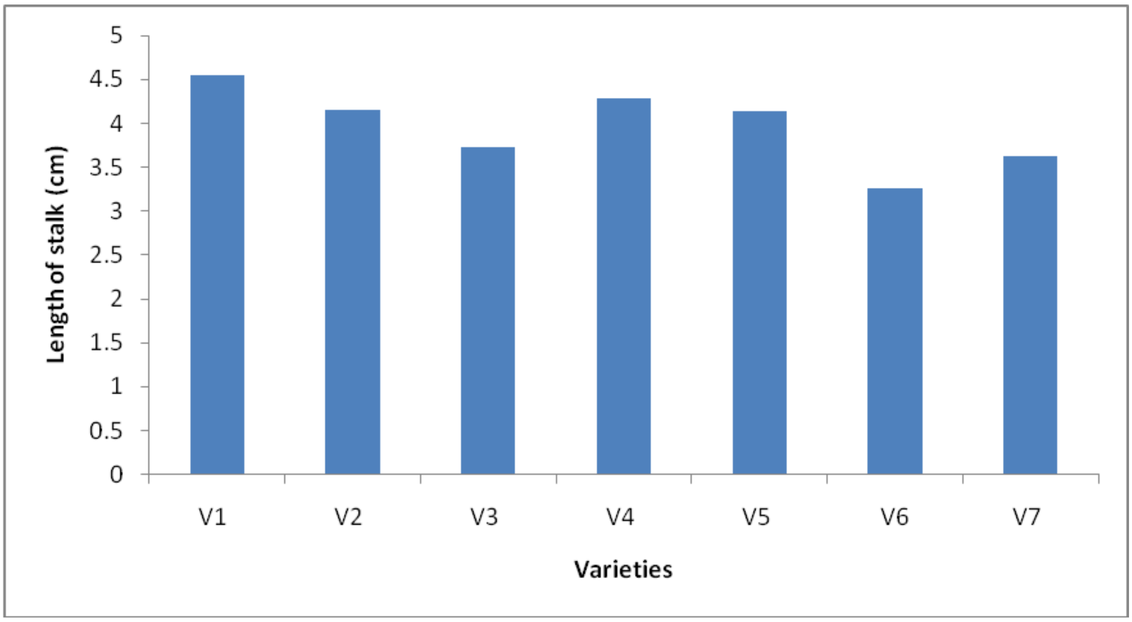

Figure 6. Length of stalk of mushroom as influenced by different varieties

V_1 = PO2, V_2 = POP, V_3 = WS, V_4 = PO10, V_5 = Oyster big, V_6 = PSC, V_7 = HK-51

4.2.2 Diameter of stalk (cm)

Non-significant variation was observed on diameter of stalk influenced by different substrates (Figure 7 and Appendix III). However, the highest diameter of stalk (1.75 cm) was observed in the substrate S_1 (Straw substrate) whereas the lowest diameter of stalk (1.65 cm) was in the substrate S_2 (Sawdust substrate). Similar result was also observed by Dubey *et al*. (2019) who obtained highest stalk diameter with rice straw substrate compared to wheat straw, banana leaves and sugarcane bagasse substrates. Supported result was also observed by Ashrafuzzaman *et al.* (2009) and Patil and Jadhav (1999).

Diameter of stalk varied significantly due to different varieties of mushroom (Figure 8 and Appendix III). The variety V_2 (POP) gave highest diameter of stalk (2.38 cm) which was significantly different from other varieties followed by V_4 (PO10). The lowest diameter of stalk (1.42 cm) was found from the variety V_6 (PSC) which was significantly different from other varieties. Such result from the study regarding varietal performance might be due to cause of genetic characters which showed variation on stalk diameter.

Different treatment combination of substrates varieties showed significant variation was on diameter of stalk (Table 2and Appendix III). The highest diameter of stalk (2.60 cm) was recorded from the treatment combination of S_1V_2 followed by S_2V_2. The lowest diameter of stalk (1.369 cm) was recorded from the treatment combination of S_2V_6 which was statistically similar with the treatment combination of S_1V_3, S_1V_6 and S_2V_7.

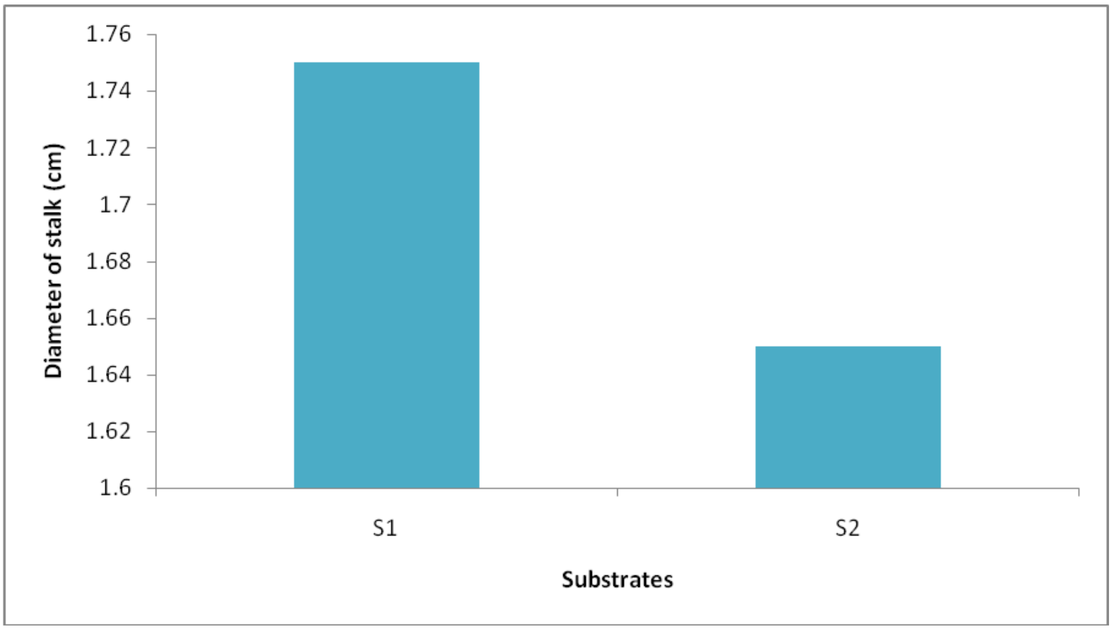

Figure 7. Diameter of stalk of mushroom as influenced by different substrates

S_1 = Straw substrate, S_2 = Sawdust substrate

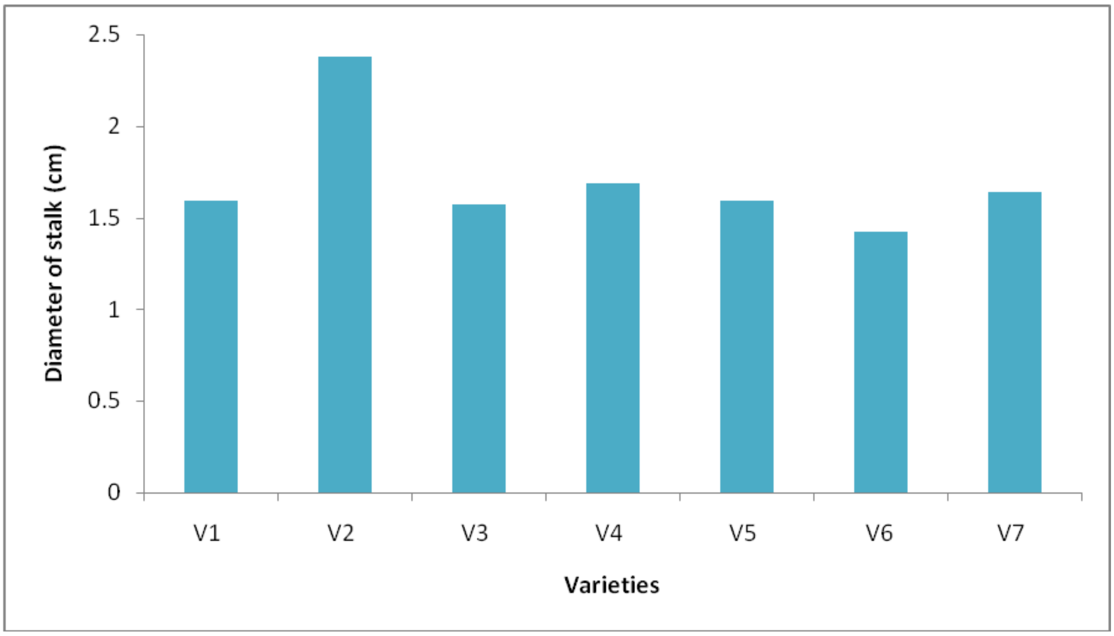

Figure 8. Diameter of stalk of mushroom as influenced by different varieties

V_1 = PO2, V_2 = POP, V_3 = WS, V_4 = PO10, V_5 = Oyster big, V_6 = PSC, V_7 = HK-51

Table 2. Performance of different substrates and oyster mushroom varieties on the size of fruiting body regarding length and diameter of stalk

Treatments	Yield contributing parameters	
	Length of stalk (cm)	Diameter of stalk (cm)
S_1V_1	5.12 a	1.54 efg
S_1V_2	4.04 de	2.60 a
S_1V_3	3.54 g	1.48 gh
S_1V_4	4.36 c	1.72 d
S_1V_5	4.74 b	1.52 fg
S_1V_6	3.34 hi	1.46 gh
S_1V_7	3.84 f	1.92 c
S_2V_1	3.98 ef	1.64 def
S_2V_2	4.26 c	2.16 b
S_2V_3	3.92 ef	1.66 de
S_2V_4	4.20 cd	1.66 de
S_2V_5	3.54 g	1.66 de
S_2V_6	3.18 i	1.36 h
S_2V_7	3.40 gh	1.38 h
$LSD_{0.05}$	0.1703	0.133
CV (%)	6.12	5.14

In a column means having similar letters) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_1 = Straw substrate, S_2 = Saw dust substrate

V_1 = PO2, V_2 = POP, V_3 = WS, V_4 = PO10, V_5 = Oyster big, V_6 = PSC, V_7 = HK-51

4.2.3 Length of pileus (cm)

Length of pileus was significantly influenced by different substrates (Table 3 and Appendix III). Results revealed that the highest length of pileus (8.07 cm) was observed in the substrate S_1 (Straw substrate) whereas the lowest length of pileus (7.85 cm) was in the substrate S_2 (Sawdust substrate). Similar result was also observed by Patil and Jadhav (1999).

Variation on length of pileus was found influenced by different varieties (Table 3 and Appendix III). Variety V_1 (PO2) showed the highest length of pileus (9.21 cm) followed by V_2 (POP) and V_3 (WS) whereas the lowest length of pileus (6.33 cm) was found from the variety V_6 (PSC).

Length of pileus was significantly varied due to different treatment combination of substrates and varieties (Table 3 and Appendix III). The highest length of pileus (9.70 cm) was recorded from the treatment combination of S_1V_1 which was statistically similar with the treatment combination of S_2V_3. The lowest length of pileus (6.12 cm) was recorded from the treatment combination of S_2V_6.

4.2.4 Diameter of pileus (cm)

The recorded data on diameter of pileus was not significantly influence by different substrates (Table 3 and Appendix III). However, the highest diameter of pileus (6.26 cm) was observed in the substrate S_1 (Straw substrate) whereas the lowest diameter of pileus (5.99 cm) was in the substrate S_2 (Sawdust substrate). Similar result was also observed by Khlood and Ahmad (2005).

Considerable influence was observed on diameter of pileus persuaded by different varieties of mushroom (Table 3 and Appendix III). The highest diameter of pileus (7.55 cm) was found from the variety V_5 (Oyster big) which was significantly different from other varieties followed by V_7 (HK-51). The lowest diameter of pileus (4.96 cm) was found from the variety V_6 (PSC) which was statistically similar with V_4 (PO10).

Remarkable variation was found on diameter of pileus due to the treatment combination of different substrates and varieties (Table 3 and Appendix III). The highest diameter of pileus (7.70 cm) was recorded from the treatment combination of S_1V_5 which was statistically similar with the treatment combination of S_2V_5. The lowest diameter of pileus (4.44 cm) was recorded from the treatment combination of S_2V_6 which was statistically identical with the treatment combination of S_2V_2.

Table 3. Performance of different substrates and Oyster mushroom varieties on the size of fruiting body regarding length, diameter and thickness of pileus

Treatments	Yield contributing parameters		
	Length of pileus (cm)	Diameter of pileus (cm)	Thickness of pileus (cm)
Effect of substrate			
S_1	8.07 a	6.26	1.14 a
S_2	7.85 b	5.99	0.85 b
$LSD_{0.05}$	0.067	NS	0.014
CV(%)	8.19	8.85	9.37
Effect of variety			
V_1	9.21 a	6.00 d	1.37 a
V_2	8.67 b	5.44 e	1.09 b
V_3	8.29 bc	6.41 c	0.78 d
V_4	7.68 d	5.71 de	0.95 c
V_5	8.21 c	7.55 a	1.06 b
V_6	6.33 e	4.96 f	0.80 d
V_7	7.32 d	6.81 b	0.93 c
$LSD_{0.05}$	0.405	0.303	0.110
CV(%)	8.19	8.85	9.37
Combined effect of substrate and variety			
S_1V_1	9.70 a	5.96 d	1.86 a
S_1V_2	9.26 ab	6.02 d	1.52 b
S_1V_3	7.38 e	5.88 de	0.78 fg
S_1V_4	8.20 cd	5.66 de	0.94 de
S_1V_5	8.12 d	7.70 a	1.02 cd
S_1V_6	6.54 f	5.48 e	0.88 ef
S_1V_7	7.28 e	7.10 b	0.98 de
S_2V_1	7.36 e	6.04 d	0.78 fg
S_2V_2	8.08 d	4.85 f	0.88 ef
S_2V_3	9.20 ab	6.94 bc	0.66 h
S_2V_4	7.16 e	5.76 de	0.96 de
S_2V_5	8.30 cd	7.40 ab	1.10 c
S_2V_6	6.12 f	4.44 f	0.72 gh
S_2V_7	8.72 bc	6.52 c	0.88 ef
$LSD_{0.05}$	0.575	0.465	0.1062
CV (%)	8.19	8.85	9.37

In a column means having similar letters) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_1 = Straw substrate, S_2 = Sawdust substrate

V_1 = PO2, V_2 = POP, V_3 = WS, V_4 = PO10, V_5 = Oyster big, V_6 = PSC, V_7 = HK-51

4.2.5 Thickness of pileus (cm)

Significant variation was observed on thickness of pileus influenced by different substrates (Table 3 and Appendix III). The highest thickness of pileus (1.14 cm) was observed in the substrate S_1 (Straw substrate) whereas the lowest thickness of pileus (0.85 cm) was in the substrate S_2 (Sawdust substrate). Similar result was also observed by Mandol *et al.* (2010) and Ashrafuzzaman *et al.* (2009) who observed that different substrates had significant effect on thickness of pileus of mushroom.

Thickness of pileus was significantly varied due to different varieties of mushroom (Table 3 and Appendix III). The highest thickness of pileus (1.37 cm) was found from the variety V_1 (PO2) followed by V_2 (POP) and V_5 (Oyster big) whereas the lowest thickness of pileus (0.78 cm) was found from the variety V_3 (WS).

Significant influence was recorded on thickness of pileus affected by treatment combination of different substrates and varieties (Table 3 and Appendix III). The highest thickness of pileus (1.86 cm) was recorded from the treatment combination of S_1V_1 which was significantly different from other treatment combinations followed by S_1V_2. The lowest thickness of pileus (0.66 cm) was recorded from the treatment combination of S_2V_3 which was statistically similar with the treatment combination of S_2V_6.

4.3 Yield parameters

4.3.1 Total number of fruiting body packet^{-1}

Significant variation was observed on number of fruiting body packet^{-1} influenced by different substrates (Table 4 and Appendix IV). The highest total number of fruiting body packet^{-1} (4.91) was observed in the substrate S_1 (Straw substrate) whereas the lowest total number of fruiting body packet^{-1} (4.00) was in the substrate S_2 (Sawdust substrate). Amin (2004) also found similar result who reported that the number of primordia grown on different substrates differed significantly. Kulsum *et al*. (2009) observed that the highest average number of fruiting body/packet was 60.42 due to sawdust supplemented with cow dung @ 10%. Akter *et al*. (2019) and Bhattacharjya *et al.* (2014) also found similar result with the present study.

Number of fruiting body packet^{-1} varied significantly due to varietal differences of mushroom (Table 4 and Appendix IV). The highest total number of fruiting body packet^{-1} (9.00) was found from the variety V_1 (PO2) followed by V_3 (WS) whereas the lowest total number of fruiting body packet^{-1} (1.70) was found from the variety V_4 (PO10). Rawte and Diwan (2019) also found similar result with the present study.

Significant variation was remarked on number of fruiting body packet^{-1} as influenced by different treatment combination of substrates varieties (Table 4 and Appendix IV). The highest total number of fruiting body packet^{-1} (10.00) was recorded from the treatment combination of S_1V_1 followed by S_1V_3. the lowest total number of fruiting body packet^{-1} (2.60) was recorded from the treatment combination of S_2V_4 which was statistically identical with the treatment combination of S_1V_4.

4.3.2 Number of effective fruiting body packet^{-1}

Number of effective fruiting body packet^{-1} was found significant with the use of different substrates (Table 4 and Appendix IV). The highest number of effective fruiting body packet^{-1} (2.89) was observed in the substrate S_1 (Straw substrate) whereas the lowest number of effective fruiting body packet^{-1} (2.23) was in the substrate S_2 (Sawdust substrate). The result of the present findings keep in with the findings of Amin, 2004; Sarker, 2004, Kulsum *et al*., 2009, Bhattacharjya *et al.* (2014) and Uddin *et al.* (2011) who reported that the number of fruiting bodies differed significantly due to variation on substrate mixtures.

Variation on number of effective fruiting body packet^{-1} was found influenced by different varieties of mushroom (Table 4 and Appendix IV). The highest number of effective fruiting body packet^{-1} (4.30) was found from the variety V_1 (PO2) followed by V_2 (POP) and V_3 (WS). The lowest number of effective fruiting body packet^{-1} (1.30) was found from the variety V_4 (PO10). The result obtained from the present study was conformity with the findings of Ferdousi *et al*. (2019) and Akter *et al*. (2019) with who found number of effective fruiting bodies differed due to varietal difference.

Number of effective fruiting body packet^{-1} affected by treatment combination of different substrates and varieties was significant (Table 4 and Appendix IV). The highest number of effective fruiting body packet^{-1} (5.20) was recorded from the treatment combination of S_1V_1 which was significantly different from other treatment combinations. The lowest number of effective fruiting body packet^{-1} (1.20) was recorded from the treatment combination of S_2V_4 which was statistically similar with the treatment combination of S_1V_4.

4.3.3 Biological yield of 1st harvest (g)

Significant variation was observed on biological yield of 1st harvest influenced by different substrates used in the present experiment (Table 4 and Appendix IV). The highest biological yield of 1st harvest (40.17 g) was observed in the substrate S_1 (Straw substrate) whereas the lowest biological yield of 1st harvest (31.84 g) was in the substrate S_2 (Sawdust substrate). Ashrafuzzaman *et al.* (2009) also found similar result with the present study who found significant variation on biological yield of 1st harvest due to different substrates.

Biological yield of 1st harvest was significantly varied due to different varieties of mushroom (Table 4 and Appendix IV). The highest biological yield of 1st harvest (47.00 g) was found from the variety V_3 (WS) which was significantly different from other varieties followed by V_5 (Oyster big) and V_7 (HK-51).

Table 4. Performance of different substrates and Oyster mushroom varieties on yield parameters regarding total number of fruiting body/packet, number of effective fruiting body/packet, harvesting number and biological yield of 1st harvest

Treatments	Yield parameters		
	Total number of fruiting body packet^{-1}	Number of effective fruiting body packet^{-1}	Biological yield of 1st harvest (g)
Effect of substrate			
S_1	4.91 a	2.89 a	40.17 a
S_2	4.00 b	2.23 b	31.84 b
$LSD_{0.05}$	0.104	0.052	3.447
CV(%)	5.70	9.51	10.18
Effect of variety			
V_1	9.00 a	4.30 a	40.20 c
V_2	5.40 c	3.10 b	33.00 d
V_3	6.20 b	3.10 b	47.00 a
V_4	1.70 f	1.30 e	19.20 f
V_5	2.80 e	2.10 c	43.90 b
V_6	2.70 e	1.80 d	24.10 e
V_7	3.40 d	2.20 c	44.63 b
$LSD_{0.05}$	0.301	0.142	1.728
CV(%)	5.70	9.51	10.18
Combined effect of substrate and variety			
S_1V_1	10.0 a	5.20 a	52.40 b
S_1V_2	5.20 c	3.20 cd	30.40 e
S_1V_3	8.60 b	4.20 b	60.40 a
S_1V_4	1.80 f	1.40 gh	20.00 hi
S_1V_5	2.80 e	2.20 ef	44.80 c
S_1V_6	2.80 e	1.60 g	23.60 gh
S_1V_7	3.20 de	2.40 e	51.20 b
S_2V_1	8.00 b	3.40 c	28.00 ef
S_2V_2	5.60 c	3.00 d	35.60 d
S_2V_3	3.80 d	2.00 f	28.85 e
S_2V_4	1.60 f	1.20 h	18.40 i
S_2V_5	2.80 e	2.00 f	43.00 c
S_2V_6	2.60 e	2.00 f	24.60 fg
S_2V_7	3.60 d	2.00 f	42.80 c
$LSD_{0.05}$	0.716	0.201	3.754
CV (%)	5.70	9.51	10.18

In a column means having similar letters) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_1 = Straw substrate, S_2 = Sawdust substrate

V_1 = PO2, V_2 = POP, V_3 = WS, V_4 = PO10, V_5 = Oyster big, V_6 = PSC, V_7 = HK-51

The lowest biological yield of 1st harvest (19.20 g) was found from the variety V_4 (PO10) which was significantly different from other varieties. Rawte and Diwan (2019) also found similar result with the present study.

Significant influence was noted on biological yield of 1st harvest affected by treatment combination of different substrates and varieties (Table 4 and Appendix IV). The highest biological yield of 1st harvest (60.40 g) was recorded from the treatment combination of S_1V_3 which was significantly different from other treatment combinations followed by S_1V_1 and S_1V_7. The lowest biological yield of 1st harvest (18.40 g) was recorded from the treatment combination of S_2V_4 which was statistically similar with the treatment combination of S_1V_3.

4.3.4 Total biological yield (g)

Remarkable variation was observed on total biological yield of mushroom influenced by different varieties (Table 5 and Appendix V). The highest total biological yield (146.63 g) was observed in the substrate S_1 (Straw substrate) whereas the lowest total biological yield (140.40 g) was in the substrate S_2 (Sawdust substrate). Supported results were also observed from the findings of Dubey *et al*. (2019), Girmay and Gorems (2016), Ashrafi *et al.* (2014), Bhattacharjya *et al.* (2014) and Mondal *et al.* (2010).

Total biological yield of mushroom varied significantly due to different varieties (Table 5 and Appendix V). The highest total biological yield (212.00 g) was found from the variety V_1 (PO2) followed by V_3 (WS) whereas the lowest total biological yield (94.30 g) was found from the variety V_4 (PO10). The result obtained from the present study was conformity with the findings of Ferdousi *et al*. (2019) and Akter *et al*. (2019).

Significant variation was remarked on total biological yield of mushroom as influenced by treatment combination of different substrates and varieties (Table 5 and Appendix V). The highest total biological yield (215.60 g) was recorded from the treatment combination of S_1V_1 which was significantly different from other treatment combinations followed by S_2V_1. The lowest total biological yield (93.60 g) was recorded from the treatment combination of S_2V_4 which was statistically similar with the treatment combination of S_1V_4 and S_2V_6.

4.3.5 Total economic yield (g)

Total economic yield was found significant with different substrates used in the present study (Table 5 and Appendix V). The highest total economic yield (142.40) was observed in the substrate S_1 (Straw substrate) and the lowest total economic yield (134.89) was in the substrate S_2 (Sawdust substrate). Supported result was also observed by Girmay and Gorems (2016), Ashrafi *et al.* (2014) and Mondal *et al.* (2010).

Variation on economic yield was recorded influenced by different varieties (Table 5 and Appendix V). The highest total economic yield (206.60) was found from the variety V_1 (PO2) which was significantly different from other varieties followed by V_3 (WS). The lowest total economic yield (89.00) was found from the variety V_4 (PO10) which was significantly different from other varieties. Ferdousi *et al*. (2019) and Akter *et al*. (2019) also found similar result which supported the present study.

Total economic yield of mushroom affected by different treatment combination of substrates varieties was significant (Table 5 and Appendix V). The highest total economic yield (209.80) was recorded from the treatment combination of S_1V_1 followed by the treatment combination of S_2V_1. The lowest total economic yield (88.20) was recorded from the treatment combination of S_2V_4 which was statistically similar with the treatment combination of S_2V_6.

Table 5. Performance of different substrates and Oyster mushroom varieties on yield parameters regarding total biological yield, economic yield and biological efficiency

Treatments	Yield parameters		
	Total biological yield (g)	Total economic yield (g)	Biological efficiency (%)
Effect of substrate			
S_1	146.63 a	142.40 a	73.31 a
S_2	140.40 b	134.89 b	70.20 b
$LSD_{0.05}$	1.364	3.529	0.879
CV(%)	7.94	5.00	8.94
Effect of variety			
V_1	212.00 a	206.60 a	106.00 a
V_2	132.00 d	126.20 d	66.00 d
V_3	192.70 b	187.80 b	96.35 b
V_4	94.30 g	89.00 g	47.15 g
V_5	155.90 c	154.70 c	77.95 c
V_6	101.10 f	95.30 f	50.55 f
V_7	116.60 e	110.90 e	58.30 e
$LSD_{0.05}$	4.421	4.304	2.553
CV(%)	7.94	5.00	8.94
Combined effect of substrate and variety			
S_1V_1	215.60 a	209.80 a	107.80 a
S_1V_2	136.80 g	131.40 g	68.40 g
S_1V_3	197.20 c	192.40 c	98.60 c
S_1V_4	95.00 k	89.80 k	47.50 k
S_1V_5	159.80 e	163.00 e	79.90 e
S_1V_6	103.40 j	97.400 j	51.70 j
S_1V_7	118.60 i	113.00 i	59.30 i
S_2V_1	208.40 b	203.40 b	104.20 b
S_2V_2	127.20 h	121.00 h	63.60 h
S_2V_3	188.20 d	183.20 d	94.10 d
S_2V_4	93.60 k	88.20 k	46.80 k
S_2V_5	152.00 f	146.40 f	76.00 f
S_2V_6	98.80 jk	93.20 jk	49.40 jk
S_2V_7	114.60 i	108.80 i	57.30 i
$LSD_{0.05}$	7.176	5.391	3.588
CV (%)	7.94	5.00	8.94

In a column means having similar letters) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_1 = Straw substrate, S_2 = Sawdust substrate

V_1 = PO2, V_2 = POP, V_3 = WS, V_4 = PO10, V_5 = Oyster big, V_6 = PSC, V_7 = HK-51

4.3.6 Biological efficiency (%)

The recorded data on biological efficiency was significantly influence by different substrates (Table 5 and Appendix V). Results showed that the highest biological efficiency (73.31) was observed in the substrate S_1 (Straw substrate) whereas the lowest biological efficiency (70.20) was in the substrate S_2 (Sawdust substrate). Similar result was also observed by Girmay and Gorems (2016), Sharma *et al.* (2013) and Uddin *et al.* (2011).

Considerable influence was observed on biological efficiency persuaded by different varieties of mushroom (Table 5 and Appendix V). The highest biological efficiency (106.00) was found from the variety V_1 (PO2) which was significantly different from other varieties followed by V_2 (POP) and V_3 (WS). The lowest biological efficiency (47.15) was found from the variety V_4 (PO10). Ferdousi *et al*. (2019), Akter *et al*. (2019) and Rawte and Diwan (2019) also found supported result with the present study.

Remarkable variation was identified on biological efficiency due to the combined effect of different substrates and varieties of mushroom (Table 5 and Appendix V). The highest biological efficiency (107.80) was recorded from the treatment combination of S_1V_1 which was significantly different from other treatment combinations followed by S_2V_1. The lowest biological efficiency (46.80) was recorded from the treatment combination of S_2V_4 which was statistically similar with the treatment combination of S_2V_6.

Table 6. Performance of different substrates and oyster mushroom varieties on yield parameters regarding total yield, economic yield and biological efficiency

Treatments	Yield parameters		
	Total biological yield (g)	Total cost per spawn packet (Tk.)	Gross return (Tk. per spawn packet)
Effect of substrate			
S_1	146.63	10.00	35.60
S_2	140.40	10.00	33.70
$LSD_{0.05}$	--	--	--
CV(%)	--	--	--
Effect of variety			
V_1	212.00	10.00	51.70
V_2	132.00	10.00	31.60
V_3	192.70	10.00	46.90
V_4	94.30	10.00	22.30
V_5	155.90	10.00	38.70
V_6	101.10	10.00	23.80
V_7	116.60	10.00	27.70
$LSD_{0.05}$	--	--	--
CV(%)	--	--	--
Combined effect of substrate and variety			
S_1V_1	215.60	10.00	52.50
S_1V_2	136.80	10.00	32.90
S_1V_3	197.20	10.00	48.10
S_1V_4	95.00	10.00	22.50
S_1V_5	159.80	10.00	40.80
S_1V_6	103.40	10.00	24.40
S_1V_7	118.60	10.00	2.8.30
S_2V_1	208.40	10.00	50.90
S_2V_2	127.20	10.00	30.30
S_2V_3	188.20	10.00	45.80
S_2V_4	93.60	10.00	22.10
S_2V_5	152.00	10.00	36.60
S_2V_6	98.80	10.00	23.30
S_2V_7	114.60	10.00	27.20
$LSD_{0.05}$	--	--	--
CV (%)	--	--	--

In a column means having similar letters) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

S_1 = Straw substrate, S_2 = Saw dust substrate

V_1 = PO2, V_2 = POP, V_3 = WS, V_4 = PO10, V_5 = Oyster big, V_6 = PSC, V_7 = HK-51

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out at the Mushroom Development Institute (MDI), Savar, Dhaka under the Department of Agricultural Extension (DAE), Dhaka, during the period from October 2019 to February 2020 to find out the performance of Oyster mushroom (*Pleuratus spp.*) species in the winter of Bangladesh. The experiment consisted of two substrates *viz*. S_1 (Straw substrate) and S_2 (Sawdust substrate) and seven varieties, *viz*. V_1 (PO2), V_2 (POP), V_3 (WS), V_4 (PO10), V_5 (Oyster big), V_6 (PSC) and V_7 (HK-51). The experiment was laid out in Completely Randomized Design (CRD) with three replications. The recorded data on various parameters were statistically analyzed using MSTAT statistical package program. The summary of the results has been presented in this chapter.

Influence of different substrates, maximum parameters studied under the present experiment showed significant variation. The highest days required from pin head initiation to 1st harvest (10.11) was observed from the substrate S_1 (Straw substrate) but the highest total cropping duration (81.74 days) was observed from S_2 (Sawdust substrate). On the other hand, the lowest days required from pin head initiation to 1st harvest (9.09) was found from S_2 (Sawdust substrate) whereas the lowest total cropping duration (80.46 days) was obtained from S_1 (Straw substrate). Similarly, the highest length of stalk (3.98 cm), diameter of stalk (1.75 cm), length of pileus (8.07 cm), diameter of pileus (6.26 cm), thickness of pileus (1.14 cm), total number of fruiting body packet^{-1} (4.91), number of effective fruiting body packet^{-1} (2.89), biological yield of 1st harvest (40.17 g), total biological yield (146.63 g), economic yield (142.40) and biological efficiency (73.31) were observed from the substrate S_1 (Straw substrate). On the other hand, the lowest length of stalk (3.95 cm), diameter of stalk (1.65 cm), length of pileus (7.85 cm), diameter of pileus (5.99 cm), thickness of pileus (0.85 cm), total number of fruiting body packet^{-1}

(4.00), number of effective fruiting body packet^{-1} (2.23), biological yield of 1st harvest (31.84 g), total biological yield (140.40 g), economic yield (134.89) and biological efficiency (70.20) was in the substrate S_2 (Sawdust substrate)

Different varieties of Oyster mushroom showed significant variation on different parameters. The highest days required from pin head initiation to 1st harvest (15.10) was found from the variety V_7 (HK-51) whereas the lowest (6.30) was found from V_2 (POP). Similarly, the highest total cropping duration (90.40 days) was found from the variety V_3 (WS) whereas the lowest total cropping duration (70.60 days) was found from the variety V_4 (PO10). Again, it was observed that the highest length of stalk (4.55 cm), length of pileus (9.21 cm), thickness of pileus (1.37 cm), total number of fruiting body packet^{-1} (9.00), number of effective fruiting body packet^{-1} (4.30), total biological yield (212.00 g), economic yield (206.60) and biological efficiency (106.00) were found from the variety V_1 (PO2). Similarly, biological yield of 1st harvest (47.00 g) was found from the variety V_3 (WS) whereas the highest diameter of stalk (2.38 cm) and the highest diameter of pileus (7.55 cm) was found from the variety V_5 (Oyster big). On the other hand, the lowest length of stalk (3.26 cm), diameter of stalk (1.42 cm), length of pileus (6.33 cm) and diameter of pileus (4.96 cm) was found from the variety V_6 (PSC) but the lowest total number of fruiting body packet^{-1} (2.70), number of effective fruiting body packet^{-1} (1.30), biological yield of 1st harvest (19.20 g), total biological yield (94.30 g), economic yield (89.00) and biological efficiency (47.15) were found from the variety V_4 (PO10) whereas the lowest thickness of pileus (0.78 cm) was found from the variety V_3 (WS).

Treatment combination of different substrate and variety of Oyster mushroom showed significant influence on different parameters studied under the present study. Results revealed that the highest days required from pin head initiation to 1st harvest (15.60) was recorded from the treatment combination of S_1V_7 whereas the lowest (5.80) was recorded from of S_2V_2. Again, the highest total cropping duration (91.20 days) was recorded from S_2V_3 whereas the lowest total cropping duration (70.20 days) was recorded from S_1V_4. Accordingly, the highest length of stalk (5.12 cm), length of pileus (9.70 cm), thickness of pileus (1.86 cm), total number of fruiting body packet^{-1} (10.00), number of effective fruiting body packet^{-1} (5.20) and total biological yield (215.60 g), economic yield (209.80) and biological efficiency (107.80) were recorded from the treatment combination of S_1V_1. Similarly, the highest biological yield of 1st harvest (60.40 g) was recorded from S_1V_3. But the highest diameter of stalk (2.60 cm) and diameter of pileus (7.70 cm) were recorded from the treatment combination of S_1V_2 and S_1V_5, respectively. Conversely, the lowest length of stalk (3.18 cm), diameter of stalk (1.369 cm), length of pileus (6.12 cm) and diameter of pileus (4.44 cm) were recorded from the treatment combination of S_2V_6. Accordingly, the lowest thickness of pileus (0.66 cm) was recorded from the treatment combination of S_2V_3. Once again, the lowest total number of fruiting body packet^{-1} (2.60), number of effective fruiting body packet^{-1} (1.20), biological yield of 1st harvest (18.40 g), total biological yield (93.60 g), economic yield (88.20) and biological efficiency (46.80) were recorded from the treatment combination of S_2V_4

From the above results, it can be concluded that Oyster mushroom (*Pleorotus ostreatus*) cultivated on straw substrate (S_1) gave the highest yield compared to sawdust substrate. S_1 also gave best economic yield and biological efficiency. In case of varietal performance, V_1 (PO2) gave highest total biological yield, economic yield and biological efficiency compared to other varieties. Regarding, treatment combination of substrate and variety, the highest total biological yield, economic yield and biological efficiency was recorded from S_1V_1 (straw substrate with PO2 variety). So, this treatment combination (S_1V_1) can be considered as best compared to other treatment combinations.

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APPENDICES

Appendix I. Monthly records of air temperature, relative humidity and rainfall during the period from November 2019 to February 2020.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2019	November	28.60	8.52	18.56	56.75	14.40
2019	December	25.50	6.70	16.10	54.80	0.0
2020	January	23.80	11.70	17.75	46.20	0.0
2020	February	22.75	14.26	18.51	37.90	0.0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix II. Performance of different substrates and oyster mushroom varieties on growth parameters

Sources of variation	Degrees of freedom	Mean square of growth parameters	
		Days required from pin head initiation to 1st harvest	Total cropping duration (days)
Replication	4	3.950	6.307
Factor A	1	6.497*	NS
Factor B	6	79.53*	526.20*
AB	6	20.25*	1.029**
Error	52	2.919	5.015

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix III. Performance of different substrates and oyster mushroom varieties on the size of fruiting body

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters				
		Length of stalk (cm)	Diameter of stalk (cm)	Length of piteus (cm)	Diameter of piteus (cm)	Thickness of piteus (cm)
Replication	4	0.260	0.131	0.626	0.689	0.214
Factor A	1	NS	NS	0.847**	NS	1.429*
Factor B	6	1.962**	0.976**	8.971*	7.668*	0.407**
AB	6	1.321**	0.210**	2.760*	1.468**	0.488**
Error	52	0.635	0.316	3.405	1.334	0.350

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IV. Performance of different substrates and oyster mushroom varieties on yield parameters regarding total number of fruiting body/packet, number of effective fruiting body/packet, harvesting number and biological yield of 1st harvest

Sources of variation	Degrees of freedom	Mean square of yield parameters			
		Total number of fruiting body/packet	Number of effective fruiting body/packet	Harvesting number	Biological yield of 1st harvest (g)
Replication	4	2.664	0.479	0.764	7.610
Factor A	1	14.629*	7.557*	NS	1215.88*
Factor B	6	65.195*	10.19*	7.257*	1180.51*
AB	6	8.995*	2.290**	0.495**	503.617*
Error	52	5.518	0.825	0.618	16.748

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Performance of different substrates and oyster mushroom varieties on yield parameters regarding total yield, economic yield and biological efficiency

Sources of variation	Degrees of freedom	Mean square of yield parameters		
		Total biological yield (g)	Total economic yield (g)	Biological efficiency (%)
Replication	4	7.836	12.607	4.459
Factor A	1	78.914*	98.129*	69.729*
Factor B	6	205.18*	209.22*	514.04*
AB	6	22.248*	23.295*	5.562**
Error	52	13.974	8.046	7.994

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level