PERFORMANCE OF MAIZE STRAW AS SUBSTRATES FOR OYSTER MUSHROOM CULTIVATION

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PERFORMANCE OF MAIZE STRAW AS SUBSTRATES FOR OYSTER MUSHROOM CULTIVATION

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CERTIFICATE

This is to certify that the thesis entitled, ***"PERFORMANCE OF MAIZE STRAW AS SUBSTRATES FOR OYSTER MUSHROOM CULTIVATION"*** *submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of Master of Science in Horticulture, embodies the result of a piece of bona fide research work carried out by* ***MOST. ATIKA BEGUM*** *Registration No.* ***18-09266*** *under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: December, 2020
Place: Dhaka, Bangladesh

Prof. Md. Hasanuzzaman Akand
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DEDICATED
TO MY
BELOVED PARENTS
AND
HONORABLE TEACHERS

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PERFORMANCE OF MAIZE STRAW AS SUBSTRATES FOR OYSTER MUSHROOM CULTIVATION

ABSTRACT

An experiment was carried out at the Tissue Culture Laboratory and Culture House of Mushroom Development Institute, Savar, Dhaka, during the period from July 2019 to December 2019 to find out the performance of different amount of maize straw substrates on the growth and yield of oyster mushroom. The experiment consisted of three varieties, viz. V_1 (*Pleurotus djamor*), V_2 (*Pleurotus florida*) and V_3 (*Pleurotus ostreatus*) and five different amount of maize straw substrates with 10% mother culture such as T_1 = 500g per packet, T_2 = 750 g per packet, T_3 = 1000 g per packet, T_4 = 1500 g per packet and T_5 = 2000 g per packet. The experiment was laid out in Completely Randomized Design (CRD) with four replications. Significant variation was found in all parameter due to the effect of different amount of maize straw substrates. The highest number of fruiting body (19.00), number of effective fruiting body (12.08) and highest yield (128.67g) were recorded in T_3 treatment. On the other hand, variety of mushroom showed influence on all parameter. The maximum yield (92.60 g), the highest number of fruiting body (17.80), number of effective fruiting body (11.10) were observed in V_2 variety. The combination between different variety of oyster mushroom and different amount of maize straw substrates was found significant variation on the yield. The maximum yield (164.75g) was produced by V_2T_3 treatment and the minimum yield (49.75g) was produced by V_1T_1 which followed by V_1T_5 treatment.

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LIST OF ABBREVIATIONS

Abbreviation	=	Full word
%	=	Percent
@	=	At the rate
°C	=	Degree Centigrade
Anon.	=	Anonymous
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
CV	=	Coefficient of Variance
cv.	=	Cultivar (s)
DAI	=	Days After Inoculation
HSD	=	Honestly Significant Difference
e.g.	=	(For example) exampoli gratia
et al.	=	(And Others) et alibi
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram
hr	=	Hour (s)
i.e.	=	That is
IRRI	=	International Rice Research Institute
ISTA	=	International Seed Testing Agency
kg	=	Kilogram
LSD	=	Least Significant Difference
no.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
T	=	Treatment
t/ha	=	Ton per Hectare
UNDP	=	United Nation Development Program
$^{W}/_{V}$	=	Weight per Volume
$^{W}/_{W}$	=	Weight per Weight
wt.	=	Weight
BE	=	Biological efficiency
MRR	=	Mycelium Running Rate
NMDEC	=	National Mushroom Development and Extension Center
MCC	=	Mushroom Culture Centre
mg	=	Milligram
CHO	=	Carbohydrate
Conc.	=	Concentration

CHAPTER I

INTRODUCTION

Oyster mushrooms are one kind of edible saprophytic fungi growing on dead organic matters of vegetative origin belonging to the genus *Pleurotus* under the class Basidiomycetes (Mondal *et al*., 2010). They (*Pleurotus djamor ,Pleurotus florida and Pleurotus ostreatus*) are having outstanding flavor and taste with fan shaped pileus which is rich source of both macro and micro nutrients. Oyster mushrooms is rich in nutritional value with protein (25-50%), fat (2-5%), sugars (17-47%), mycocellulose (7-38%) and minerals (potassium, phosphorus, calcium, sodium) of about 8- 12% (Sher, 2010). The vegetative part of mushroom consists of thread like long thin mycelium which under suitable condition forms fruiting body or sporocarps. This fruiting body is used as edible mushroom. Mushroom is a highly nutritious, delicious, medicinal and economically potential vegetable (Alam and Saboohi, 2001). Mushrooms can be eaten raw or processed. As a vegetable, Mushroom can play an important role to meet the nutritional requirements of the population of Bangladesh.

Oyster mushroom is cultivated worldwide, especially in Southeast Asia, India, Europe and Africa. They can be cultivated under both temperate and tropical climatic conditions and harvested all over the year. Mushrooms are recognized as important food items from ancient times. Usages of mushrooms are increased day by day because of the significant role in human health and nutrition (Khan *et al.,* 2008). The oyster mushrooms (*Pleurotus spp*) are in the third place after the white button and shiitake among the world mushroom production (Gyorfi *et al.,* 2007). Oyster mushrooms are the easiest and least expensive commercial mushrooms to grow because they are well known for conversion of crop residues to food protein. Mushroom cultivation is one of the most commercially important steps towards diversification of agriculture.

Ecological requirements of oyster mushrooms vary at the various stages of growing period. The growth of oyster mushroom requires high humidity (80-90%) and high temperature (25-30°C) for the vegetative growth called spawn running and lower temperature (18-25°C) with high humidity 80 to 95% during fruit body formation, (Onyango *et al.*, 2011 and Nadir *et al.,* 2016). Oyster mushroom naturally grows in the forest and since the forest light is bluish fluorescent light can be used for lighting (Kong,

2004). Species of oyster mushroom show good adaptability to a wide range of temperature, making it possible to grow this mushroom almost round-the-year without recourse to controlled climatic conditions (Chadha, 2001). The mushroom is cultivated indoors using the container system with polyethylene bags being widely used. Culture of Oyster mushroom is becoming popular throughout the world because of abilities to grow at a wide range of temperatures and to utilize various lignocelluloses.

Cultivation of edible mushrooms with agricultural and agro-industrial residues as substrate is an efficient and economically reliable technology for converting these materials into a valuable protein rich food and a cash crop of commercial interest (Zhang *et al.*, 2002). Growing medium of the mushroom is generally known as substrate. *Pleurotus spp*. can consume a vast variety of crop residues because it has a great ability to grow on residues (Mamiro & Mamiro, 2011). *Pleurotus* species require carbon, nitrogen and inorganic compounds as their nutritional sources. The main nutrients are less nitrogen and more carbon so materials containing cellulose, hemicellulose and lignin (i.e., rice, maize and wheat straw, cotton seed hulls, sawdust (SD), waste paper, leaves, and sugarcane residue) can be used as mushroom substrates (Chang *et al.*, 1989). Oyster mushroom can grow on a wide variety of substrate. However, the yield and the quality of oyster mushroom depend on the chemical and nutritional content of substrates (Badu *et al.*, 2011 and Patil *et al.*, 2010). Again agricultural substrates such as paddy straw, vegetable residues, maize stalks and cotton waste are utilized for cultivation of oyster mushroom (Hassan *et a*l., 2011).Substrates having high levels of nitrogen and carbohydrate contents are categorized as ideal for mushroom growth (Khare *et al*., 2010). Majority of farmer use rice straw for oyster mushroom production as and they are not familiar with efficiency and methods of *Pleurotus* mushroom production using other agro bi-products like maize straw, maize cob, lentil straw, wheat straw etc. During the main harvesting period, maize straw is in abundance and farmers dispose of them by burning. If grounded maize straw can support the growth of oyster mushroom, then it would serve as a cheap source of substrate for mushroom growers. The grounded form of maize straw is very firm and retains good amount of moisture to make it a plausible alternative to saw dust (Buah *et al.,* 2010). An alternative way of use of agricultural residues/wastes is in the use of the organic material in mushroom production (Chang *et al*., 2004 and Khare *et al.,* 2010).

Maize straw is very common and suitable substrate for oyster mushroom cultivation. The utilization of maize residues as substrate for oyster mushroom cultivation under controlled conditions has been reported by Atikpo *et al.*, (2008), Obodai *et al.*, (2003), and Onyango *et al*., (2010). Straw such as from the cereals like maize are rich in carbon hence, low biological efficiencies of less than 100% were previously reported when sole substrates were used to grow mushrooms (Zireva *et al*., 2007). Again maize straw is a lignocellulosic biomass which contains components such as cellulose (34.0%), hemicellulose (37.5%), and lignin (22%) (Feng *et al.*, 2012). It is well known that, mycelium growth and mushroom production both are affected by cellulose, hemicelluloses and lignin proportions along with nitrogen content of the cultivating substrate (Mata and Savoie, 2005). The carbon nitrogen ratio (C/N ratio) for maize straw is about 66.31% (Hills and Roberts, 1981).

Nowadays maize is one of the major crops grown in Bangladesh and its residues (husks, cobs, and stalks) are abundant and available during the year and could be exploited as a sustainable substrate for mushroom growing. Rice straw is very good for mushroom cultivation but in Bangladesh rice straw is very famous as cattle feed on the other hand maize straw is mostly used as fuel. So in mushroom cultivation we can use maize straw as a substitute of rice straw. The extrapolation of laboratory growing successes of mushroom in abroad on maize residues but in Bangladesh need to be tested under control conditions using homegrown crop varieties like *Pleurotus djamor ,Pleurotus florida and Pleurotus ostreatus* before it can be recommended to local farmers. On the other hand environmental pollution is a threat from many industries including agro-based ones due to the dumping of wastes like wood shavings and cotton waste from ginneries. Farm wastes like maize straw also have the same effect. There is thus need to utilize and evaluate the productivity potential of these waste materials for mushroom production since they are rich in lingo-cellulose, hence, helping reduce environmental pollution. This study investigated the relative performance of indigenous maize stalks in oyster mushroom cultivation suitable laboratory under control conditions. The potential of these substrates with mother culture to support oyster mushroom cultivation was also determined.

Moreover, In our country oyster mushroom is now widely cultivated because the weather and climate of Bangladesh is suitable for its cultivation and the necessary materials required for oyster mushroom cultivation such as maize straws are available and cheap. The present studies were planned to find out the easiest, economical and practicable methodology of preparation and use of maize straw, which may also be helpful to increase the growth and productivity of oyster mushroom. The results will help and guide the mushroom growers, especially the people interested in the cultivation of oyster mushrooms. Keeping the above facts in mind, the present research work was carried out to study the responses of maize straw on oyster mushroom with the following objectives:

1. To find out better variety for maize straw substrates.
2. To determine the optimum amount of substrate for growth and yield of oyster mushroom.
3. To find out the benefit cost ratio of maize straw based spawn packets.

CHAPTER II

REVIEW OF LITERATURE

In this chapter an attempt has been made to review the available information in home and abroad regarding the performance of maize straws as substrates for oyster mushroom cultivation. Many research organization of our country has limited information about the oyster mushroom cultivation along with maize straws. But in foreign countries there are more numbers of relevant data. A review of the previous research and findings of researchers having relevance to this study which were gathered from different sources like literature, journals, thesis, reports, newspaper etc. will be represented by this chapter. However, some of the literature related to this investigation are reviewed in this chapter under the following heads:

2.1 Overview of Oyster mushroom

Mushrooms are one kind of edible fungi belonging to the genus *Pleurotus* under the class Basidiomycetes (Mondal *et al.*, 2010). Oyster mushroom (*Pleurotus ostreatus*) is an edible mushroom having outstanding flavor and taste. Recently, its importance and nutritive value has been realized and well utilized in human consumption diet. There are several species of Pleurotus identified in the world. Most of them are suitable for cultivation. Some *Pleurotus* species are *Pleurotus ostreatus, Pleurotus columbinus, Pleurotus florida, Pleurotus salignus, Pleurotus spodoleucus, Pleurotus pulmonarius; and subspices are Pleurotus sajor-caju, Pleurotus sapidus, Pleurotus populinus, Pleurotus cornucopiae, Pleurotus djamor, Pleurotus flabellatus, Pleurotus eryngii, Pleurotus cystidiosus, Pleurotus calyptratus, Pleurotus dryinus, Pleurotus purpureo-olivaceus and Pleurotus tuber-regiu* (Nadir *et al*., 2016). However, the most important cultivated species is *Pleurotus ostreatus*, being easier to cultivate, favourable to eat, and grow economically on different kinds of organic waste raw material (Kong, 2004).

Uddin *et al.*, (2011) investigated the production of four species of oyster mushroom: *Pleurotus ostreatus, P. florida, P. sajor-caju* and *P. djamor* high king cultivated in every season (January to December) in Bangladesh. The temperature (in ºC) 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 (14-27ºC, 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^{0}C with relative humidity 70-80%) for better production and biological efficiency.

Shukla and Jaitly (2011) conducted an investigation, in India, on genetic diversity of oyster mushroom species observing different morphological traits such as mycelia growth, stipe length, and cap diameter, margin of fruit body, color of fruit body, total yield, carbohydrate content and protein content, along with their DNA markers. The reported that *Pleurotus* species *florida, P. djamor, P. citriopileatus, P. sajor-caju* and *H. ulmarius* show great diversity in their morphological characters as well as biochemical parameters.

Pleurotus spp. can consume a vast variety of crop residues because it has a great ability to grow on residues (Mamiro and Mamiro, 2011).

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.

Mushroom is a macro fungus with a distinctive fruiting body, which can either be epigeous or hypogeous, and large enough to be seen with naked eye, and to be picked by hand. Mushrooms belong to the Kingdom of Fungi, a group very distinct from plants, animals and bacteria. Mushrooms lack chlorophyll. Most mushrooms are saprophytic; they obtain organic matter from dead plants and recycle carbon in the soil. The biology

of this group of fungi is therefore from the mycelium to the basidiocarp (fruiting body) (Kashangura *et al.,* 2005). The living body of the mushroom fungus is mycelium made out of a tiny web of threads (or filaments) called hyphae. Under specific conditions, sexually compatible hyphae will fuse and start to form spores. The larger spore producing structures bigger than about 1 mm are called mushrooms (Oei and Nieuwenhuijzen, 2005). The mycelium is the vegetative body of the mushroom and is responsible for its nutrition.

Mushrooms in nature grow on roots of trees and in the soil as mycelium like as the case of *Pleurotus spp*. (Kashangura *et al.,* 2005).
Mushroom production fits in very well with sustainable farming as it uses agricultural waste products, high production per surface area can be obtained, and the spent substrate is still a good soil conditioner (Oei and Nieuwenhuijzen, 2005). The rapid development and growth of the mushroom industry from a primitive cave culture into one using more highly technical and controlled methods was stimulated in the 1960s (Hall, 2003).

Oyster mushroom (*Pleurotus ostreatus*) is a common edible mushroom long cultivated in Asia. China is the world's largest edible mushroom producer (Dinghaun and Xiaoyong, 2004). Recently, oyster mushroom is cultivated around the world, especially in subtropical and temperate regions. It is a saprophyte that acts as a primary decomposer of woods especially deciduous trees, particularly beech (Phillips and Roger, 2006). Oyster mushroom can adapt better than other species of mushroom outside their place of origin (Chang and Miles, 2004).

The life cycle of a mushroom fungus is shorter than that of plants. Fungi mushrooms multiply by producing millions of spores. When a spore settles in a suitable environment, it can germinate and branch to form a mycelium. When two sexually compatible mycelia meet they may fuse to form a so-called secondary mycelium, which is capable of forming fruiting bodies (mushrooms) (Oei, 2003).

Culture of Oyster mushroom is becoming popular throughout the world because of abilities to grow at a wide range of temperatures and to utilize various lignocelluloses. *Pleurotus* species have extensive enzyme systems capable of utilizing complex organic

compounds that occur as agricultural wastes and industrial by-products. These mushrooms are also found to be one of the most efficient lignocelluloses solid state decomposing types of white rot fungi. (Baysal *et al.*, 2003).

2.2 The Importance of mushroom cultivation

Oyster mushrooms (*Pleurotus spp*.) have high value and short life cycle of up to 30 days (Chitamba, 2007) that results in quick returns; coupled with a huge local demand. Its production can be done irrespective of age, gender or skill (Gume *et al.,* 2013). Thus, mushroom cultivation is a potential income generating activity for the poor particularly in sub-Saharan Africa (Ahmed *et al*., 2013; Gume *et al.,* 2013).

Other advantages of oyster mushroom are that it is rich in all essential amino acids, and minerals and vitamins such as ascorbic acid, thiamine, riboflavin, folic acid and niacin (Pathmashini *et al*., 2008; Yehia, 2012; Ahmed *et al*., 2013; Gume *et al*., 2013). Mushrooms have some medicinal properties against non-communicable diseases such as cancer and cardio-vascular diseases (Tikdari and Bolandnazar, 2012; Gume *et al*., 2013).

Oyster mushroom does not require large capital investments (Tikdari and Bolandnazar, 2012). Almost all crop residues are suitable as oyster mushroom substrates (Aguilar *et al.*, 2010; Yehia, 2012).

Oyster mushrooms are mainly saprophytes that get their nutritional requirements from a host substrates or from the agricultural wastes that are rich in lignin, cellulose and hemicelluloses (Tikdari and Bolandnazar, 2012).

Patel *et al.,* (2012) in their comprehensive review on "Medicinal Properties of *Pleurotus Species"* pointed out the culinary values owing to their protein, vitamin, fibre contents and medicinal properties. They stated out that the bioactive compounds like "polysaccharides, lipopolysaccharides, proteins, peptides, glycoproteins, nucleosides, triterpenoids, lectins, lipids and their derivatives" determine their chemical nature that gives them therapeutic values such as antimicrobial, antiviral, antineoplastic, antitumor, antimutagenic, antioxidant, antilipidemic, hyperglycemic, hypotensive,

antiinflammatory, hypocholesterolemic, immunomodulatory, hepatoprotective and antiageing properties; make them so called nutraceuticals

According to Yehia (2012), most Pleurotus species have the ability to utilise cellulose, hemicelluloses and lignin because of their ability to produce lignocellulosic enzymes. These enzymes digest complex carbohydrates into simple sugars, which are readily absorbed and utilized by the mushrooms as carbon sources (Aguilar *et al*., 2010).This helps to transform inedible residues into edible biomass that is of high market value (Yang *et al.,* 2013). The waste produced after mushroom production can be used as compost and is good in controlling nematodes (Aguilar *et al.,* 2010).

Oyster mushrooms are the easiest and least expensive commercial mushrooms to grow because they are well known for conversion of crop residues to food protein. They are also rich source of proteins, minerals and vitamins (Caglarirmak, 2007).

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*.

Reports have been made on the use of Perenniporia mundula to treat pleurisy and impotence in Zambia, Malawi and Zimbabwe. Some tribes use the same fungus to cure nose bleeding and dizziness (Kashangura *et al*., 2005).

Spent substrate from mushroom production can also be utilized as a soil conditioner (Oei and Nieuwenhuijzen, 2005).

On a large scale, harvesting of mushrooms also require a lot of labour hence creating employment for both people in the rural and peri-urban areas (Kurtzman, 2004).

Mushrooms also contain vitamins B, C, D, and carbohydrates. They also lower blood cholesterol level and are low in sodium which makes them ideal for persons with certain types of heart and kidney ailments. In addition they also contain phosphorus, potassium and low levels of iron (Pauli, 2003).

Oyster mushrooms are a more valuable source of protein than either cattle or fish on dry weight basis, and are good source of almost all the essential amino acids when compared with most vegetables and fruits (Matila *et al.,* 2002). They are also good sources of non-enzymatic antioxidant vitamins (Kumari and Achal, 2008). *Ganoderma spp*. was believed to boost the immune system (Atkins, 2001).

Research has shown that mushrooms are a good protein source and they may be eaten fresh or sun dried. They are rich in lysine and tryptophan that are deficient in cereals (Chadha, 2001). Mushrooms are a good source of high quality proteins containing both essential and non-essential amino acids for the human diet. They contain 20-35% protein on a dry wet basis, which is higher than that in vegetables, fruits and legumes (Bose *et al*., 2001).

They secrete various enzymes that hydrolyze unwanted waste material from industry. Fungi also degrade polycyclic aromatic hydrocarbons while some mushrooms produce oxidative enzymes used in bioleaching and bio pulping to replace the unfriendly chemicals such as chlorine that usually end up in drinking water. Mushrooms also absorb heavy metals, thus they can be used to clean up the environment (Ryvarden *et al*., 2001).

Lin and Lin (2001) revealed that the oyster mushrooms are primary decomposers that help on the recycling of matter by decomposing woody material into sugars and mineral elements to be absorbed by plants for growth and development.

About 1800 species are used as medicines. Some cultivated mushrooms such as *Lentinula edodes* and *P. ostreatus* are medicinal because they lower blood pressure and they have low cholesterol content (Stamets and Chiton, 2000).

2.3 Oyster mushroom cultivation technology

Ecological requirements of oyster mushrooms vary at the various stages of growing period. The optimal temperatures for growing mycelia and pin forming are between 20 to 30^0C and 10 to 20^oC respectively. Substrate moisture should be 60 to 75%, but it should be 80 to 95% during the fruiting, because 80% or over of the fruit body is water (Nadir *et al.*, 2016).

Siwulski *et al*., (2012) studied the effects of imposed lighting intensity and period on yield four strains of oyster mushroom using Day-Light Fluorescent lamps in the cultivation room. The results revealed that lighting had a significant effect on yield. The carpophore morphological features- cap diameter as well as the length and thickness of the stem - were also affected by the duration and intensity of lighting.

Nunes *et al.,* (2012) have grown *Pleurotus ostreatus* mushrooms on corncobs, eucalyptus sawdust, eucalyptus bark, sugarcane bagasse, coffee husks, supplemented with 0.5% urea or 20% rice bran and studied the biological efficiency, mineral element composition, β-glucan and protein contents. It was concluded that supplementation with nitrogen increased both yield and nutritional quality of the mushrooms.

Oseni *et al.*, (2012b) pointed out that the cultivation of oyster mushroom is easy owing to their strong enzymatic action on growing medium. However, the preparation of substrates is troublesome. Thus they tried to devise practical ways of substrate preparation. For this purpose the authors tested autoclaving (121°C) and hot water pasteurization (60°C) of sugarcane bagasse and horse manure compost. All substrates were supplemented with 20% wheat bran. Results of tests showed that the contamination was high in horse manure compost. Pasteurization with hot water at 60°C for 3 h of sugarcane bagasse could be a promising method of substrate pre-treatment in places where autoclave sterilization is not practical.

Sanchez *et al.,* (2011) tested an alternate method to steam heating for substrate pasteurization in mushroom production. The composted growing substrate *Digitaria decumbens* containing 2% lime. Four different moisture contents (55, 60, 65 and 70%) were tested. The self-heating of the material in the composting wooden boxes during 48 hour period was comparably effective, in eliminating organisms like flies, bacteria and competitor fungi, to steam pasteurization at 90ºC for 1 h).

Moonmoon *et al.,* (2010) studied king Oyster mushroom *Pleurotus eryngii* on saw dust and rice straw in Bangladesh and found that saw dust showed the highest biological efficiency (73.5%) than other strains.

Hasan *et al.,* (2010) carried out experiments to test the effects of 12 different lime containing mixtures of growth medium on the growth and yield of oyster (*Pleurotus ostreatus*) in Bangladesh. They recorded the highest yield with the growth medium consisting of rice straw mixed with 10% of poultry litter and 1% lime. Other parameters like mycelium running, growth rate and duration of mushroom production were also affected by the growing mixtures, containing horse dung or cow dung, at various degrees.

Onokpise *et al.,* (2007) reported that recycling waste and supplementation techniques in the production of mushrooms especially *Pleurotus* species that live on a wide range of substrates is beneficial to reduce pollution control.

Pleurotus species are popular and widely cultivated throughout the world mostly in Asia and Europe owing to their simple and low cost production technology and higher biological efficiency (Mane, 2007).

Pleurotus ostreatus is different from the other cultivated mushroom which prefers a low level of light during its growth. Oyster mushroom naturally grows in the forest and since the forest light is bluish, fluorescent light can be used for lighting (Kong, 2004).

Mushroom science dealing with mushroom cultivation and production embodies principles of microbiology, environmental technology, and solid-state fermentation

involving the conversion of lignocelluloses biomass waste materials, into food for humans (Lin and Lin, 2001).

The technology for mushroom cultivation can be primitive as in rural farming in developing countries and it can also be highly industrialized. The latter requires advanced knowledge of mushroom biology and technology, and the use of sophisticated equipment, which are largely a monopoly of the developed countries (Stamets, 2000). It should be noted that the cultivation of mushrooms deals with living organisms: not only the mushroom itself, but also other microorganism including both harmful and beneficial ones. Therefore, the methods employed in mushroom cultivation require some modification from one region to another, since different environmental conditions and different species of microorganisms may be encountered (Jandaik *et al*., 2000).

2.4 Oyster mushroom production constraints

Insect pests that attack the oyster mushroom belong to the Order Diptera. These include cecid fly, phorid fly and the sciarid fly. Mites are also a common problem. Rats are also a problem as they eat the mushroom bags along the spawn layers (Kashangura *et al*., 2005).

Royse, (2003) reported that deformed fruit body may be caused by insufficient ventilation, smoke, chemical vapors, overheated substrate during spawn run, extreme low fruiting temperature of below 100^{o}C and insufficient light.

Oei (2003) reported that substrate having high quality lignin and cellulose contents takes a longer time to start pinning and fruit body formation.

Viruses, molds and bacteria may also compete with the mushroom mycelium thereby decreasing production (Chiu *et al.*, 1998).

Mushrooms are usually eaten for their culinary properties, providing a flavouring and garnish for other foods. They are cultivated using special techniques and are usually consumed by the rich people, because the price of mushrooms is usually higher than that of the most common vegetables. These may give one the impression that mushrooms constitute a luxury food item, and that their promotion would only benefit

relatively rich people. There is a notion that most mushrooms are poisonous and deadly hence their rejection by people for adoption in their culture (Van der Westhuizen, 1994).

2.5 Effect of different variety of substrates used for mushroom culture

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 study emphatically indicated that reuse of spent mushroom substrate with supplementation can be a good solution to address the disposal problem whereas supplemented SMS can be a good substrate for further mushroom production.

Randive (2012) experimented with two different agricultural waste: paddy rice straw and wheat straw to grow grey and pink oyster mushrooms and studied their yield and nutritional value. It was concluded that the utilized agricultural wastes and methods of production were suitable for obtaining high yield and nutrient content.

Stanley (2011) has evaluated the effect of supplementing corn cob substrate with rice bran on yield of *Pleurotus pulmonarius* (Fr) Quel. Un-supplemented corn cob (0% supplementation) gave the best yield in terms of the mean diameter of pileus 5.50cm, mean fresh weight of fruiting bodies 53.2g, mean height of stipe 3.64cm and number of healthy fruiting bodies as 12. The least yield was recorded with 30% supplementation as follows: mean diameter 3.20cm, mean fresh weight of fruiting bodies 30.0g, mean height of stipe 1.65cm and number of healthy fruiting bodies as 5.in terms of quantity and quality, the un-supplemented substrate produced better edible mushrooms.

Saidu *et al*., (2011), in Malaysia, studied the effects of four different growth media containing oil palm monocarp fiber, rice bran, sawdust lime at varying percentages on spawn running time and development of fruiting bodies of oyster mushrooms. Results revealed that the mixtures containing the oil palm fiber was a good substrate for the cultivation of this mushroom.

Moonmoon *et al.,* (2010) has reported on saw dust, the yield and efficiency were better than those cultivated on rice straw, however, on straw; the mushroom fruiting bodies were larger in size. This study shows the prospects of *P. eryngii* cultivation in Bangladesh and suggests further study in controlled environment for higher yield and production.

Dündar and Yildiz (2008) conducted a research to study the cultivation of *Pleurotus ostreatus* in Turkey. Within this study, they used wheat stalk, cotton stalk, and 100 g of main material with (70% moisture) to the substrate. This study illustrated that the shortest mycelium growing time, the shortest harvest time and total harvested amount were realized on soybean stalk, while the longest for harvesting and growing times for mycelium and the total lowest harvested amount were obtained with cotton stalk.

Ali *et al*., (2007) conducted a trial, in Pakistan, to test some industrial and agricultural wastes as substrates (ring sweeping, saw dust, luckrine razing, cotton boll locules, chimney gutter and blow gutter) for growing various *Pleurotus* species. Their results showed that the fat contents of the species were affected by the growing medium, chimney gutter giving the highest fat content. The maximum protein content was obtained by from *Pleurotus cornucopiae* growing on blow gutter.

Growing mushrooms on a substrate of water hyacinth was first promoted by the Chinese University of Hong Kong, and has been taken up by the African University of Mutare in Zimbabwe. The advantage of using water hyacinth, which is an unwanted weed that clogs up many waterways in Africa, is that the costs of preparing the substrate can be kept down (The Schumacher Centre for Technology and Development, 2006).

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).

Silva *et al.*, (2005) reported that mycelium extension is related to bio availability of nitrogen when they found that eucalyptus residues supplemented with cereal bran supported fast growth. However, the low amount of available nitrogen (N) in the lignocellulosic substrate of wood components is often considered as a limitation to its use as mushroom substrate.

Ananbeh and Almomany (2005) investigated the use of agricultural waste olive cake for oyster mushroom production in Jordan. Six different mixtures of olive cake and wheat straw were tested against a control consisting wheat straw + wheat bran + gypsum mixture. Growth parameters such as primordial induction and fructification period, earliness, average weight of individual basidiomata, average yield for each treatment, diameter of the pileus, as well as the nutritional value and micro and macro element contents of *Pleurotus ostreatus* growing on these mixtures were determined. The results show that the growth medium containing 30% olive cake gave the highest yield, average weight average cap length and biological efficiency with carbohydrate. Mineral element concentrations (P, Ca, Mg and microelements) were similar in all treatments.

Shah *et al.*, (2004) tested different substrates such as wheat straw, leaves, and sawdust for *Pleurotus ostreatus* production in Pakistan, focusing on the nutritional value, yield, and number of fruiting body and biological efficiency of mushroom growing on these substrates. They concluded that sawdust was the best one among the others with respect to yield, quality and efficiency

Al Amin (2004) in his experiment revealed that the highest number of primordia and fruiting bodies of Oyster mushroom was found in sterilized paddy straw.

Maniruzzaman (2004) in his study found that substrate rice was the best for spawn production of Oyster mushroom. Oyster mushroom (locally known as dhingri) is easy to grow comparatively in tropical and subtropical climate. These species are characterized by the rapidity of their mycelial proliferation.

Substrate productivity refers to the potential of a substrate to produce yield of fresh mushrooms. Substrate productivity is evaluated by using three parameters which are

mushroom number, weight as well as biological efficiency. Mushroom quality is evaluated on the basis of four mushroom cap size groups (larger than 7 cm, 5 to 7 cm, 3 to 5 cm, and smaller than 3 cm), and a "deformed group" (Rossi *et al*., 2003).

Baysal (2003) investigated paper waste supplemented with rice husk, chicken manure and peat for *Pleurotus ostreatus* cultivation. Highest yield for fresh weight was recorded as 350.2 grams in the substrate containing 20% rice husk. The values of commercial cultivation of mushrooms, especially in a developing economy like Nigeria, is the availability of large quantities of several agro-industrial wastes which can serve as substrates for the cultivation of mushrooms.

Nasir Ahmad Khan (2002) has observed that *Pleurotus ostreatus* gave the maximum yield in the first flush followed by second and third flush. The maximum yield was obtained on Kikar sawdust 282.2gm followed by Mango sawdust 257.7gm, mixed sawdust 233gm, Simbal sawdust 216.5gm and Kael 200.5gm.Oyster mushroom showed relatively more yield on control treatment of cotton waste as compared to other substrates. The maximum biological efficiency was obtained in kicker sawdust which was 70.56 %. The lowest biological efficiency was obtained in kicker sawdust which was 50.12 %. Among all substrates, sawdust of Kicker proved the best substrates for the effective cultivation of Oyster mushroom.

Comparing rice straw with wheat straw, rice straw yielded about 10% more mushroom than wheat straw under the same cultivation conditions (Zhang *et al.*, 2002).

Obodai *et al.*, (2002) reported that sawdust substrate for mushroom production should undergo a period of composting to breakdown the cellulose and lignin components of the wood in order to release the essential materials for the establishment of mushroom mycelium. The lingo-cellulosic materials in sawdust are generally low in protein content and thus insufficient for the cultivation of mushrooms, and therefore require additional nitrogen, phosphate and potassium.

Mushrooms can be cultivated on a wide variety of substrates. The quality of the substrate is the main factor in the success of growing mushrooms as it provides all the energy and nutrients that the mushrooms will use while growing. Different strains of

mushroom will require different substrate mixes. The substrate must not be rotten, moldy and should be kept dry while in storage (Stamets and Yao, 2001). However, unlike in Agaricus bisporus, composting is not essential in oyster mushroom production (Mswaka *et al.,* 2001).

Maria Florence and Balasundaran (2000) stated that mushroom cultivation has created an opportunity for self-employment for a large number of people. In their study, growing different species of *Pleurotus* were experimented on wood waste, fallen trees and forest leaf litter. Leaf litter was found to be the best substrate to cultivate *Pleurotus* because it gave the highest yield and the best quality. These researchers stated that the polythene bag method was economical and resulted in higher yield of mushrooms.

Agricultural wastes are often used as a source of material for the substrate including; cassava stalks, cocoa pods, coffee bean husks, coffee pulp, corn cobs, corn stubble, cotton seed cake, pulse husks, rice hulls, sawdust, sugarcane bagasse, tealeaves, tobacco stalks, wheat straw and water hyacinth. In many parts of Zimbabwe wheat straw, bush grass and horse manure are commonly used with the addition of chicken manure, cottonseed meal, ammonium nitrate or urea, gypsum (calcium carbonate) (Stamets and Chiton, 2000).

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.

2.6 Effect of maize as substrate used for mushroom culture

Earnshaw *et al.,* (2012) conducted a research to study the suitability of various agricultural wastes as substrate for oyster mushroom production. Substrates like banana leaves, sugar cane and maize wastes were amended (0, 10 and 15%) and used as growth medium of *Pleurotus ostreatus*. Parameters such as the yields of mushroom flushes, yields, pileus diameters and stipe lengths were recorded. Various substrate mixtures yielded significantly differing results concerning the observed parameters. The highest yields were obtained on maize stover and cobs which were amended with 15% wheat bran.

Mamiro *et al*., (2011) tested the effects of two different mixtures of growth medium on oyster mushroom growth in Tanzania. The basal substrate rice straw was supplemented with banana leaves, *Leucaena leucocephala*, maize bran or maize cobs at various ratios (0 to 100%) or supplemented with sunflower or cotton seed cake at o to 5 %. The result showed that the 50-50% banana leaves - rice straw mixture resulted in the highest yield and biological efficiency. The largest mushrooms, however, were obtained from rice straw alone.

Pathmashini *et al.*, (2008) tested four the types of locally available grain spawns (kurakkan, maize, sorghum and paddy) on oyster mushroom production using sawdust as the growth medium. They concluded that biological efficiency, size and yield of mushrooms were significantly enhanced by kurakkan (*Eleusine coracana*) spawn in comparison to other spawns used in the experiment.

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).

Banjo *et al*.,(2004) has been reported that mushrooms can grow on chopped cocoa pods, cotton waste, dried chopped maize straw, oil palm (fibre and bunch) wastes, tobacco straw, used tea leaves, rice straw, sugarcane bagasse, newsprint, old rags and sawdust.

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.

Obodai *et al*., (2003) evaluated eight lignocellulosic by-products as substrate, for cultivation of the oyster mushroom. *Pleurotus ostreatus* (Jacq. ex. fr.) Kummer. The yields of mushroom on different substrates were 183.1, 151.8, 111.5, 87.5, 49.5, 23.3, 13.0 and 0.0 g for composted Sawdust of *Triplochiton scleroxylon*, Rice straw, Banana leaves, Maize stover, Corn husk, Rice husk, Fresh Sawdust and Elephant grass respectively. The biological efficiency (BE) followed the same pattern and ranged from 61.0%, for composted Sawdust to 50.0% for elephant grass. The Yield of mushroom was positively correlated to cellulose (r2 = 0.6). Lignin (r2 = 0.7) and fiber (r2 = 0.7) contents of the substrates. Based on the yield and BE of the substrates tested, Rice straw appeared to be the best alternate substrate for growing oyster mushroom.

Badshah *et al.,* (1994) mentioned that *Pleurotus ostreatus* and *P. florida* were grown on wheat straw, sugarcane bagasse, corn cobs or sawdust, by mixing 120-130 g of spawn with 2 kg of substrate and placing the mixture in sterilized polyethylene bags which were kept in the dark at 25°C for 2-3 weeks. Once the bags became full of mycelial growth, they were removed, leaving the substrate uncovered. Watering was carried out 2-3 times a day. Fruiting bodies were harvested at maturity. *P. ostreatus* and *P. florida* yields ranged from 49.8 and 277.7 g/2 kg substrate respectively on sawdust, to 432.8 and 420.5 g/ 2 kg substrate respectively, on wheat straw. Controls (grown in the field) yielded only 18.5 and 28.5 g/2 kg substrate for *P. ostreatus* and *P, florida,* respectively. In both species, wheat straw and sugarcane bagasse substrates resulted in the highest mushroom ascorbic acid contents and protein, fat and fiber contents were also affected by substrate. *Pleurotus florida* had higher fat but lower protein contents than *P. ostreatus.*

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out to find out the performance of different amount of maize straw substrates on the growth and yield of oyster mushroom. This chapter deals with a brief description on location and design of experiment, experiments and treatments, preparation of substrates, preparation of packets, cultivation of spawn packet, collection of produced mushrooms, data recording and their statistical analysis under the following headings and sub-headings.

3.1 Location

The experiment was carried out at the Tissue Culture Laboratory and Culture House of Mushroom Development Institute, Savar, Dhaka, during the period from July 2019 to December 2019. Experimental site was given in appendix I.

3.2 Experimental materials

Three oyster Mushroom varieties such as-V_1 (*Pleurotus djamor*), V_2 (*Pleurotus florida*) and V_3 (*Pleurotus ostreatus*) were tested on different amount of maize straw substrates. Five spawn packets of 500 g, 750 g, 1000 g, 1500 g and 2000 g was prepared by through spawning method and was maintain the definite substrates amount.

3.3 Treatments

The experiment was consisted with the following two treatment factors:

Factor-A: Mushroom variety

V_1 = *Pleurotus djamor (Pop)*

V_2 = *Pleurotus florida (Flo)*

V_3 = *Pleurotus ostreatus (Po2)*

Factor-B: Amount of maize straw substrates with 10% mother culture

T_1= 500 g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

3.4 Experimental design:

The experiment was laid out in Completely Randomized Design (CRD) with four replications. The experiments with fifteen treatments with four replications were conducted to achieve the desired objectives.

3.5 Preparation of pure culture:

Pure cultures of three strains were prepared on Potato Dextrose Agar (PDA) medium. A fresh and juvenile stage sporophore of above mentioned mushrooms were collected and surface sterilized with 70% alcohol by rubbing cotton soaked in alcohol. Tissues were collected from inner region of the joint of stalk and pileus. The tissues cut into small pieces and placed on the solidified test tube containing PDA. After inoculation, the tube was covered with cork. All operations were done under sterile condition in a clean bench. The inoculated tubes were kept in a growth chamber maintaining temperature at 20-25^{0}C and incubated 8-15 days until the tubes full of whitish mycelia. Then the pure culture was used for inoculation of mother culture.

3.6 Preparation of mother culture:

To prepare mother culture of test mushroom (*Pleurotus djamor*, *Pleurotus florida and Pleurotus ostreatus*) good quality paddy grains were used as media of mother culture. At first 2 kg of grains collected which was free from diseases and not broken, old, and insect damaged. The grains were throughly washed in sufficient water three to four times to remove unfilled grain, soil debris, straw particles and other undesirable things. Then washed grains were soaked in sufficient water for 2-3 hours and boiled in a container (saucepan) for 30- 45 minutes until cracking. Excess water from the boiled grains was removed by heating and continuous shaking. When the water removed burner was stopped. Then the boiled grains were kept 1-2 hours for cooling. The cooled grains were thoroughly mixed with sawdust containing master mother culture at 10% rate. This mixing was done the same container after wearing gloves and the mixed grains were poured into polypropylene bags (18cm × 25cm) at 250-300 g/bag and their mouths were plugged by inserting absorbing cotton without neck. The bags were kept in rack at room temperature. After 10 to 15 days the mother culture became white due to complete the mycelium running and then it was ready for spawning of spawn packets.

3.7 Preparation of substrates:

Maize straw were used as media. The substrates were prepared by pasteurization method. At first maize straw was chopped 4-5 cm by chaff cutter machine. Then 40 kg maize straw mixed with 35 litter of water and mixture was poured into cribriform nylon bag. After that the bags containing maize straw were kept in a pasteurization chamber at 60-70 ^{0}C for one and half hour. The bags were kept in same place for 18-20 hours to get cool slowly. After 20 hours the prepared maize straw were spread over polythene sheet in open place to reduce moisture 63%. These substrates were ready for spawn packet preparation.

3.8. Preparation of spawn packets

According to treatment combination prepared substrates and 10% mother culture were mixed throughly and filled into different size' (8×11) inch, (9×12) inch, (10×14) inch, (12×16) inch and (14×18) inch of polypropylene bags and in right amount such as 500 g, 750 g, 1000 g, 1500 g and 2000g per bag. The mouths of the filled polypropylene bags were plugged by inserting absorbing cotton with the help of plastic neck and rubber band by spawning method.

3.8.1 Mycelium running in spawn packets/ Incubation:

The spawn packets were kept at room temperature until the packets become white with the mushroom mycelium. After completion of the mycelium running the rubber band, 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.

3.8.2 Opening the packet:

Two ends, opposite to each other of the upper position i.e. on shoulder of plastic bag were cut in "D" shaped with a blade and opened by removing the plastic sheet after which the opened surface of substrate was scraped slightly with a blade for removing the thin whitish mycelial layer.

3.8.3 Cultivation of spawn packet:

The spawn packets by maize straw substrate were placed separately on the rack of culture room. The moisture of the culture room was maintained 80-85% relative

humidity by spraying water 3-5 times a day. The light around 150-200 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. The harvesting time also varied depending upon the type of substrate and variety.

3.8.4 Cultural operation, collection of produced and harvesting of mushroom:

After completing the first harvest again the packets were scrapped at the place where the 'D' shaped cut had been done 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.

3.9 Data collection:

Data were collected on the following parameters:

3.9.1 Days required pinhead initiation to 1st harvest:

Days required from pinhead initiation to 1st harvest were recorded.

3.9.2. Number of fruiting body/packet:

Number of total fruiting body was recorded.

3.9.3. Number of effective fruiting body/packet:

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

3.9.4. Dimension of pileus and stalk:

Thickness of the pileus of four randomly selected fruiting bodies were recorded using a slide caliper. Length and diameter of pileus, length and diameter of stalk were recorded.

3.9.5. Yield:

Yield in g/packet was recorded by weighing all the fruiting bodies in a packet after removing the lower hard and dirty portion.

3.10 Biological efficiency:

Biological efficiency was determined by the following formula:

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

3.11 Benefit cost ratio:

The benefit cost ratio for different amount of substrates were computed based on present market price of mushroom and cost of different inputs in the markets (Sarker, 2004).

Benefit cost ratio= Price per packet /Production cost per packet

3.12 Statistical analysis:

The recorded data were compiled and analyzed by CRD design to find out the statistical significance of experimental results by using the "Analysis of variance" (ANOVA) technique with the help of statistics 10 that was an analysis software. The mean differences were adjudged by Tukey HSD (Honestly Significant Difference) test.

CHAPTER IV
RESULTS AND DISCUSSION

This chapter represents the results of the screening of different oyster mushroom with maize straw which are presented in several Figures and Tables for better understanding. The findings of the study and interpretation of the results under different critical sections comprising growth, yield contributing characteristics, yield and quality parameters are also presented and discussed in this chapter under the following sub-headings to achieve the objective of the study.

4.1 Days required from pinhead initiation to 1st harvest

Days required from pinhead initiation to 1st harvest is important growth parameters of mushroom cultivation. Significant variation was observed in days required from pinhead initiation to 1st harvest due to the effect of substrates amount. The lowest time (3.00 days) from pinhead initiation to 1st harvest was in the treatment T_5 and the highest time (4.48 days) from pinhead initiation of 1st harvest was observed in the treatment T_3 (Figure 1). Aguilar *et al.,* (2010) and Yang *et al.,* (2013) reported that oyster mushrooms require materials which are high in lignocellulosic materials. The optimum substrate combination was a 4:1 ratio of maize straw to bean straw. Crop residues vary in nutritional composition, with some being more nutritious than others. Mushroom growth is favored by substrates that are high in lignocellulose (Tikdari and Bolandnazar, 2012). Royse (2002) found as the spawn rate increased the number of days to production decreased. A highly nutritive substrate also improves the sustenance of mycelia vegetative growth which leads to vigorous growth and late pinning (Kimenju *et al.,* 2009).

On the other hand, in case of variety of mushroom also influence on days required from pinhead initiation to 1st harvest. The lowest time (3.18 days) from pinhead initiation to 1st harvest was in the treatment V_3 (*Pleurotus ostreatus*) and the highest time (4.10 days) from pinhead initiation to 1st harvest was observed in the treatment V_2 (*Pleurotus florida*) (Figure 2).

Interaction effect of varieties and different amount of substrates was found significant on days required from pinhead initiation to 1st harvest. The lowest time (3.00 days) from pinhead initiation to 1st harvest was in the treatment V_1T_1, V_1T_5, V_2T_5, V_3T_1 and V_3T_5 and the highest time (5.50 days) from pinhead initiation to 1st harvest was observed in

the treatment V_2T_3 that was *Pleurotus florida* treated with maize straw (1000 g per packet) (Table 1).

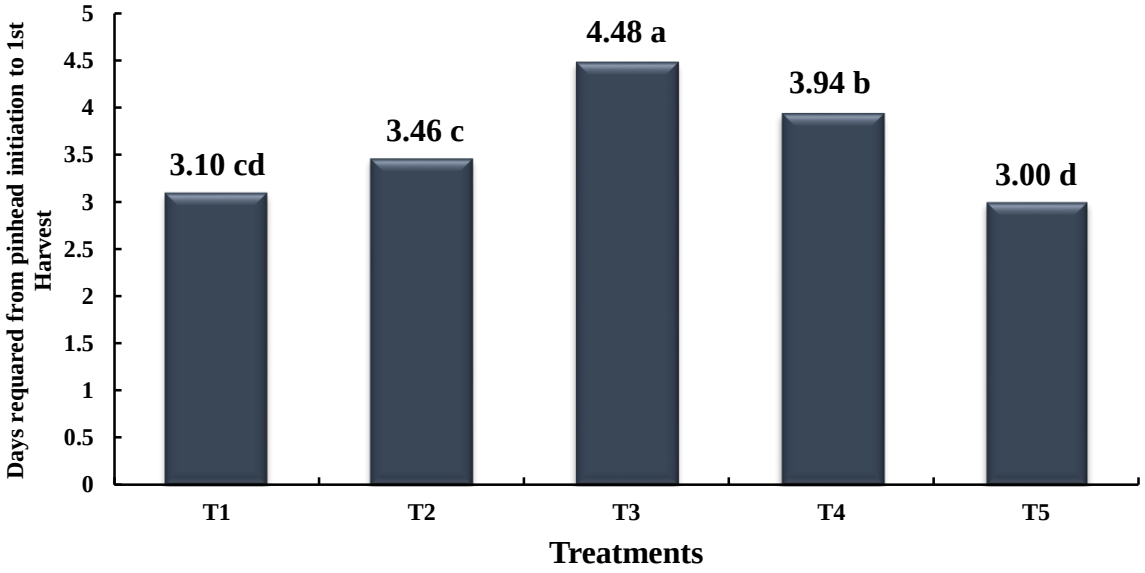

Figure 1. Effect of different amount of substrates on days required from pinhead initiation to 1st harvest of oyster mushroom

Here, T_1 = 500g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

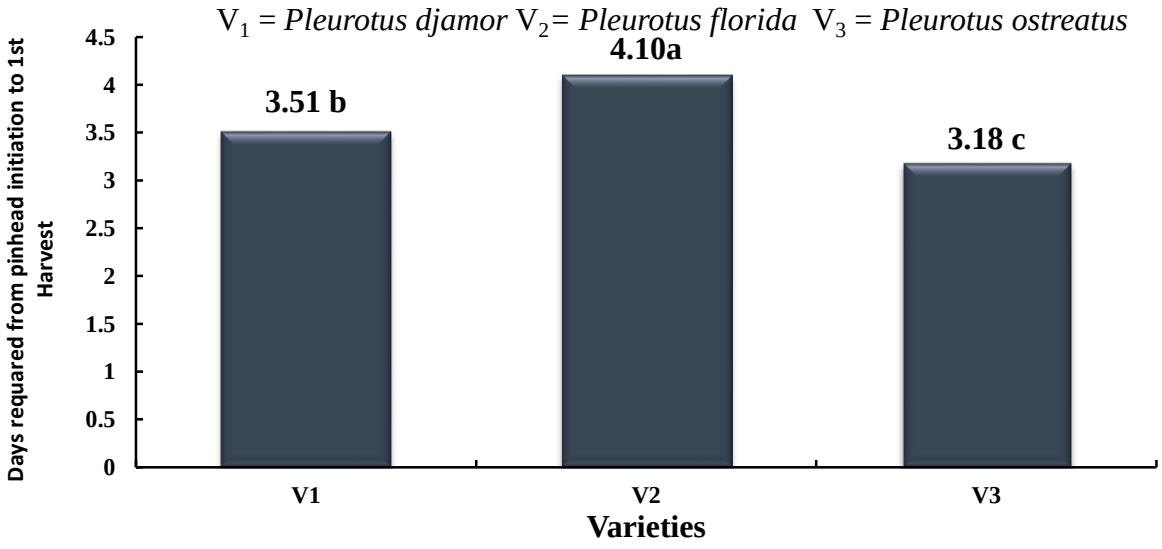

Figure 2. Effect of variety on days required from pinhead initiation to 1st harvest of oyster mushroom

4.2 Number of fruiting body/packet

Number of fruiting body/packet is an important yield determining factor in mushroom cultivation. The number of fruiting body was influenced by the application of different level of maize straw and mother culture. The highest number of fruiting body (19.00) was recorded in the treatment T_3 that was 1000g's packet, which was statistically followed by T_4 treatment and the lowest number of fruiting body (7.17) was in the treatment T_5 (Figure 3). Amin (2004) reported that the number of primordia grown on different substrates differed significantly. Sarker (2004) found that the number of primordia increased with the levels of supplement and continued up to a certain range and decline. Maize husk and stalk were the most suitable in terms of the number of fruiting bodies and fresh weight of mushroom and are therefore recommended as potential substrate for cultivation of oyster mushroom reported by Abena *et al.*, (2015).

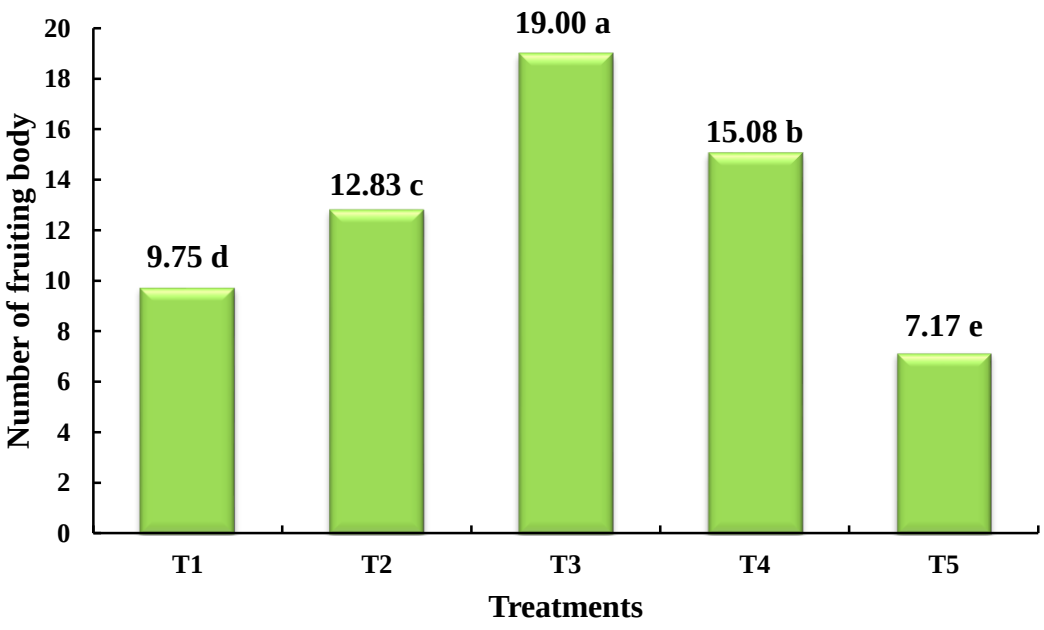

Figure 3. Effect of different amount of substrates on number of fruiting body of oyster mushroom

Here, T_1 = 500g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

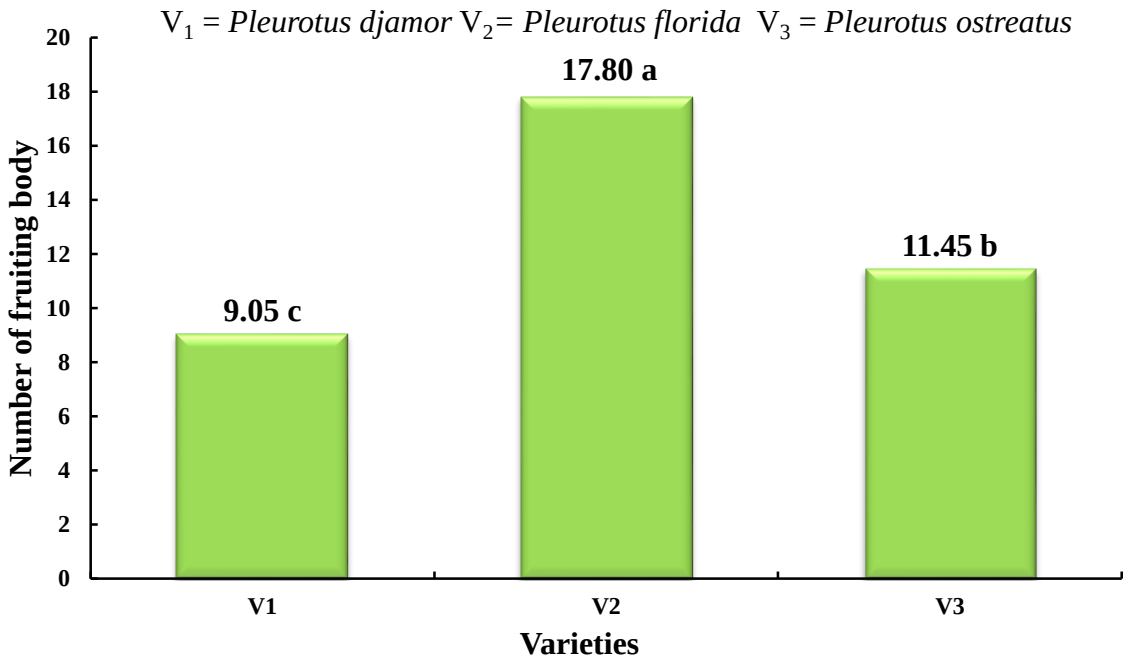

Figure 4. Effect of variety on number of fruiting body of oyster mushroom

Results showed that there were significant difference in number of fruiting body per packet among varieties (Figure 4). V_2 (*Pleurotus florida*) had highest number of fruiting body (17.80). On the other hand, V_1 had lower number of fruiting body that was 9.05. Combined effect of varieties and amount of substrates were showed significant variation on number of fruiting body (Table 1). The highest number of fruiting body (27.50) was founded in the treatment V_2T_3 (*Pleurotus florida)* with maize straw and the lowest number of fruiting body (5.25) was in the treatment V_1T_5 (*Pleurotus djamor)* with maize straw.

4.3 Number of effective fruiting body/packet

Number of effective fruiting body/packet is also an important parameter contributing towards the final yield. Data presented in (figure 5) show that number of effective fruiting body/packet was significantly affected by different levels of substrates amount. The comparison of treatments revealed that maximum number of effective fruiting body/packet (12.08) was recorded from T_3 treatment which was statistically followed by T_4 treatments. The minimum number of effective fruiting body/packet (3.17) was recorded from T_5 treatment. The treatment may be ranked in order of $T_3>T_4>T_2>T_1>T_5$.

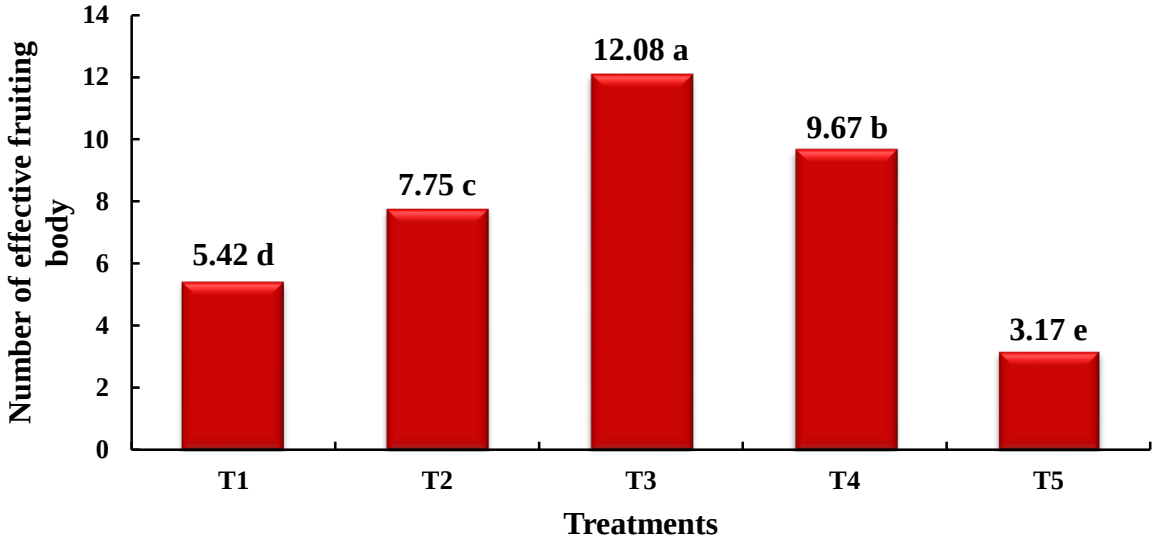

Figure 5. Effect of different amount of substrates on number of effective fruiting body of oyster mushroom

Here, T_1 = 500g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

V1 = *Pleurotus djamor* V2= *Pleurotus florida* V3 = *Pleurotus ostreatus*

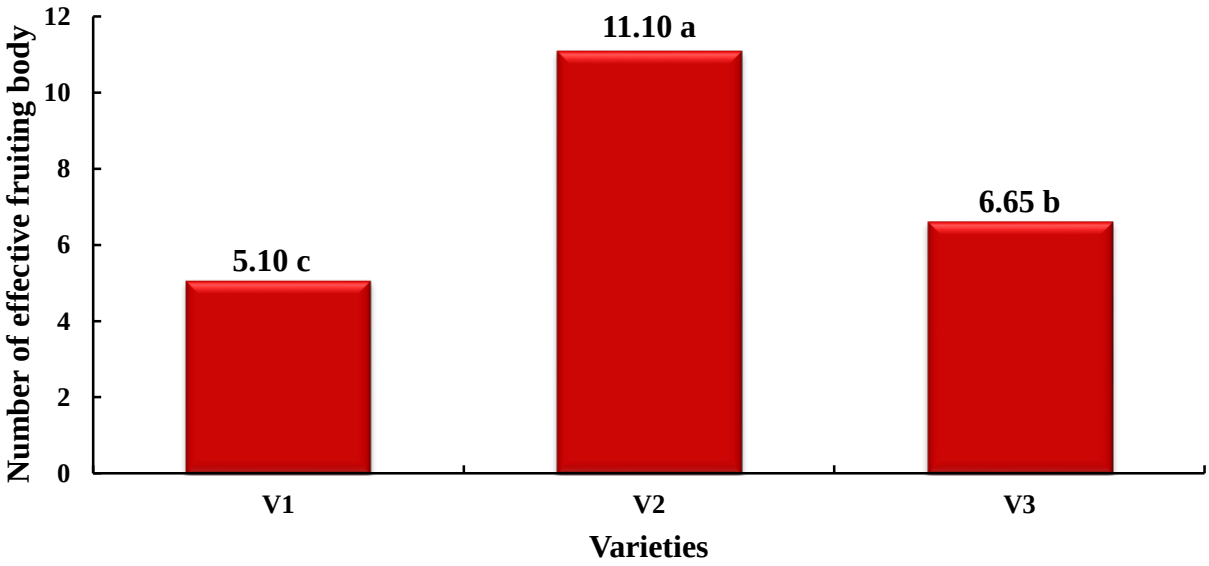

Figure 6. Effect of variety on number of effective fruiting body of oyster mushroom

Table 1. Combined effect of varieties and different amount of substrates on days required pinhead initiation to 1st harvest, number of fruiting body and number of effective fruiting body of oyster mushroom

Treatments (Combinations)	Days required from pinhead initiation to 1st Harvest	Number of fruiting body	Number of effective fruiting body
V_1T_1	3.00 f	7.00 hi	3.25 fgh
V_1T_2	3.31 def	9.00 gh	5.00 ef
V_1T_3	4.38 bc	13.50 de	8.25 d
V_1T_4	3.88 bcde	10.50 efg	6.75 de
V_1T_5	3.00 f	5.25 I	2.25 h
V_2T_1	3.31 def	13.00 de	8.25 d
V_2T_2	4.00 bcd	17.25 c	11.25 c
V_2T_3	5.50 a	27.50 a	17.75 a
V_2T_4	4.69 ab	21.75 b	14.00 b
V_2T_5	3.00 f	9.50 fgh	4.25 fg
V_3T_1	3.00 f	9.25 fgh	4.75 fg
V_3T_2	3.06 ef	12.25 ef	7.00 d
V_3T_3	3.56 cdef	16.00 cd	10.25 c
V_3T_4	3.25 def	13.00 de	8.25 d
V_3T_5	3.00 f	6.75 hi	3.00 gh
Significant level	**	*	*
CV (%)	8.96	9.83	10.24

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.
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Here, V_1 = Pleurotus djamor, V_2= Pleurotus florida and V_3 = Pleurotus ostreatus

T_1 = 500g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

***Significant at 1% probability level and * Significant at 5% probability level.*

Yoshida *et al*., (1993) reported that the number of fruiting bodies was lower but increased when the substrates was mixed with different supplements. Amin (2004)

reported that the number of primordia grown on different substrates differed significantly. Sarker (2004) found that the number of primordia increased with the levels of supplement and continued up to a certain range and decline thereafter.

Data presented in figure 6 show that number of effective fruiting body/packet was affected significantly by different mushroom varieties. The maximum number of effective fruiting body (11.10) was observed from V_2 treatment. The minimum number of effective fruiting body (5.10) was found from V_1 treatment.

Combined effect of varieties and amount of substrates was showed significant variation on number of effective fruiting body (Table 1). The highest number of effective fruiting body (17.75) was observed in the treatment V_2T_3 (*Pleurotus florida)* with maize straw (1000g/packet) and the lowest number of fruiting body (2.25) was in the treatment V_1T_5 (*Pleurotus djamor)* with maize straw (2000g/packet).

4.4 Diameter of stalk

The application of different amount of maize straw substrates affect the diameter of stalk significantly varied (Figure 7). The highest statistically superior diameter of stalk was 1.34 cm recorded in the treatment T_3. On the other hand, the lowest diameter of stalk 0.63 cm was obtained in the treatment T_5. Longer stalk were observed from T_3 treatment flowed by T_4 and T_2 Treatments.

Among the varieties a significant variation in the diameter of stalk was clearly observed. The largest stalk diameter (1.25 cm) was obtained from V_2 treatment that was followed by V_3, and the shortest stalk diameter (0.68 cm) was obtained from V_1 treatment (Figure 8).

Significant variation was found on number of diameter of stalk to the interaction effect of mushroom varieties and different amount of substrates (Table 2). However, the maximum diameter of stalk (1.65 cm) was recorded from *Pleurotus florida* with maize straw (1000g/packet) and minimum diameter of stalk (0.50) was found *Pleurotus djamor* with maize straw (2000g/packet).

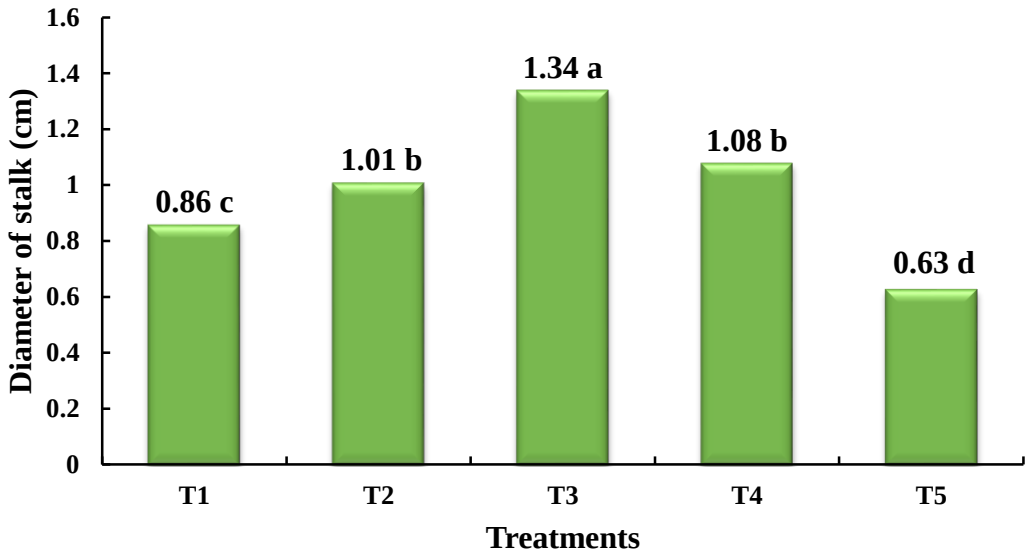

Figure 7. Effect of different amount of substrates on diameter of stalk of oyster mushroom

Here, T_1 = 500g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

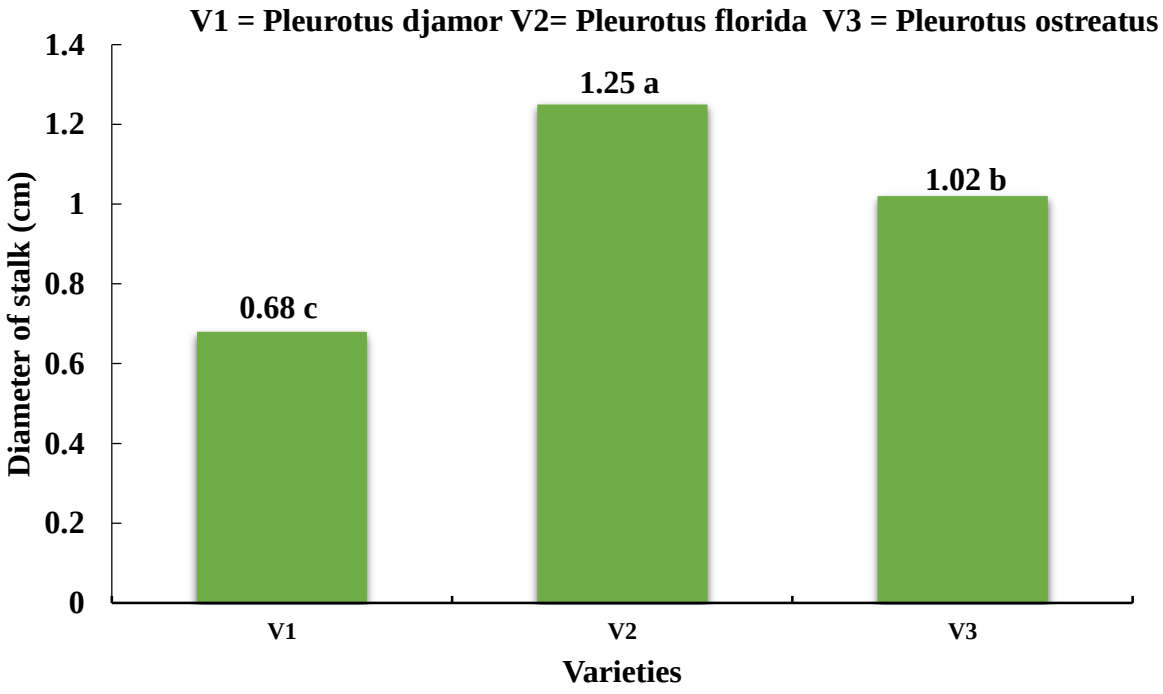

Figure 8. Effect of variety on diameter of stalk of oyster mushroom

4.5 Length of stalk

Application of different amount of maize straw substrates showed a positive effect on the length of stalk. The application of substrates amount significantly increased the length of stalk of mushroom except that found in T_5 showed in Figure 9. The length of stalk varied from 5.46 cm to 2.58 cm. The highest statistically superior length of stalk was 5.46 cm recorded in the treatment T_3. On the other hand, the lowest length of stalk 2.58 cm was obtained in the treatment T_5. The straw that is ideal for the growth of mushroom should contain high proportions of carbon and nitrogen compounds (Aguilar *et al.*, 2010) which was typical of a combination between maize and bean straws.

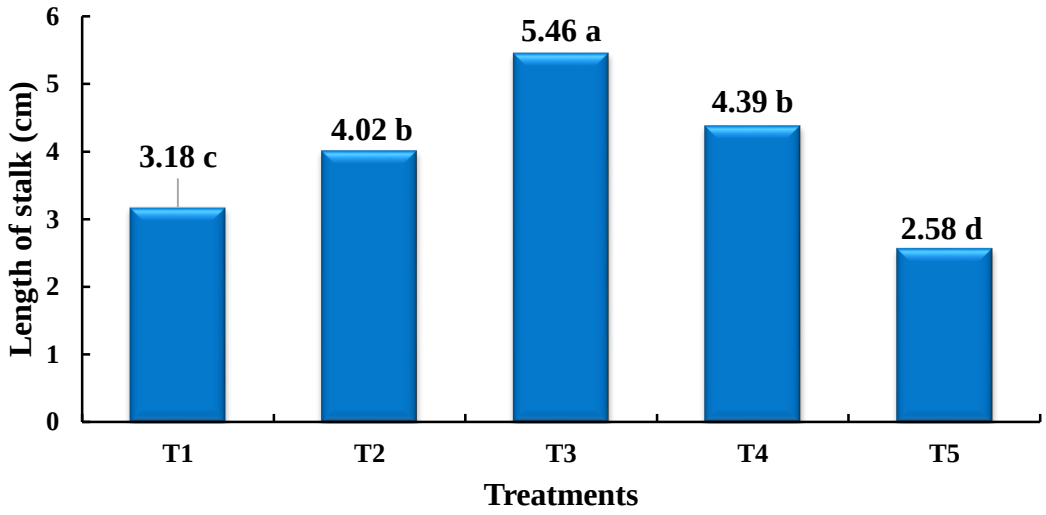

Figure 9. Effect of different amount of substrates on length of stalk of oyster mushroom

Here, T_1 = 500g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

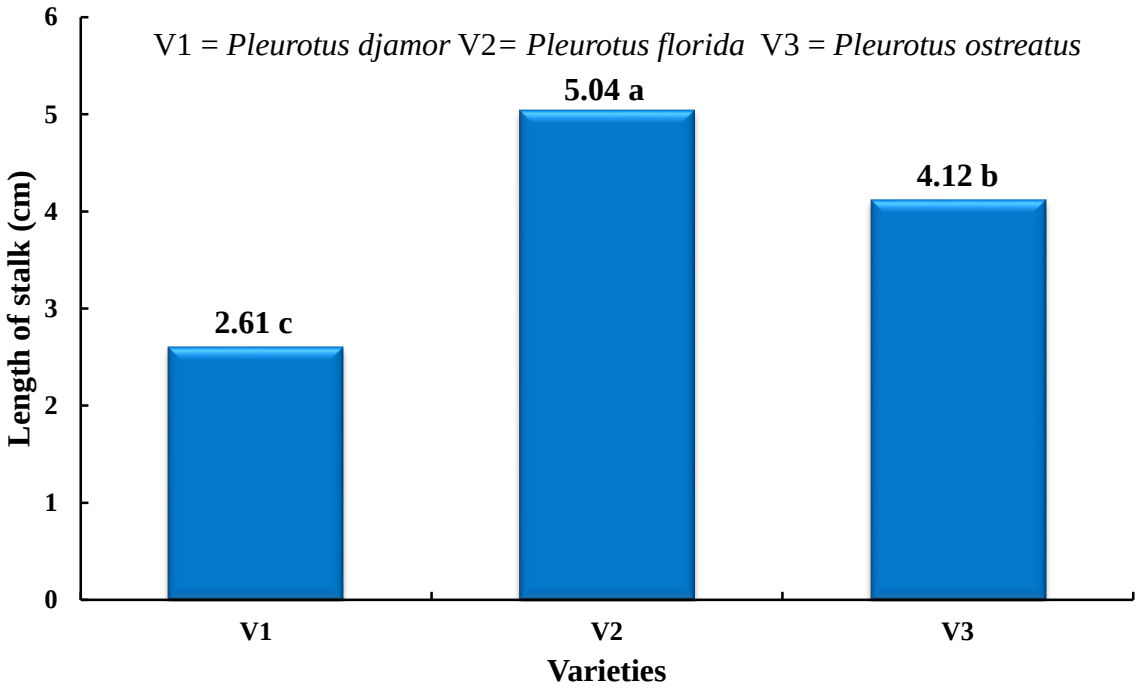

Figure 10. Effect of variety on length of stalk of oyster mushroom

The maize straw is rich in cellulose while bean residue is not only nutritionally rich in cellulose, but also contain other macro- and micro-elements needed in the proper growth of mushrooms. Our findings was also supported by the Iqbal *et al.,* (2005) and Kimenju *et al.,* (2009), they also reported that the growth of the mushroom is considered to be dependent upon the performance of the substrates. Zadrazil (1978) who reported that the quality of oyster mushroom depends on the length of stalk and the higher the length of stalk, the poor the quality of mushroom.

A significant variation in the length of stalk was found among the varieties. The longest stalk length (5.04 cm) was obtained from V_2 treatment and the shortest stalk length (2.61 cm) was obtained from V_1 treatment (Figure 10).

The interaction between different variety of oyster mushroom and different amount of maize straw substrates was found significant on the stalk length. The maximum length of stalk (7.08cm) was recorded from *Pleurotus florida* with maize straw (1000g/packet) and minimum length of stalk (1.83) was found *Pleurotus djamor* with maize straw (2000g/packet).

Table 2. Combined effect of varieties and different amount of substrates on diameter of stalk and length of stalk of oyster mushroom

Treatments (Combinations)	Diameter of stalk	Length of stalk
V_1T_1	0.58 hi	2.24 gh
V_1T_2	0.63 ghi	2.67 fgh
V_1T_3	0.98 def	3.39 ef
V_1T_4	0.73 fghi	2.93 fg
V_1T_5	0.50 i	1.83 h
V_2T_1	1.15 bcd	3.98 de
V_2T_2	1.31 bc	5.15 bc
V_2T_3	1.65 a	7.08 a
V_2T_4	1.35 bc	5.65 b
V_2T_5	0.80 fgh	3.35 ef
V_3T_1	0.85 efg	3.32 ef
V_3T_2	1.09 cde	4.22 cde
V_3T_3	1.40 ab	5.93 b
V_3T_4	1.17 bcd	4.59 cd
V_3T_5	0.59 ghi	2.55 fgh
Significant level	**	*
CV (%)	10.93	9.51

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.
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Here, V_1 = Pleurotus djamor, V_2= Pleurotus florida and V_3 = Pleurotus ostreatus

T_1 = 500 g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

***Significant at 1% probability level and * Significant at 5% probability level.*

4.6 Length of pileus

Length of pileus is important yield contributing parameters of oyster mushroom cultivation. Length of pileus statistically significant to the different amount of substrate composition. The highest pileus length (7.99 cm) observed at T_3 treatment which was significantly higher than other amount of substrates. The minimum pileus length (6.46 cm) observed at T_5 treatment. Results are shown in Figure 11. Oei (2003) reported that oyster mushroom performed better when cultivated in lignocelluloses rich waste materials like maize straw, sawdust, palm kernel cake and cotton waste.

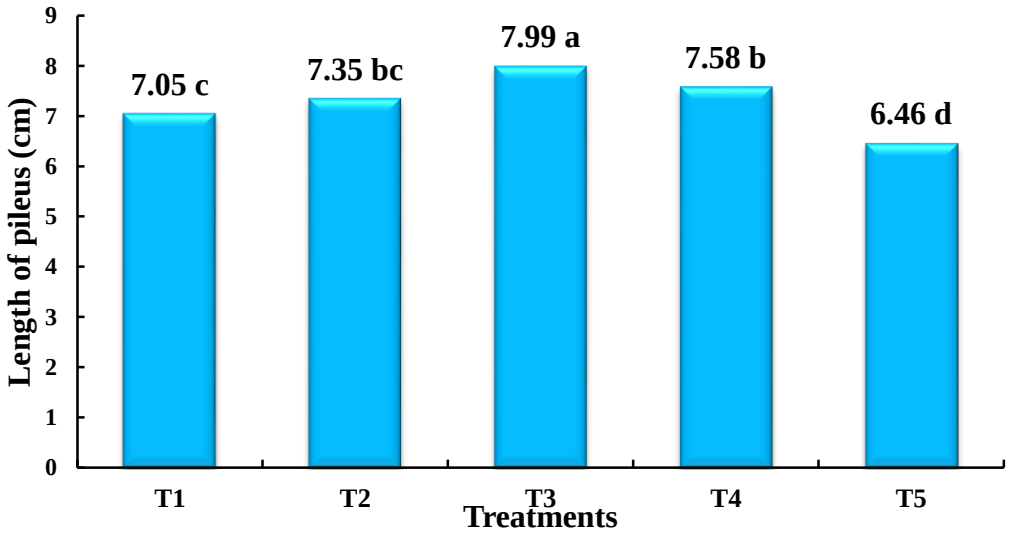

Figure 11. Effect of different amount of substrates on length of pileus of oyster mushroom

Here, T_1 = 500g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

Pileus length as centimeter was significantly differed on the different varieties. Among the tested varieties the highest pileus length (8.41 cm) was recorded on *Pleurotus florida* (V_2) followed by *Pleurotus ostreatus* (V_2) (7.50 cm) while the lowest pileus length (5.94 cm) was recorded on *Pleurotus djamor* (V_1) (Figure 12).

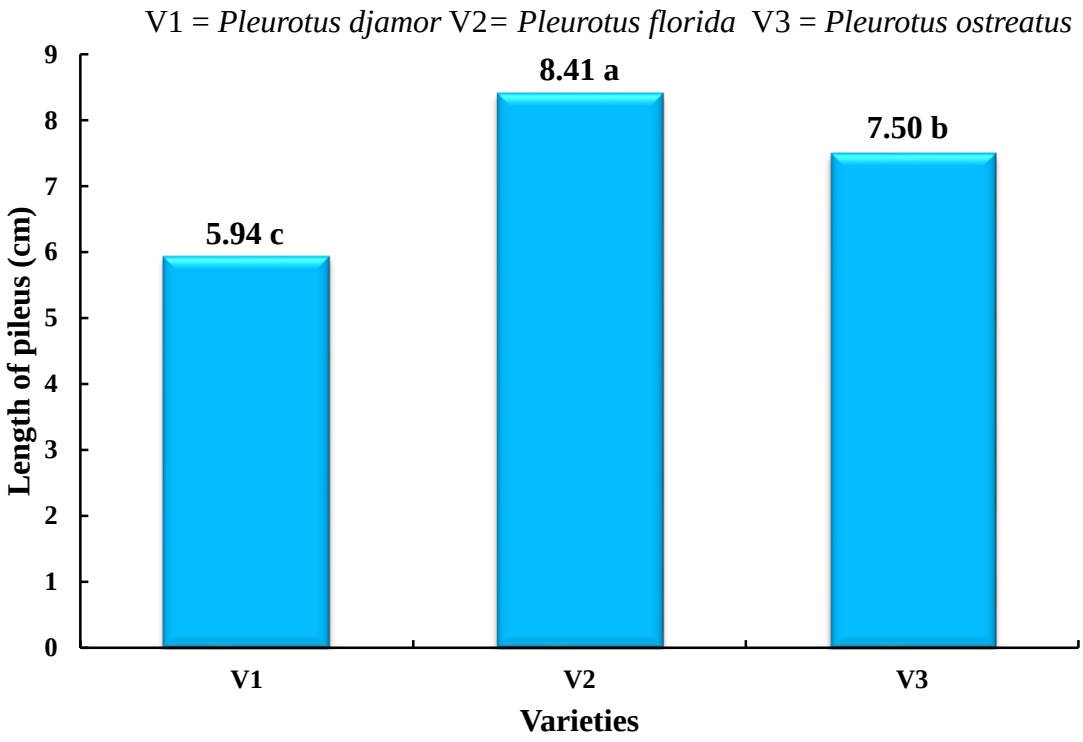

Figure 12. Effect of variety on length of pileus of oyster mushroom

The interaction between different variety and different amount of substrates was found significant on the pileus length. The maximum length of pileus (9.30 cm) was produced by V_2T_3 and the lowest length of pileus (5.31 cm) was produced by V_1T_5 (Table 3).

4.7 Diameter of pileus

The diameter of the pileus differed significantly on different amount of maize straw substrate. The pileus diameter was measured as an average of five samples taken randomly from each treatment. The highest pileus diameter (8.83 cm) was recorded on T_3 treatment followed by T_4 (8.29 cm) and T_2 (7.97 cm) while the lowest diameter (6.31 cm) was recorded on T_5 that was treated under similar environment and cultural practices along with other amount of substrates composition.

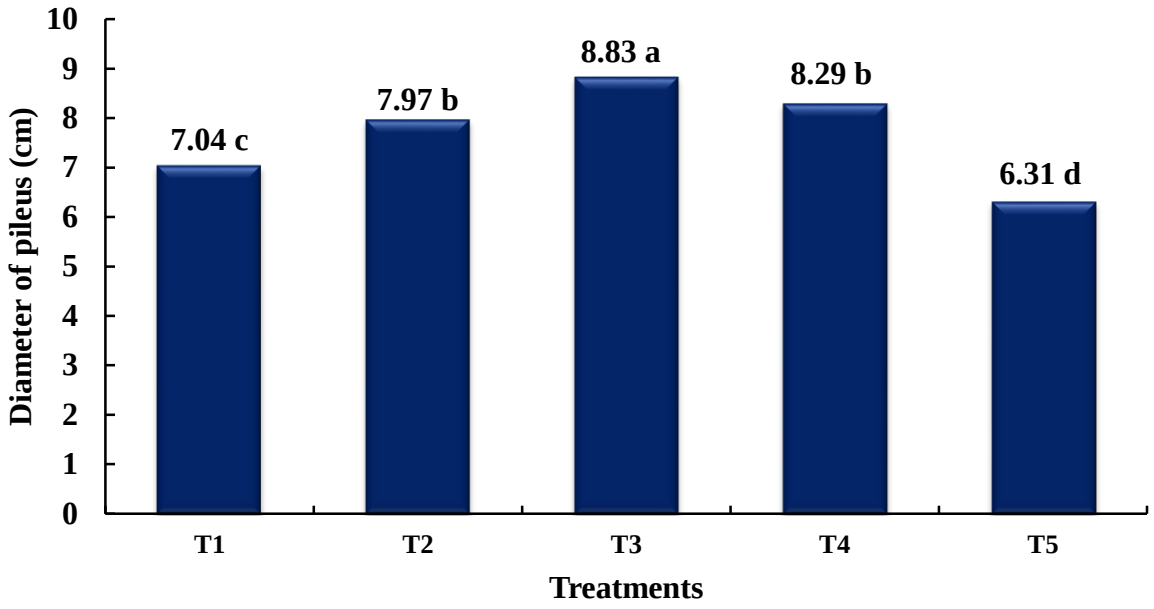

Figure 13. Effect of different amount of substrates on diameter of pileus of oyster mushroom

Here, T_1 = 500 g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

V1 = *Pleurotus djamor* V2= *Pleurotus florida* V3 = *Pleurotus ostreatus*

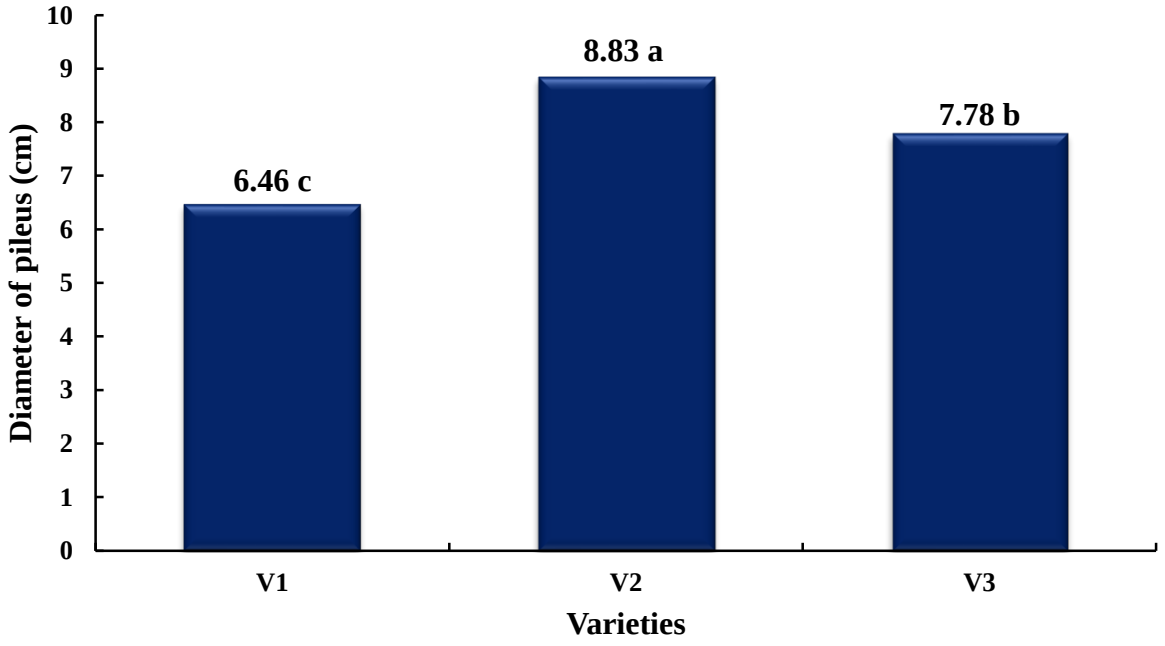

Figure 14. Effect of variety on diameter of pileus of oyster mushroom

A variation in the diameter of pileus was found among the varieties. The largest pileus diameter (8.83 cm) was obtained from V_2 treatment, and the shortest pileus diameter (6.46 cm) was obtained from V_1 treatment (Figure 14).

The interaction between different variety and different amount of substrates was found significant variation on the pileus diameter. The maximum diameter of pileus (10.10 cm) was produced by V_2T_3 and the diameter of pileus (5.14 cm) was produced by V_1T_5 (Table 3).

4.8 Thickness of pileus

Thickness of pileus is one of the yield contributing character of mushroom. Thickness of pileus significantly varied due to the different amount of substrates. The highest (0.90 cm) thickness of pileus was recorded from T_3, While T_5 gave the minimum (0.53 cm) thickness of pileus (Figure 15).

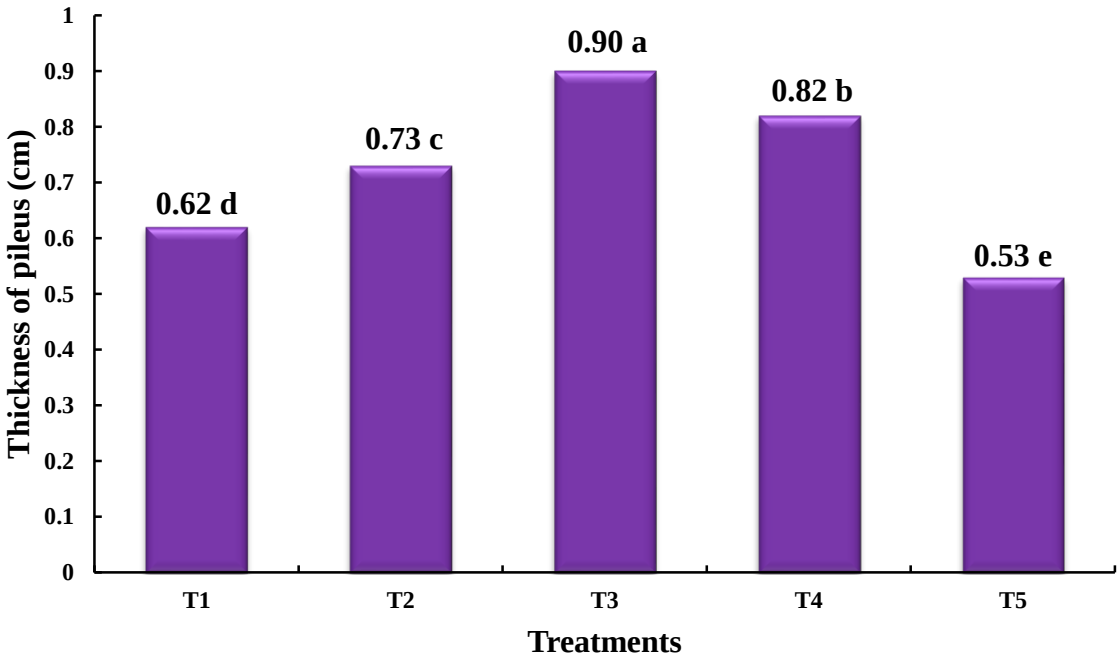

Figure 15. Effect of different amount of substrates on thickness of pileus of oyster mushroom

Here, T_1 = 500 g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

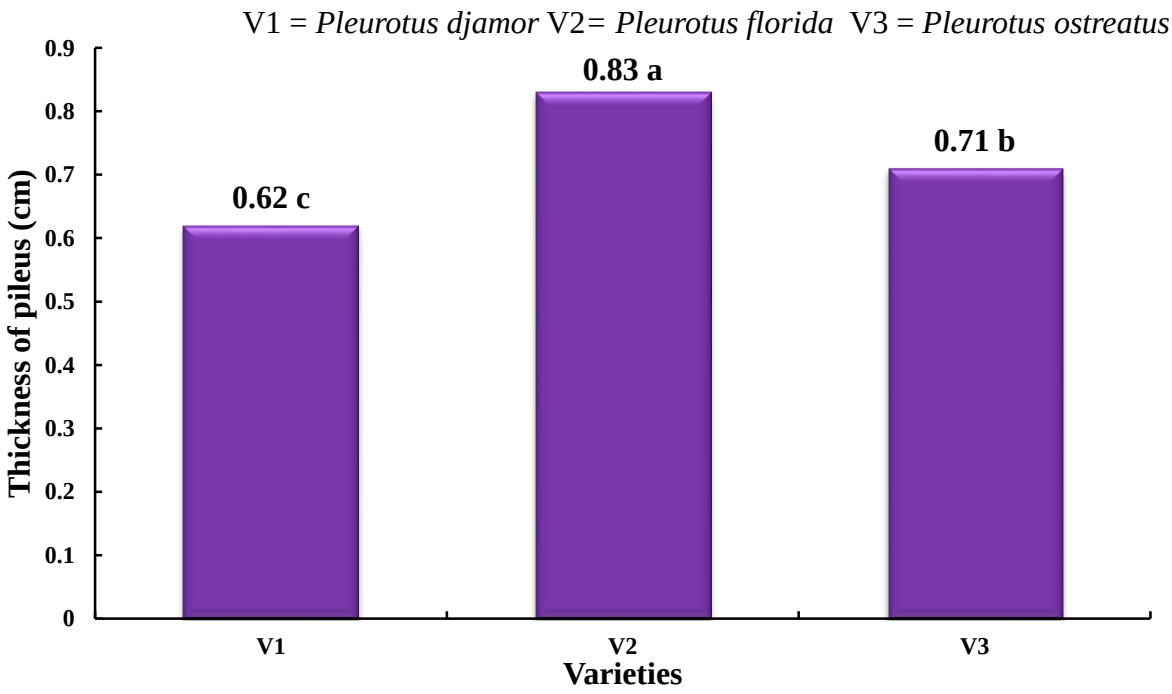

Figure 16. Effect of variety on thickness of pileus of oyster mushroom

A variation in the Thickness of pileus was recorded among the varieties. The maximum thickness of pileus (0.83 cm) was obtained from V_2 treatment, and the minimum thickness of pileus (0.62 cm) was obtained from V_1 treatment (Figure 16).

The interaction between different variety and different amount of substrates was observed significant variation on the thickness of pileus. The maximum thickness of pileus (1.03 cm) was produced by V_2T_3 and the minimum thickness of pileus (0.48 cm) was produced by V_1T_5 (Table 3). As it is a yield attributing character so the higher thickness of pileus may increase the yield.

Table 3. Combined effect of varieties and different amount of substrates on yield contributing character of oyster mushroom

Treatments (Combinations)	Length of pileus (cm)	Diameter of pileus (cm)	Thickness of pileus (cm)
V_1T_I	5.86 jk	5.64 fg	0.53 ij
V_1T_2	5.95 ijk	6.68 ef	0.63 gh
V_1T_3	6.47 hij	7.60 de	0.78 def
V_1T_4	6.13 ij	7.25 de	0.70 fg
V_1T_5	5.31 k	5.14 g	0.48 j
V_2T_I	8.07 bcde	8.25 bcd	0.73 ef
V_2T_2	8.49 abc	9.20 ab	0.85 cd
V_2T_3	9.30 a	10.10 a	1.03 a
V_2T_4	8.83 ab	9.35 ab	0.95 ab
V_2T_5	7.37 efg	7.23 de	0.60 hi
V_3T_I	7.21 fgh	7.23 de	0.60 hi
V_3T_2	7.60 def	8.03 cd	0.70 fg
V_3T_3	8.21 bcd	8.80 bc	0.90 bc
V_3T_4	7.78 cdef	8.28 bcd	0.80 de
V_3T_5	6.72 ghi	6.57 ef	0.53 ij
Significant level	**	**	**
CV (%)	4.42	5.83	5.20

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.
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Here, V_1 = Pleurotus djamor, V_2= Pleurotus florida and V_3 = Pleurotus ostreatus

T_1 = 500 g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

***Significant at 1% probability level and * Significant at 5% probability level.*

4.9 Yield (g/packet)

Yield varied significantly due to the effect of different amount of substrates showed in figure 17. The highest yield (128.67 g) was recorded under treatment T_3 application, whereas the lowest yield (55.50 g) was recorded under treatment T_5. Several authors have recommended supplementing the cereals such as maize straw with bean straw in order to achieve high yields. For example, Tikdari and Bolandnazar (2012) stated that small quantities of protein rich additives are recommended to boost yield. The supplementation of cereals with beans becomes very crucial under the small holder sector

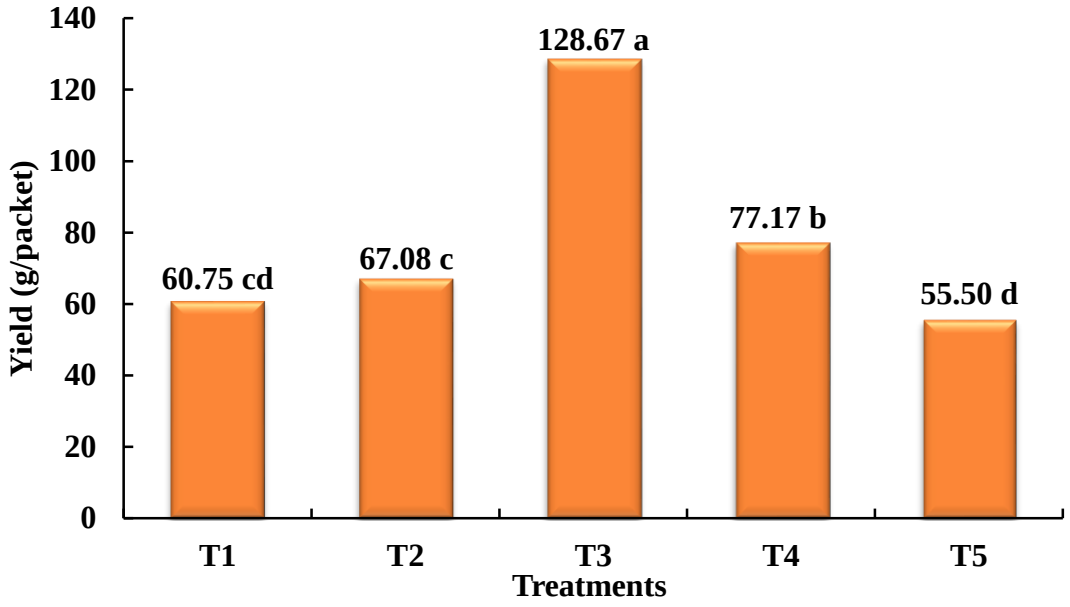

Figure 17. Effect of different amount of substrates on yield of oyster mushroom

Here, T_1 = 500 g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

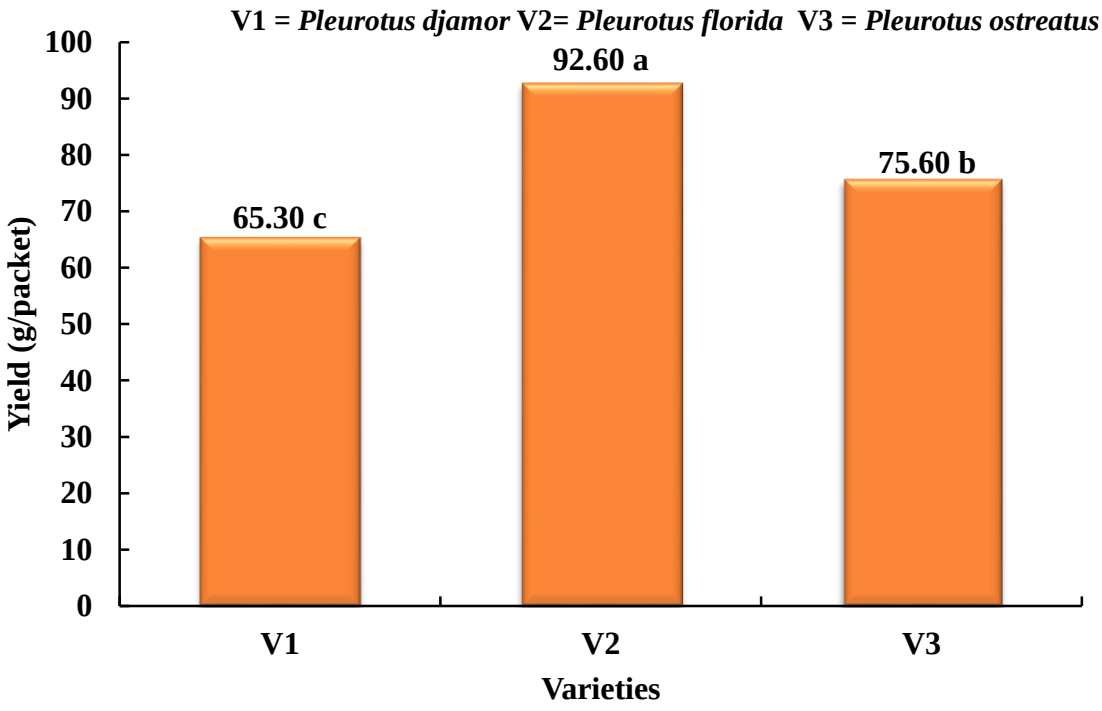

Figure 18. Effect of variety on yield of oyster mushroom

Significant variation was found on yield due to the varietal effect of oyster mushroom (Figure 18). However, maximum yield (92.60 g) was recorded from *Pleurotus florida* (V_2), whereas the minimum yield (65.30 g) was recorded from *Pleurotus djamor* (V_1).

The interaction between different variety and different amount of substrates was found significant variation on the yield. The maximum yield (164.75 g) was produced by V_2T_3 and the minimum yield (49.75g) was produced by V_1T_1 which followed by V_1T_5 treatment (Figure 19).

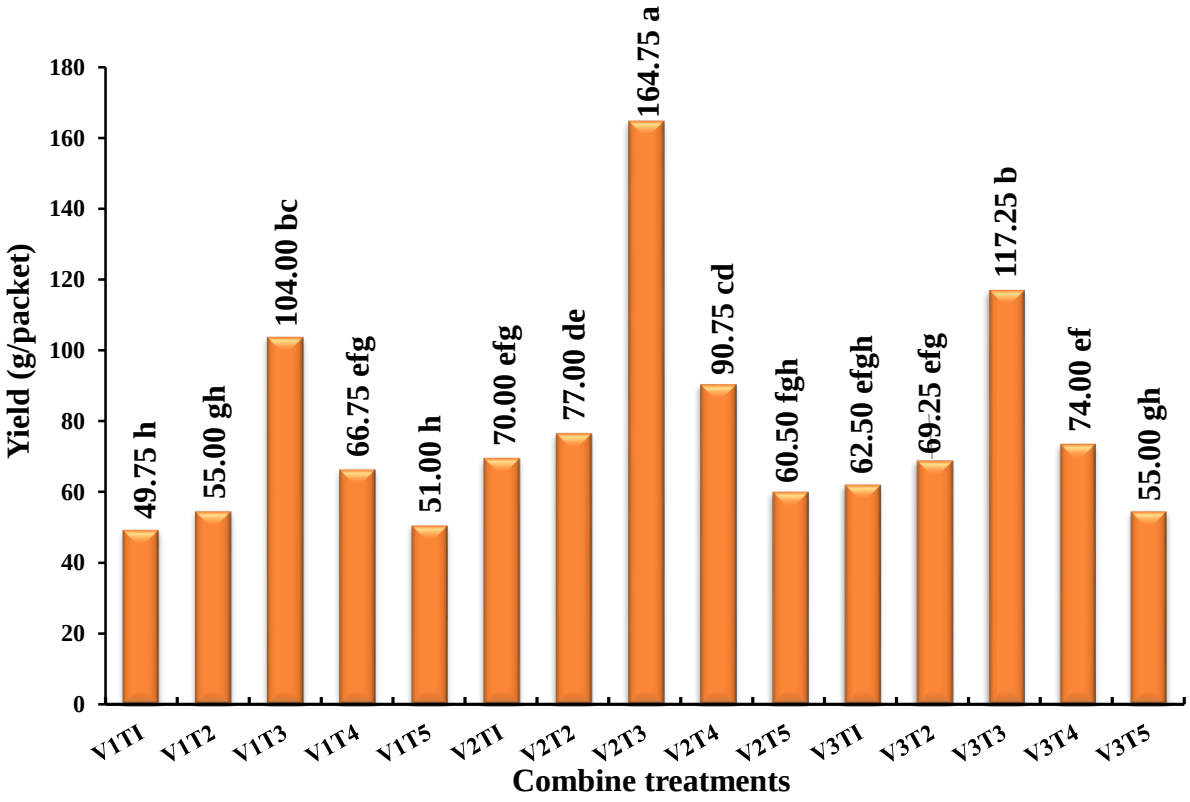

Figure 19. Combined effect of varieties and different amount of substrates on yield of oyster mushroom

Here, V_1 = Pleurotus djamor, V_2= Pleurotus florida and V_3 = Pleurotus ostreatus

T_1 = 500 g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

4.10 Biological efficiency

The highest biological efficiency 49.47 % was observed in the treatment V_2T_3 and the lowest biological efficiency 7.66 % was observed in V_1T_5. The rest of the treatments varied significantly (Table 4 and Appendix VI).

4.11 Benefit cost ratio

The highest benefit cost ratio 3.74 was calculated from the treatment V_2T_3 and the lowest benefit cost ratio 0.71 was calculated from V_1T_5 treatment. The rest of the treatments varied significantly (Table 4 and Appendix VI).

Table 4. Combined effect of varieties and different amount of substrates on biological efficiency and benefit cost ratio of oyster mushroom

Treatments	Biological efficiency (%)	Benefit cost ratio
V_1T_I	29.88 d	1.56 de
V_1T_2	22.02 e	1.45 e
V_1T_3	31.23 cd	2.36 bc
V_1T_4	13.36 g	1.15 f
V_1T_5	7.66 i	0.71 h
V_2T_I	42.04 b	2.19 c
V_2T_2	30.83 cd	2.03 cd
V_2T_3	49.47 a	3.74 a
V_2T_4	18.17 f	1.57 de
V_2T_5	9.08 h	0.84 fg
V_3T_I	37.54 bc	1.95 d
V_3T_2	27.73 de	1.82 d
V_3T_3	35.21 bcd	2.67 b
V_3T_4	14.81 fg	1.28 ef
V_3T_5	8.26 hi	0.76 gh
Significant level	*	*
CV (%)	3.44	3.20

In a column, means followed by a common letter are not significantly differed of 5% level by Tukey HSD test.
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Here, V_1 = Pleurotus djamor, V_2= Pleurotus florida and V_3 = Pleurotus ostreatus

T_1 = 500 g per packet

T_2 = 750 g per packet

T_3 = 1000 g per packet

T_4 = 1500 g per packet

T_5 = 2000 g per packet

***Significant at 1% probability level and * Significant at 5% probability level.*

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The experiment was carried out at the Tissue Culture Laboratory and Culture House of Mushroom Development Institute, Savar, Dhaka, during the period from July 2019 to December 2019 to find out the performance of maize straw substrates on the growth and yield of oyster mushroom. The experiment consisted of three varieties, viz. V_1 (*Pleurotus djamor*), V_2 (*Pleurotus florida*) and V_3 (*Pleurotus ostreatus*) and five different amount of maize straw substrates with 10% mother culture such as T_1 = 500g per packet, T_2 = 750 g per packet, T_3 = 1000 g per packet, T_4 = 1500 g per packet and T_5 = 2000 g per packet. The experiment was laid out in Completely Randomized Design (CRD) with four replications. The recorded data on various parameters were statistically analyzed using the "Analysis of variance" (ANOVA) technique with the help of statistics 10 that was an analysis software. The mean differences were adjudged by Tukey HSD (Honestly Significant Difference) test. The summary of the results has been discussed in this chapter.

The effect of different amount of maize straw substrates was recorded significantly differed in all parameter. The lowest time (3.00 days) from pinhead initiation to 1st harvest was in the treatment T_5 and the highest time (4.48 days) from pinhead initiation to1st harvest was observed in the treatment T_3. The highest number of fruiting body (19.00) and number of effective fruiting body (12.08) was observed in the treatment T_3 that was 1000g's packet. The maximum diameter of stalk (1.34 cm) and length of stalk (5.46 cm), was recorded from T_3 treatment. The highest length of pileus (7.99 cm), diameter of pileus (8.83 cm) and thickness of pileus (0.90 cm) was recorded from T_3 treatment. Significant variation was observed in yield due to different amount of maize straw substrates. The highest yield (128.67 g) was recorded under treatment T_3 and the lowest yield (55.50 g) was recorded under T_5 treatment.

Variety of mushroom showed influence on days required from pinhead initiation to 1st harvest. The lowest time (3.18 days) from pinhead initiation to 1st harvest was in the treatment V_3 (*Pleurotus ostreatus*). The highest number of fruiting body (17.80) was observed in V_2 (*Pleurotus florida*). The highest number of effective fruiting body (11.10) was obtained from V_2 treatment. The largest stalk diameter (1.25 cm) and longest stalk length (5.04 cm) was obtained from V_2 treatment. The longest pileus length (8.41 cm) and largest pileus diameter (8.83 cm) was obtained from V_2 treatment. The maximum thickness of pileus (0.83 cm) was obtained from V_2 treatment. The maximum yield of mushroom (92.60 g) was obtained from V_2 (*Pleurotus florida*) treatment, and the minimum yield (65.30 g) was obtained from V_1 (*Pleurotus djamor*) treatment.

Interaction effect of varieties and different amount of substrates was found significant on all parameter. The lowest time (3.00 days) from pinhead initiation to 1st harvest was in the treatment V_1T_1, V_1T_5, V_2T_5, V_3T_1 and V_3T_5. The highest number of fruiting body (27.50) was founded in the treatment V_2T_3 (*Pleurotus florida* with maize straw) .The highest number of effective fruiting body (17.75) was observed in the treatment V_2T_3. The maximum diameter of stalk (1.65 cm) and maximum length of stalk (7.08 cm) was produced by V_2T_3 combined treatment. The maximum length of pileus (9.30 cm) was produced by V_2T_3. The maximum diameter of pileus (10.10 cm) was produced by V_2T_3. The maximum Thickness of pileus (1.03 cm) was produced by V_2T_3. The interaction between different variety and different amount of substrates was found significant variation on the yield. The maximum yield (164.75 g) was produced by V_2T_3 and the minimum yield (49.75g) was produced by V_1T_1 which followed by V_1T_5 treatment.

5.2 Conclusion

Considering the stated findings, it may be concluded that yield and yield contributing parameters are positively correlated with variety and amount of substrates. However, *Pleurotus florida* in combination with maize straw substrates (1000g per packet) would be beneficial for the farmers.

5.3 Recommendations

1. Maize straw can therefore substitute of rice straw. Because rice straw is commonly use in mushroom cultivation in Bangladesh and it is highly demandable as cattle feed. In paper factory maize straw use as fuel purpose and it is cheaply available all year round. So, mushroom grower and cattle farmers both should be economically gainer.

2. There is also need to carry out various evaluations on other plant residues on their potential to produce mushrooms since plant residues are a source of lignocelluloses necessary for oyster mushroom growth.

3. Further studies can be done thoroughly modification of environment making suitable temperature and humidity for the better growth and development of oyster mushroom.

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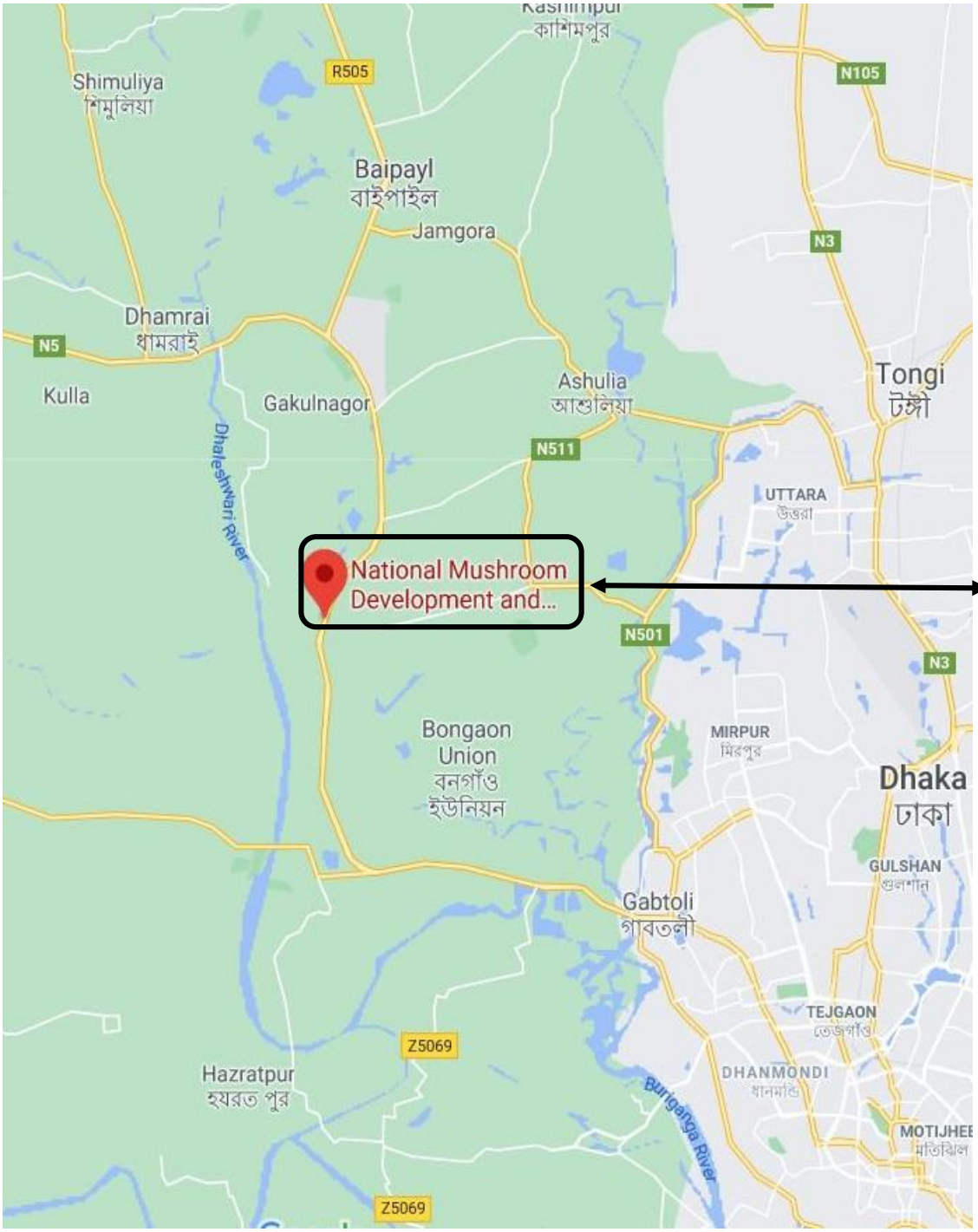
APPENDICES

Appendix I: Map showing the experimental sites under study.



Appendix II. Temperature and Relative humidity of culture house and outside during oyster mushroom cultivation through the year

Months	Temperature (^{0}C) of culture house	RH (%) of culture house	Outside Temperature (^{0}C)	Outside RH (%)
January	15-28	73-79	17-29	55-58
February	15-26	71-82	23-35	50-54
March	20-32	74-83	25-36	45-51
April	20-33	74-83	24-35	52-62
May	20-33	74-83	27-35	65-74
June	25-32	78-89	27-36	78-83
July	20-28	89-95	27-37	79-85
August	26-32	86-92	27-37	79-86
September	26-32	86-92	27-37	80-85
October	26-32	86-92	22-34	75-76
November	24-29	65-70	21-29	66-68
December	15-25	69-76	15-25	66-65

**RH: Relative humidity*

Appendix III. Factorial ANOVA tables.

Source	DF	SS	MS	F-Value	Pr(>F)
1. Days required from pinhead initiation to 1st harvest					
Replication	3	0.6198	0.20660		
Factor A	2	8.7646	4.38229	42.17	0.0000
Factor B	4	18.1521	4.53802	43.67	0.0000
A×B	8	5.1104	0.63880	6.15	0.0000
Error	42	4.3646	0.10392		
Total	59	37.0115			
2. Number of fruiting body/packet					
Replication	3	52.33	17.444		
Factor A	2	817.63	408.817	259.50	0.0000
Factor B	4	1016.23	254.058	161.27	0.0000
A×B	8	156.37	19.546	12.41	0.0000
Error	42	66.17	1.575		
Total	59	2108.73			
3. Number of effective fruiting body/packet					
Replication	3	2.72	0.906		
Factor A	2	388.03	194.017	319.14	0.0000
Factor B	4	585.77	146.442	240.88	0.0000
A×B	8	72.13	9.017	14.83	0.0000
Error	42	25.53	0.608		
Total	59	1074.18			
4. Diameter of stalk (cm)					
Replication	3	0.56252	0.18751		
Factor A	2	3.29394	1.64697	142.05	0.0000
Factor B	4	3.38152	0.84538	72.92	0.0000
A×B	8	0.27976	0.03497	3.02	0.0091
Error	42	0.48695	0.01159		
Total	59	8.00470			
5. Length of stalk (cm)					
Replication	3	1.422	0.4741		
Factor A	2	60.165	30.0823	215.79	0.0000
Factor B	4	59.501	14.8752	106.70	0.0000
A×B	8	6.684	0.8355	5.99	0.0000
Error	42	5.855	0.1394		
Total	59	133.627			

Source	DF	SS	MS	F-Value	Pr(>F)
6. Length of pileus (cm)					
Replication	3	3.0653	1.0218		
Factor A	2	62.3091	31.1546	300.39	0.0000
Factor B	4	15.8353	3.9588	38.17	0.0000
A×B	8	0.8731	0.1091	1.05	0.4139
Error	42	4.3560	0.1037		
Total	59	86.4388			
7. Diameter of pileus (cm)					
Replication	3	7.415	2.4718		
Factor A	2	56.202	28.1008	140.07	0.0000
Factor B	4	48.951	12.2378	61.00	0.0000
A×B	8	0.896	0.1120	0.56	0.8057
Error	42	8.426	0.2006		
Total	59	121.890			
8. Thickness of pileus (cm)					
Replication	3	0.17383	0.05794		
Factor A	2	0.44633	0.22317	159.77	0.0000
Factor B	4	1.04733	0.26183	187.45	0.0000
A×B	8	0.02367	0.00296	2.12	0.0553
Error	42	0.05867	0.00140		
Total	59	1.74983			
9. Yield (g/plant)					
Replication	3	208.1	69.4		
Factor A	2	7602.5	3801.3	102.18	0.0000
Factor B	4	41887.8	10472.0	281.50	0.0000
A×B	8	3789.5	473.7	12.73	0.0000
Error	42	1562.4	37.2		
Total	59	55050.3			

Appendix- IV: Production cost analysis of oyster mushroom cultivation

Treatments	Production cost per packet (Tk)	Yield per packet (Tk)	Price per packet yield (Tk)	Profit/loss Per packet (Tk)	Benefit cost ratio	Biological efficiency (%)
V_1T_I	8	49.75	12.44	+4.44	1.56 de	29.88 d
V_1T_2	9.5	55.00	13.75	+4.25	1.45 e	22.02 e
V_1T_3	11	104.00	26.00	+15.00	2.36 bc	31.23 cd
V_1T_4	14.5	66.75	16.69	+2.19	1.15 f	13.36 g
V_1T_5	18	51.00	12.75	-5.25	0.71 h	7.66 i
V_2T_I	8	70.00	17.50	+9.50	2.19 c	42.04 b
V_2T_2	9.5	77.00	19.25	+9.75	2.03 cd	30.83 cd
V_2T_3	11	164.75	41.19	+30.19	3.74 a	49.47 a
V_2T_4	14.5	90.75	22.69	+8.19	1.57 de	18.17 f
V_2T_5	18	60.50	15.13	-2.88	0.84 fg	9.08 h
V_3T_I	8	62.50	15.63	+7.63	1.95 d	37.54 bc
V_3T_2	9.5	69.25	17.25	+7.75	1.82 d	27.73 de
V_3T_3	11	117.25	29.31	+18.31	2.67 b	35.21 bcd
V_3T_4	14.5	74.00	18.50	+4.00	1.28 ef	14.81 fg
V_3T_5	18	55.00	13.75	-4.25	0.76 gh	8.26 hi

Appendix- V: Some plates of the experiment

Pure Culture of Oyster Mushroom

Mother Culture of Oyster Mushroom

Chopping of Maize Straw

Pasteurization chamber

Spawn Packets

Mycelium Running in Spawn Packets

Mature Fruiting body of Mushroom

Lifecycle of Mushroom

Harvesting and Data Collection