# PERFORMANCE OF DIFFERENT SUPPLEMENTS AND THEIR LEVELS ON GROWTH AND YIELD OF THREE OYSTER MUSHROOM SPECIES

**HAFSA BINTAY HARUN**

**REGISTRATION NO. 14-06064**

**DEPARTMENT OF HORTICULTURE**

**SHER-E-BANGLA AGRICULTURAL UNIVERSITY**
**DHAKA -1207**

**JUNE, 2021**

**PERFORMANCE OF DIFFERENT SUPPLEMENTS AND THEIR LEVELS ON GROWTH AND YIELD OF THREE OYSTER MUSHROOM SPECIES**

**BY**

**HAFSA BINTAY HARUN**

**REGISTRATION NO. : 14-06064**

A Thesis
*Submitted to the Department of Plant Pathology*
*Sher-e-Bangla Agricultural University, Dhaka*
*In partial fulfillment of the requirements*
*for the degree of*

**MASTER OF SCIENCE (MS)**

**IN**

**HORTICULTURE**

**SEMESTER: JANUARY-JUNE 2021**

**Approved by:**

**Md. Hasanuzzaman Akand**
Professor
Department of Horticulture
SAU, Dhaka
**Supervisor**

**Dr. Akhter Jahan Kakon**
Mushroom Specialist
Mushroom Development Institute
Savar, Dhaka
**Co-Supervisor**

**Prof. Dr. Md. Jahedur Rahman**
**Chairman**
Examination Committee

**DEPARTMENT OF HORTICULTURE**
**Sher-e-Bangla Agricultural University**
**Sher-e-Bangla Nagar,Dhaka-1207**

# *CERTIFICATE*

This is to certify that the thesis entitled **"PERFORMANCE OF DIFFERENT SUPPLEMENTS AND THEIR LEVELS ON GROWTH AND YIELD OF THREE OYSTER MUSHROOM SPECIES"** 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 **MASTERS OF SCIENCE (M.S.)** in **HORTICULTURE**, embodies the result of a piece of bonafide research work carried out by **HAFSA BINTAY HARUN**, Registration No. **14-06064** 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.

**June, 2021**
**Dhaka, Bangladesh**

**(Md. Hasanuzzaman Akand)**
**Professor**
Department of Horticulture
SAU, Dhaka

# Dedicated to
# My
# Beloved Parents

## *ACKNOWLEDGEMENTS*

*The author seems it a much privilege to express her enormous sense of gratitude to the Almighty for there ever ending blessings for the successful completion of the research work.*

*The author wishes to express her gratitude and best regards to her respected Supervisor,* ***Md. Hasanuzzaman Akand****, Professor, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for his continuous direction, constructive criticism, encouragement and valuable suggestions in carrying out the research work and preparation of this thesis.*

*The author wishes to express her earnest respect, sincere appreciation and enormous indebtedness to her reverend Co-supervisor,* ***Dr. Akhter Jahan Kakon****, Mushroom Specialist, Mushroom Development Institute, Savar, Dhaka for her scholastic supervision, helpful commentary and unvarying inspiration throughout the research work and preparation of the thesis.*

*The author feels to express her heartfelt thanks to the honorable Chairman,* ***Prof. Dr. Khaleda Khatun*** *Department of Horticulture along with all other teachers and staff members of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for their co-operation during the period of the study.*

*The author feels proud to express her deepest and endless gratitude to all of her course mates and friends to cooperate and help her during taking data from the field and preparation of the thesis. The author wishes to extend her special thanks to her lab mates, class mates and friends for their keen help as well as heartiest co-operation and encouragement.*

*The author expresses her heartfelt thanks to her beloved parents, husband and brother and all other family members for their prayers, encouragement, constant inspiration and moral support for her higher study. May Almighty bless and protect them all.*

*The Author*

**PERFORMANCE OF DIFFERENT SUPPLEMENTS AND THEIR LEVELS ON GROWTH AND YIELD OF THREE OYSTER MUSHROOM SPECIES**

**By**

**HAFSA BINTAY HARUN**

## ABSTRACT

The experiment was conducted at the Mushroom Development Institute (MDI), Savar, Dhaka, during the period from June to September 2020 to find out the performance of different supplements and their levels on growth and yield of three oyster mushroom species. The experiment consisted of three Oyster mushroom species *viz*. $V_1$ (*Pleurotus djamor*), $V_2$ (*Pleurotus florida*) and $V_3$ (*Pleurotuso streatus* po10) with seven supplements to sawdust substrate, *viz*. $S_1$ (Wheat bran; WB), $S_2$ (Maize powder; MP), $S_3$ (Rice straw; RS), $S_4$ (Wheat bran + maize powder; 1:1), $S_5$ (Maize powder + rice straw; 1:1), $S_6$ (Rice straw + wheat bran; 1:1) and $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1). The experiment was laid out in Completely Randomized Design (CRD) with three replications. In case of the performance of mushroom species, $V_1$ (*Pleurotus djamor*) showed best performance on the most of the growth, yield contributing parameters and yield compared to $V_2$ (*Pleurotus florida*) and $V_3$ (*Pleurotuso streatus* po10). Similarly, the performance of supplements to sawdust substrate, the highest mycelium run rate, total number of fruiting body and effective fruiting body packet$^{-1}$, biological yield, economic yield and biological efficiency per spawn packet were observed from the treatment $S_7$ (wheat bran + maize powder + rice straw; 1:1:1) compared others whereas the lowest was from $S_3$ (Rice straw; RS). Regarding combined effect of mushroom species and supplements to substrate, $V_1S_7$ gave the highest mycelium ran rate (0.82 cm day$^{-1}$) and shortest duration of mycelium run complete, pin head initiation and pin head initiation to harvest (14.25, 20.50 and 4.00 days, respectively). $V_1S_7$ also gave the highest total number of fruiting body (24.75), number of effective fruiting body (17.13), length, diameter and thickness of pileus (6.39, 8.33 and 1.00 cm, respectively), biological yield (183.10 g), economic yield (173.50 g) and biological efficiency (73.24%) whereas $V_1S_3$ gave least performance. So, this treatment combination ($V_1S_7$) can be considered as best compared to other treatment combinations.

# LIST OF CONTENTS

## LIST OF CONTENTS (Cont'd)

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF APPENDICES

## 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 Agriculture 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

Mushrooms are incredibly popular foods in most countries. Edible and medicinal mushrooms are regarded as the ideal health foods. They are well appreciated for their exquisite taste and flavor and are consumed both in the fresh and processed forms (Stamets, 2000). Oyster mushroom (*Pleurotus spp*.) is an edible mushroom that belongs to the family Pleurotaceae (Randive, 2012). Mushrooms are one kind of edible fungi belonging to the genus *Pleurotus* under the class Basidiomycetes due to unique fungal characteristics (Mondal *et al*. 2010, Song, 2004). They are saprophytic because their tissues contain no chlorophyll for carbohydrate synthesis. Nevertheless, people have been collecting them from the wild for ages and cultivating them as a valuable food. Mushrooms consist of cap, gills, stalk or stipe, spores, ring, volva and mycelium (Thongnaitham, 2012).

About 2000 of mushroom species are identified and edible, and about 20-60 species are commercially cultivated (Maria Florence and Balasundaran, 2000; Cheung, 2008; Marshall and Nair, 2009; Dündar, Yildiz, 2009; Patel *et al*., 2012; Aishah and Wan Rosli, 2013), and most of these species are collected from the wild. People who aware of their nutrition value have started them to grow to supplement the amount harvested from the forests (Marshall and Nair, 2009).

Mushrooms are rich in proteins, contain less fat, less carbohydrates and salt and rich in fibres and have high vitamin B12 and folic acid which are uncommon in vegetables. High availability of lysine and tryptophan and other amino acids usually absent in cereals make them ideal for food for patients suffering from hypertension, diabetes and obesity (Caral *et al*., 2010). It 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).

There are several species of *Pleurotus* identified in the world. Most of them are suitable for cultivation. However, the most important cultivated species are *Pleurotus ostreatus*, *Pleurotus florida*, *Pleurotus columbinus*, *Pleurotus djamor*, *Pleurotus sajor-caju*, being easier to cultivate, favorable to eat, and grow economically on different kinds of organic waste raw material (Kong, 2004).

Different species of oyster can play a significant role on growth and yield. The species of these genera show much diversity in their adaptation the varying agro-climatic condition which makes more cultivated species than other mushrooms (Zadrazil and Dube, 1992). 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. Different yield contributing characters and yield of *Pleurotus spp.* Also differed significantly due to species difference.

In Bangladesh, huge amount of agricultural wastes is produced annually, and are of no uses. These wastes could be used as source of food i.e. substrate for mushroom cultivation. Oyster mushroom can be grown on various substrates including paddy straw, wheat straw, maize stalks/cobs, maize powder, wheat bran, vegetable or plant residues, biogases etc. However, an ideal substrate should contain nitrogen (supplement) and carbohydrates for rapid mushroom growth (Ashraf *et al*., 2013). Hence good growth and better yield of mushroom can be achieved when different substrates are supplemented. Supplements are commonly manufactured products containing defatted vegetable meal, such as soybean meal, and other organic protein sources, among them cereal bran, enriched with minerals or vitamins, which are frequently used for the cultivation of *Agaricus* and *Pleurotus* species (Zied *et al*. 2011 and Burton *et al*. 2015). In addition to these existing supplements, the use of low-cost agricultural by-products (e.g. rice, wheat or maize straw or powder etc.) available at the productive regions is a promising approach. Most organic matters containing cellulose, hemicelluloses and lignin can be used as mushroom substrate and/or supplementation i.e. rice and wheat straw, banana leaves, cottonseed hulls, corncob, sugarcane baggase, sawdust, waste paper, leaves, and so on. The amount of nutrition requirement differs according to mushroom species and types of substrate with or without supplementation used.

Among the numerous species of mushroom, oyster mushrooms are more advantages in terms of easiness in cultivation. To improve the productivity and nutritional value of mushrooms several techniques, substrates, cultivation conditions and strains have been tested. Some studies show that supplementation increase the biomass and mushroom's productivity (Nidhi Sinha and Chourasia, 2021). 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.

In Bangladesh, not much work has been done on the cultivation technology of *Pleurotus spp*. It is in the light of these facts; the aim of current work was to evaluate different spawn rates and to determine the influence of different substrate supplementation materials on the growth parameters and yields of *Pleurotus* cultivation. To assess the performance of different supplements and their levels on growth and yield of three oyster mushroom species, the following objectives was followed:

I. to increase the production and quality of mushroom
II. to evaluate the effect of different supplements on growth and yield of mushroom

# CHAPTER II

# REVIEW OF LITERATURE

A number of literatures relating to the performance of different supplements with sawdust substrate and their levels on growth and yield of three oyster mushroom species were presented in this chapter. The review of literature given below was based on the present information regarding the performance of Oyster mushroom *(Pleurotus ostreatus)* species and the effect of different supplements with sawdust 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 species are presented as follows:

## 2.1 Effect of different *Pleurotus species on growth and yield*

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 $PO_2$, whereas the strains $PG_1$ and $PG_3$ 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 $PO_2$ strain. The strain PHK produced the highest number of mature fruiting bodies, while the lowest was found in the strain $PG_3$. The heaviest single fruiting body was found in $PG_1$ strain followed by the strain $PG_3$. Among the tested strains, both the highest biological and economic yields were reflected in $PG_1$ strain and the lowest were recorded in $PO_3$. The highest (95.8%) biological efficiency (BE) was recorded in $PG_1$, whereas the lowest (56.4%) in $PO_3$ 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

Oystermushroom 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 nonconventional 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.

Kinge *et al*. (2016) indicated that the growth and yield of *P. ostreatus* and *P. florida* varied widely depending on the kind of substrate used. Sawdust had the greatest influence on both growth and total yield. It took least days for pin head formation and maturity period but had the highest number of fruiting bodies produced. *P. ostreatus* had the highest weight, height and biological yield while *P. florida* had the least pin head formation, maturity period and number of fruiting bodies.

Singh and Prasad (2012) conducted an investigation to determine the morphological properties of *Pleurotusviz. P. sajor-caju* and *P. floridawere* species and to study their response to various supplements. Their results indicate that *Pleurotus sajor-caju* gave higher yield on wheat straw substrate with supplemented with soybean flour.

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.

Ingale and Ramteke (2010) studied the yield and biological efficiency of three *Pleurotus spp*. (*P.sajor-caju, P. florida* and *P. eous*) on soybean straw. They reported highest yield of *P. eous* in terms of fresh weight, dry weight and biological efficiency (383.91 g/500 g dry substrate, 57.92 g and 76.76 %, respectively), followed by *P. Sajar-caju* (303.63 g /500 g dry substrate, 43.37 g and 60.72%, respectively) and *P. florida* (283.21 g /500 g dry substrate, 39.73 g and 56.64%, respectively.

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 biological yield, economic 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.*

Das and Bora (2003) were carried out an experiment to use of water hyacinth as substrate for cultivation of oyster mushroom in Assam. Three species of oyster mushroom, *Pleurotus sajor-caju*, *P. citrinopileatus* and *P. ostreatus*, were cultivated on leaves and petiole of water hyacinth (*Eichhomia crassipes*), a common weed of the wetlands in Assam and the northeastern region of India, as an alternative to paddy straw. *P. sajor-caju* recorded significantly higher yields and biological efficiency than *P. citrinopileatus* and *P. ostreatus* on both paddy straw and water hyacinth in both winter and pre-monsoon seasons. Productivity was higher in November, December and January (567, 625 and 684 g, respectively) when temperature ranged between 23 and 28°C, humidity ranged between 70 and 90%, and rainfall was almost nil. Although the yields and biological efficiency of all mushrooms was higher on paddy straw than water hyacinth, the latter could still be considered as a viable alternative for oyster mushroom cultivation in Assam and adjoining states of India.

Hamza *et al.* (2003) were conducted a study to investigate the: (i) ability of five species of oyster mushroom to degrade lignocellulosic material in maize stalks and cumulative yield; and (ii) effect of the best species on the basis of feed value. The five culture's species of oyster mushroom collected from Germany were *Pleurotusostreatus* var. *florida* (FBI Nr49 and FBI Nr8), *Pleurotus sp*. (FBI Nr.103 and FBI Nr.112) and *P. sajor-caju* (FBI Nr. 117). Digestibility trial was carried out for the spent maize stalks cultivated by *Pleurotus sp*. 112 to determine nutrient availability coefficients, feeding values of experimental untreated and treated maize stalks. Six mature Rahmani rams were used in two digestibility trials. Fibre fractions analysis showed that cellulose and hemicellulose content in raw maize stalks decreased due to growth of all the five strains of fungi. The strains *Pleurotus* var. *florida* (8) and *Pleurotus sp*. (112) were the best effective strains for cellulose and hemicellulose degradation. The effect of fungi treatment on lignin content was insignificant. The crude protein content of maize stalks was increased due to the growth of strains *P. sajor-caju* (103), *Pleurotus sp*. (112) and *P. sajor-caju* (117). The highest protein increase (90% over the untreated maize stalks level) was recorded by Pleurotus sp. (112). The in vitro dry matter digestibility (IVDMD) was significantly improved by biological treatment with *Pleurotus sp*. (112) and *P. sajor-caju* (103) of spent maize stalks compared with raw maize stalks. The in vitro digestibility percentage of hemicellulose, cellulose and lignin in spent maize stalks indicated that *Pleurotus sp*. (112) and *Pleurotus sp*. (103) significantly improved the nutritive value of spent maize stalks to be available for utilization by ruminant animals. The total digestible nutrients of spent maize stalks ration was higher (66.35%) than that on the raw maize stalks ration (59.62%). The starch value was also higher for the spent maize stalk ration (58.6%) compared with the control ration (53.79%).

Singh (1998) cultivated six species of *Pleurotus*, namely *P. abalonus*, *P. citrinopileatus*, *P. flabellatus*, *P. florida*, *P. Ostreatus* and *P. sajor-caju* were cultivated on sugarcane residues (sugarcane green leaves and tops, trash, bagasse), wheat straw and sawdust alone as well as in different combinations. *P. florida* gave maximum yield on wheat straw, bagasse and green leaves whereas, *P. sajor-caju* gave a higher yield on trash and sawdust. *P. florida* adjudged as the best species for cultivation on mixture of sugarcane trash and wheat straw.

Mathew *et al*. (1996) investigated that *Pleurotus sajor-caju*, *Pleurotus citrinopileatus*, *Pleurotus florida*, *Pleurotus platypus* and *Pleurotus ostreatus* and evaluated their yield performance on various substrates, both for spawn production and cultivation. Sorghum, wheat and paddy grains were equally good for spawn production. *Pleurotus sajor-caju*, *Pleurotus citrinopileatus* and *Pleurotus florida* were the most suitable species for cultivation in both the plains and the high ranges. These 3 species were successfully cultivated on paddy straw, *Eliocharis plantogena* [*Eleocharis plantaginea*] and rubber wood [Hevea] sawdust, although for commercial cultivation of *Pleurotus sajor-caju*, rubber wood sawdust was not rated as an ideal medium.

Patra and Pani (1995) mentioned that five species of *Pleurotus* were cultivated in polythene [polyethylene] bags containing chopped paddy straw (2 kg) + spawn (200 g) + boiled wheat (200 g). Highest yield was observed in *P. Florida*, followed by *P. sajor-caju*, *P. citrinopileatus*, *P. sapidus* and *P. flabellatus*. The fungi took 13-I6 days for complete mycelial run in the bags and 20-24 days for initiation of fruiting bodies. *P. sajor-caju* produced the heaviest fruiting bodies (12.2 g) and *P. citrinopileatus* the lightest (6.9 g).

Marimuthu *et al*. (1994) investigate *Pleurotus sajor-caju*, *P. citrinopileatus* and *P. platypus* on paddy straw were tested for their response to substrate amendment with neem cake, rice bran, wheat bran and tapioca thippi (Factory waste). Neem cake at 5% level increased the yield of *P. citrinopileatus*, *P. sajor-caju* and *P. pathypus* by 26-49, 24-79 and 16% respectively and reduced the number of days required for completion of spawn run by 2-6, 5 and 6 days, respectively compared with control.

## 2.2 Application of mushroom supplements

The correct timing and methods of application of supplements is an essential condition for obtaining the expected results, with several important culture aspects, such as the composting process, the control of temperature for mycelial growth before and after casing, the hygiene measures, the choice of supplement and its application time and, especially, the uniform distribution of the product used in the substrate, all affecting subsequent yields (Desrumaux *et al*. 1999).

To achieve a successful supplementation, particularly at spawning, it is necessary to design supplements which retard the availability of nutrients. The delayed-released nutrients where firstly reported by Carrol and Schisler (1976) through a treatment with formaldehyde. According to the authors formaldehyde limited the solubility and denatured the proteins of supplements, in addition it inhibited their availability for competitors moulds and then the mushroom mycelium could take the gradually accessible nutritional content when it became dominant within the mass of compost.

The increase in temperature immediately after supplementing should also be controlled. For instance, in modern facilities (equipped with air-conditioned growing-rooms and mechanized shelves to manage the crop) supplements can be added to the colonized compost just before applying the casing layer. Therefore, because environmental conditions can be controlled, excessive compost temperatures are avoided during spawn running, and the incidence of fungal competitors is minimized. This also applies when the compost is incubated in tunnels at the composting plant (phase III). However, cropping in bags with phase II compost, the primary system used in many parts of the world, requires supplementation during spawning primarily due to mechanical restrictions (Pardo-Gimenez *et al*. 2017).

Therefore supplements, which are based on slow nutrient release formulas, can be applied at different points along the mushroom cropping cycle. They are most commonly applied at the end of the substrate preparation, prior to spawning, to promote the vegetative growth throughout the substrate (Naraian *et al*. 2009), at the end of spawn run (with the substrate fully colonized by mushroom mycelium) to promote the mushroom colonization in the casing material (if required) and enhance mushroom fructification (Pardo-Gimenez *et al*. 2016, 2018). However, the application of supplements along cropping has been also tested to increase the production of late flushes by supplementing the 2$^{nd}$ flush compost in *A. bisporus* (Royse and Chalupa 2009; Royse 2010).

### 2.3 The nutritional content of mushrooms: Effect of supplementation

Cultivated mushrooms are a highly nutritious food that can be grown on biological wastes, agricultural wastes or agro-industrial wastes (Sanchez 2010; Atila 2017). Researchers have reported variations in the nutritional content of mushrooms cultivated on different substrates. When comparing the effects of different agro-wastes on the nutritional composition of oyster mushrooms and *Pleurotus cystidiosus*, formulas with 100% sugar bagasse and 100% corncob showed higher values of protein, fiber, ash and mineral content (Ca, K, and Mg) than 100% sawdust (Hoa *et al*. 2015).

The cultivation of *Pleurotus ostreatus* on various sawdust substrates was reported to give the best nutritional composition in mushrooms for the substrates based on fig tree sawdust, with the mushroom showing the highest amount of dry matter, lipid, nitrogen, iron, zinc and selenium; followed by a mixture of various sawdusts and an Ipil-ipil tree sawdust, all supplemented with 30% wheat bran and 1% lime (Bhattacharjya *et al*. 2015).

Supplementation of substrates in *A. bisporus* with trace elements has been described as reliable for the production of fruiting bodies enriched with Se, Cu and Zn (Werner and Beelman 2002; Rzymski et al. 2017), micronutrients that frequently are deficient in the human diet (Bird *et al*. 2017).

The formula employed for the design of the substrate deeply influences the yield and quality of the basidiomes harvested (Moonmoon *et al*. 2011; He *et al*.

2018). Compost supplementation with defatted pistachio meal and defatted almond meal significantly improved the quality of white button mushroom, *A. bisporus*, (larger mushrooms with firmer texture and greater content in dry weight and protein) and increased more than 30% the yield in oyster mushroom, *P. ostreatus*, in comparison to non-supplemented substrates (Pardo-Gimenez *et al*. 2016, 2018).

Sawdust supplemented with different levels of wheat bran, rice bran or maize powder improved yield and quality of *Lentinula edodes*, with 25% wheat bran and 40% wheat bran reported as the best rate to obtained highest yield and best quality respectively (Moonmoon *et al*. 2011). Finally, *Pleurotus* species produced on substrates containing grape marc or olive mill wastes showed higher content of bioactive compounds and comparable productivity than wheat-based substrates (Koutrotsios *et al*. 2018).

### 2.4 Effect of different *supplements with substrate on growth and yield*

Sinha *et al*. (2021) carried out a study aimed to evaluate different spawn rates and to determine the influence of different substrate supplementation materials on the growth parameters and yields of *Pleurotus* cultivation. *Pleurotus florida* was cultivated on wheat straw, in pure form and supplement of wheat bran @10%, rice bran@10%, and pulses husk@10% added to find out their effect on, days of spawn run, pinhead appearance, their maturity, flush wise yield, total yield, and biological efficiency. The results obtained during the present investigation, maximum yield (1180.00 g/kg of a dry substrate with 98.3% biological efficiency), the highest number of fruiting bodies (35), maturity (22 days), and minimum days for spawn run (16 days) was observed in 50% wheat Straw + 50% paddy straw + @ 10% pulse husk combination. The pinhead appearance (32 days) their maturity (34 days), total yield (1050.0g), and the percent of biological efficiency (96.5%) was recorded on wheat straw + @ 10% pulse husk. Among all the used combinations the late pinhead appearance (43days) their maturity (48days), minimum yield in each flush, total yield (630.0g), and least percent of biological efficiency (63.3%) was recorded on paddy straw+ @10%rice bran. Based on the results obtained, pulse husk would be recommended as appropriate organic supplements for the combination of substrate of Wheat straw +Paddy straw for the best production of oyster mushroom sp. (*Pleurotus*).

Muswati *et al*. (2021) conducted a research work aimed at evaluating the effect of mixing substrates on the growth and yield of Oyster mushrooms (*Pleurotus ostreatus*). Seven substrates, namely, Trt1 (cotton waste), Trt2 (wheat straw), Trt3 (crushed baobab fruit shells, 100%), Trt4 (cotton husk + wheat straw + crushed baobab fruit shells, 1:1:1), Trt5 (baobab fruit shells + cotton husks, 1:1), Trt6 (baobab fruit shells + wheat straw, 1:1), and Trt7 (cotton waste + wheat straw, 1:1) were used. Each treatment was replicated 5 times and laid out in a CRD. %e duration of developmental stages, yield, and biological efficiency was recorded. Cotton waste demonstrated a significantly ($p<0.05$) higher mycelial colonization rate taking an average of 18.20 days to complete full spawn run, 23.20 days from spawning to pinhead formation, 2.80 days for pins to mature, and an average of 26.00 days to first harvest. %ere was a significant ($p<0.05$) difference in the total number of pins with cotton waste being the highest with an average of 29.80 pins, although it was not significantly different from Trt4. %e highest (5.40 cm) stipe girth was recorded from Trt4 while the highest (5.22 cm) cap diameter was recorded in Trt1. %ere was a significant ($p<0.05$) difference in yield and biological efficiency. Trt1 had the highest (1.292 kg) average yield; however, it was not significantly ($p>0.05$) different from that of Trt4 (1.289 kg). From the research, it was observed that mixing substrate can help to increase yield and, as a result, a higher benefit-cost ratio. Therefore, further studies should be done to evaluate the effects of mixing other substrates besides the ones used in this current research.

Liang *et al*. (2019) conducted an experiment with *Auricularia polytricha* which was cultivated on a sawdust basal substrate supplemented with different proportions (30%, 45%, and 60%, respectively) of stalks of three grass plants, i.e., *Panicumrepens* (PRS), *Pennisetum purpureum* (PPS), and *Zea mays* (ZMS), to determine the most effective substrate. The mycelial growth rate, total colonization time, days to primordial formation, biological efficiency and chemical composition of fruiting bodies were evaluated. The results indicated that 30PPS was the best substrate for mycelial growth of *A. polytricha*, with a corresponding total colonization period of 32.0 days. With the exception of 30PPS, the total biological efficiency of all of the substrates containing *P. repens* stalk, *P. purpureum* stalk and *Z. mays stalk* was higher ($P < 0.05$) than that of the control. The most suitable substrate with a high biological efficiency was 60PRS (148.12%), followed by 30ZMS (145.05%), 45ZMS (144.15%) and 30PRS (136.68%). The nutrient values of fruiting bodies were affected by different substrates. The ash contents of *A. polytricha* cultivated on a substrate containing *Z. mays* stalk were higher than that of the control; meanwhile, the protein contents of mushroom cultivated on a substrate containing *P. repens* stalk (except substrate 45PRS) were higher than that of the control. The biological efficiency of the substrates was tested, and according to the results, it is feasible to use the stalks of *P. repens* and *Z. mays* on partially replaced sawdust to cultivate *A. polytricha*.

Sitaula *et al*. (2018) conducted an experiment to find out the growth and yield performance of oyster mushroom (*Pleurotus ostreatus*) in Completely Randomized Design (CRD). The treatment includes the four different substrate i.e. paddy straw (100%), maize cob+ paddy straw (1:1), sugarcane bagasses+paddy straw (1:1) and sawdust+ paddy straw (1:1). The parameters taken for the observation during the experiment were colonization period, fruit initiation period, length of stalk and pileus, diameter of stalk, diameter of pileus, fresh weight of the first and second flush of mushroom and also the biological efficiency (BE) of various substrates. Among the used substrates, the time for colonization and fruit initiation was found to be shorter in case of the paddy straw i.e.18.25 days and 21.75 days respectively. However, the length of stalk and pileus was highest in sugarcane bagasses+paddy straw (1:1) i.e. 6.10 and 7.12 cm, but the diameter of stalk and pileus were highest in paddy straw i.e. 0.80 cm and 7.90 cm respectively. Similarly, the biological efficiency was found to be highest in case of the paddy straw (96.29%) followed by maize cob+paddy straw (1:1), sugarcane bagasses+ paddy straw (1:1) and sawdust+ paddy straw (1:1) respectively.

Carrasco *et al*. (2018) reported that mushroom supplementation is an agronomic process which consists of the application of nutritional amendments to the substrates employed for mushroom cultivation. Different nitrogen and carbohydrate rich supplements have been evaluated in crops with a substantial impact on mushroom yield and quality; however, there is still controversy regarding the nutritional requirements of mushrooms and the necessity for the development of new commercial additives. The addition of external nutrients increases the productivity of some low-yielding mushroom varieties, and therefore is a useful tool for the industry to introduce new commercially viable varieties. Spent mushroom compost is a waste material that could feasibly be recycled as a substrate to support a new commercially viable crop cycle when amended with supplements. On the other hand, a new line of research based on the use of mushroom growth promoting microorganisms is rising above the horizon to supplement the native microbiota, which appears to cover nutritional deficiencies. Several supplements employed for the cultivated mushrooms and their agronomic potential in terms of yield and quality are reviewed in this paper as a useful guide to evaluate the nutritional requirements of the crop and to design new formulas for commercial supplementation.

Mkhize *et al*. (2016) carried out a study aimed to improve the performance of mushroom in terms of high production and fast growth rate is essential in mushroom cultivation. The performance of *Pleurotus ostreatus* was evaluated using varying levels of wheat bran (WB) and maize flour (MF). The results indicated that *Pleurotus ostreatus* was highly influenced by different levels of supplementation, with 8% WB, 18% WB and 2% MF having higher contamination rate. The low levels of supplementation gave significantly better mycelial growth rate (MGR) and shorter colonization period as observed that the control had highest MGR whereby 20% MF had lowest MGR. The pinning time (TP) was shortest at the first flush with minimum of 3 days (12% MF). The higher levels of supplementation showed maximum biological efficiency (BE) such as 14% MF, 12% WB and 14% WB. The yield was also higher at high levels of supplementation such as 20% MF and 8% MF being the exception in the lower levels. Based on the results it was observed that for fast production of oyster mushroom there is no need to supplement the maize stalk substrate but for improved productivity supplements can be added up to certain limits such as 14% MF and 12 WB.

Hoa *et al*. (2015) conducted a study to compare the effects of different agro-wastes on the growth, yield, and nutritional composition of oyster mushrooms *Pleurotus ostreatus* (PO) and *Pleurotus cystidiosus* (PC). Seven substrate formulas including sawdust (SD), corncob (CC), sugarcane bagasse (SB) alone and in combination of 80 : 20, 50 : 50 ratio between SD and CC, SD and SB were investigated. The results indicated that different substrate formulas gave a significant difference in total colonization period, characteristics of fruiting bodies, yield, biological efficiency (BE), nutritional composition and mineral contents of two oyster mushrooms PO and PC. The results showed that increasing CC and SB reduced C/N ratio, and enhanced some mineral contents (Ca, P, and Mg) of substrate formulas. The increased amount of CC and SB of substrate formulas enhanced protein, ash, mineral contents (Ca, K, Mg, Mn, and Zn) of fruiting bodies of both mushrooms. Substrates with 100% CC and 100% SB were the most suitable substrate formulas for cultivation of oyster mushrooms PO and PC in which they gave the highest values of cap diameter, stipe thickness, mushroom weight, yield, BE, protein, fiber, ash, mineral content (Ca, K, and Mg) and short stipe length. However, substrate formula 100% CC gave the slowest time for the first harvest of both mushrooms PO and PC (46.02 days and 64.24 days, respectively). It is also found that the C/N ratio of substrate formulas has close correlation with total colonization period, mushroom weight, yield, BE and protein content of mushroom PO and PC.

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 whereas, supplemented SMS can be a good substrate for further mushroom production.

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.

Survase (2012) Studied the performance of *Pleurotus sajor-caju* on different agricultural wastes *viz*., wheat straw, paddy straw, soybean straw, pigeon pea straw and green gram straw singly or in combination with wheat + soybean, wheat + pigeon pea, wheat + green gram (1:1). He reported maximum yield on wheat + pigeon pea straw (638 g/bed) with number of fruiting bodies (36), followed by wheat + soybean straw (622 g/bed) with highest number of fruiting bodies (40), pigeon pea straw (608 g/bed and 35), paddy straw (587 g/bed and 34), wheat straw (562 g/bed and 32), wheat + green gram straw (533 g/bed and 33), soybean (526 g/bed and 32) and green gram (412 g/bed and 27).

Mateus Dias Nunes *et al*. (2012) studied on nitrogen supplementation on the productivity and the chemical composition of oyster mushroom. The fungi were grown in various substrates supplemented with urea or rice bran, and the biological efficiency, mineral composition, protein and β-glucan content were evaluated. The growth of *P. ostreatus* in substrates with nitrogen supplementation increases the mushroom's productivity and nutritional value.

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.

Patil *et al*. (2010) Conducted experiment to evaluate the substrate for maximum yield and nutritional content of *Pleurotus sajor-caju* when grown on different agro wastes like soybean, paddy, wheat straw and their combinations in 1:1 proportion. Significantly maximum yield (with 85.76 % B.E.), protein (26.00%), fat (2.60 %), carbohydrate (56.66 %), crude fiber (7.20 %) content were found when mushroom was cultivated on soybean straw. Paddy straw showed maximum moisture (89.09 %) and ash content (6.65 %) in mushroom fruit bodies.

Patil *et al*. (2010) studied the effect of different agrowastes *viz*., soybean, paddy and wheat straw alone or in combination on the yield performance of *Pleurotus ostreatus*. They reported maximum yield (851.66 g /kg dry substrate) with highest/kg dry substrate and 84.56 %), soybean straw + paddy straw (816.99 g /kg dry substrate and 81.69 %), soybean straw + wheat straw (776.66 g /kg dry substrate and 77.66 %), wheat straw (720.66 g and 72.06 %) and wheat straw + paddy straw (717.66 g and 71.76 %).

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.

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% ($T_3$).

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).

Ngezimana and Mtaita (2008) studied onimproving biological efficiency of Oyster mushroom, *Pleurotus ostreatus*, through composting and use of organic supplements. Supplements were equally effective for improving the performance of Oyster mushroom in almost all the substrates used. Composting of the substrates was beneficial in cotton residues and wheat straw substrates with biological efficiency of 145.7 and 28.2% respectively compared to their controls (32.3 and 5.3 respectively). It was concluded that both supplement can be used to enhance production and composting was not beneficial with maize stover.

Bhuyan (2008) conducted an experiment to study the effect of various supplements at different levels with sawdust showed significant effort on mycelium running rate and reduced the required days to complete mycelium running in the spawn packet. The supplementation of sawdust found to be significant in yield and yield contributing characters of oyster mushroom with some extent. The highest biological yield, economic yield, dry yield, biological efficiency (BE) and benefit cost ratio (BCR) of 270.5 g, 266.5 g, 26.34 g, 93.29, 9.57%, respectively was observed in sawdust supplemented with NPK mixed fertilizer (N=0.6%, P=0.3%, K=0.3%). Sawdust supplemented with different levels has a profound effect on chemical composition of oyster mushroom. Sawdust supplemented at different substrate found to be significant with mineral content of the fruiting body. Considering all the parameters in five experiments, NPK mixed fertilizer (N=0.6%, P=0.3%, K=0.3%) supplemented with sawdust is found promising for lowering the cost of production as well as increasing the yield and quality of fruiting body. Cow dung (11.5%) and starch (5.5%) as supplement with substrate may be the fair choice.

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).

Ngezimana (2007) studied on the use of organic supplements and composted substrates in oyster mushroom (*Pleurotus ostreatus*) production. Wheat straw performed best at 14% level (104.2% BE), with significant difference from lower supplement levels. Composted cotton residues and wheat straw gave significantly higher yields than maize stover and their controls. First two flushes contributed more to the total yields (approximately 70%) than subsequent flushes.

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.

Sharma (2004) conducted a laboratory experiment to study the effects of different organic amendments (gram dal powder, Lathyrus dal powder, moong dal powder and soyabean dal powder) on the growth and yield of the oyster mushroom, *Pleurotus djamor*. Chopped rice and wheat straw served as substrates. Observations were recorded on the number of days for spawn run, number of days for the initiation of primordia formation and yield. The effect of supplements did not differ significantly for the time taken for spawn run and initiation of pinhead stage. *P. djamor* yield was significantly influenced by the different supplements on both substrates. The addition of 2% moong dal powder resulted in the highest yield in both substrates while the lowest yield was recorded when Lathyrus dal powder was added to the substrates. Rice straw supplemented with gram dal powder showed a significantly lower yield than even the untreated control.

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.

Banik and Nandi (2004) found popularity of oyster mushroom is increasing 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 lignocellulosic crop residue - rice straw supplemented with biogas residual slurry manure in 1:1 ratio as substrate. Residual slurry manures obtained from biogas plants utilising either cattle dung, 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 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 sajor-caju* 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.

Vyas *et al*. (2002) found that the yield of *Pleurotus florida* cultured on wheat straw supplemented with wheat bran, rice bran or neem cake under laboratory condition maintaining 26°C temperature and 80-85 % relative humidity and found that wheat straw supplemented with neem cake was the most favorable substrate for florida production.

Khan *et al*. (2002) were conducted an studies on cultivation of oyster mushroom (*Pleurotus spp*.) on different forest wastes .The sawdust of Shisham (*Dalbergia sissoo*) supplied alone or in combination with 10% cotton seed hulls, 5% horse dung, 5% wheat bran or 5% cow dung were evaluated for the productivity of *P. ostreatus*. Sisham sawdust combined with 10% cotton seed hulls proved the best for spawn running with a mean 13.35 days, followed by sisham sawdust combined with 5% horse dung, 5% wheat bran, 5% cow dung and shisham sawdust alone. Maximum yield was obtained by shisham + 10% cotton seed hulls while minimum yield was obtained by shisham sawdust alone.

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.

Shen and Royse (2001) evaluated the effects of various, combinations of wheat bran, rye and millet (At 20% and 30% of total dry substrate Wt) on crop cycle time, biological efficiency (BE) and mushroom quality for a commercially used isolate of Grifola frondoso (maitake). Supplements were combined with a basal ingredient of mixed oak (primarily red oak) sawdust and the resulting mixture was pasteurized, cooled, inoculated and bagged with an autoclaving mixer. Times to mushroom primordial formation and mushroom harvest were recorded, and mushroom quality was rated on a scale of 1-4, where 1 was the highest quality and 4 was the lowest quality. The combinations of 10%, wheat bran, 10% millet and 10% rye (BE 47.1%, quality 1.5 and crop cycle 12 weeks) and 10% wheat bran plus 20% rye (BE 44%, quality 1.7 and crop cycle 10 weeks) gave the most consistent yields and best basidiome quality over time.

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.

Mandhare (2000) studied the effect of different straws *viz*., soybean straw, wheat straw, paddy straw and cotton straw single or in combination on productivity of five Pleurotus species (*P. eous*, *P. flabellatus*, *P. florida*, *P. sapidus* and *P. sajor-caju*). He reported highest yield of *P. florida* on cotton straw (118.26 g /kg dry substrate), followed by soybean straw (109.33 g), cotton + wheat straw (105.73 g) and paddy straw (95.30 g).

Permana *et al*. (2000) reported that Sugarcane bagasse supplemented with soyabean meal or wheat bran served as valuable substrate for production of *Pleurotus sajor-caju, P. eiyngii* and *Agrocybe aegerita*. Comparable lignin degradation, fruiting body yield and increase in vitro digestibility, as obtained with other traditional substrates, were achieved. Judging from the above, sugarcane industries could source further benefits through recycling of bagasse in the production of mushroom substrate and animal feed, which can be commercialized. The resulting compost can further be incorporated in the soil to boost the fertility status of tropical soils. Appropriate technology for this bioconversion is a subject for which further studies are needed.

Chowdhury *et al*. (1998) examined the effects of adding rice husks, soybean meal, pea meal, wheat bran, poultry manure or neem cake (each at 2 or 5%) to rice straw for growing oyster mushrooms (*P. sajor-caju*). Adding 5% soybean or pea meal gave the highest yield of 630 g/kg dry straw.

Pani and Mohanty (1998) used water hyacinth alone and in combination with paddy straw (3:1, 1:1 and 1:3 ratios) for cultivation of *Pleurotus sajor-caju* and *P. Florida*. Paddy straw alone sustained highest mushroom yield (83.3-84.6% BE). Water hyacinth in combination with paddy straw produced higher yields than when used alone.

Biswas *et al*. (1997) reported that methods including spawning percentage, combinations of paddy straw, wheat straw and supplements, to improve the biological efficiency (BE) of *P. florida*. Increasing spawning rates reduced the time required for spawn runs. The highest BE (66.8-101.25%) was observed after the use of the highest spawning percentages. A 1:1 mixture of paddy straw wheat and straw promoted a high BE (106.5%); supplementation of this substrate with 5% rice flour also promoted BE (125.75%).

Zakia *et al*. (1993) supplemented the rice straw substrate of *P. sajor-caju* with powdered oilseed cakes and (mustard, niger [Guizotia abyssinica], sunflower, cotton or soyabean) increased mushroom yields by between 50 and 100%, compared with unsupplemented substrate, and also increased the protein content of the fruiting bodies. The highest yield (2232 g FW/kg dry straw, compared with 1133 g FW/kg dry straw for control) was obtained with cotton seed cake at a concentration of 0.45% N by DW. Oilseed cake supplementation also increased the contents of free sugars and amino acids of the substrate, and reduced the substrate cellulose and hemicelluloses contents, with corresponding increases in the activities of carboxymethylcellulase, hemicelluloses and protease. In vitro dry matter enzymatic digestibility (the percentage organic matter lost during a 2-step enzymatic digestion of spent substrate with pepsin and cellulose) was significantly greater for supplemented straw substrates than for the unsupplemented substrate.

Khan *et al*. (1991) used sawdust to prepare compost for spawn running amended with lime and different combinations of wheat chaff, wheat bran, paddy straw and cotton waste. Sawdust from *D. sisso* was the most suitable for spawn preparation and all types of sawdust amended with cotton waste were found to give optimum conditions for spawn running.

# CHAPTER III

# MATERIALS AND METHODS

The experiment was carried out to find out the performance of different supplements and their levels on growth and yield of three oyster mushroom species (*Pleuratusspp*.). This chapter deals with a brief description on location and design of experiment, experimental treatments, preparation of substrates and/or with supplements, 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 June 2019 to September 2019. The environmental condition of the experimental location was given in Appendix I.

## 3.2 Experimental materials

### 3.2.1 Mushroom species

Three species *viz*. (i) $V_1$ = *Pleurotus djamor*, (ii) $V_2$ = *Pleurotus florida* and (iii) $V_3$ = *Pleurotuso streatus* po10 were used

### 3.2.2 Substrates with supplements

Sawdust was used as substrate with seven supplements *viz*. (i) $S_1$ = Wheat bran (WB), (ii) $S_2$ = Maize powder (MP), (iii) $S_3$ = Rice straw (RS), (iv) $S_4$ = Wheat bran + maize powder (1:1), (v) $S_5$ = Maize powder + rice straw (1:1), (vi) $S_6$ = Rice straw + wheat bran (1:1) and (vii) $S_7$ = Wheat bran + maize powder + rice straw (1:1:1).

## 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: Mushroom species –( 3)

1. $V_1$ = *Pleurotus djamor*
2. $V_2$ = *Pleurotus florida*
3. $V_3$ = *Pleurotus ostreatus* po10

#### 3.4.1 Factor B: Supplements – (7)

1. $S_1$ = Wheat bran (WB)
2. $S_2$ = Maize powder (MP)
3. $S_3$ = Rice straw (RS)
4. $S_4$ = Wheat bran + maize powder (1:1)
5. $S_5$ = Maize powder + rice straw (1:1)
6. $S_6$ = Rice straw + wheat bran (1:1)
7. $S_7$ = Wheat bran + maize powder + rice straw (1:1:1)

**Treatment combinations:**$V_1S_1$, $V_1S_2$, $V_1S_3$, $V_1S_4$, $V_1S_5$, $V_1S_6$, $V_1S_7$, $V_2S_1$, $V_2S_2$, $V_2S_3$, $V_2S_4$, $V_2S_5$, $V_2S_6$, $V_2S_7$, $V_3S_1$, $V_3S_2$, $V_3S_3$, $V_3S_4$, $V_3S_5$, $V_3S_6$ and $V_3S_7$.

### 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 21 treatment combinations one spawn packet was in each replication.

### 3.6 Preparation of substrates, spawn packets with supplements

#### 3.6.1 Sawdust substrate

Sawdust (SD) substrate was prepared by sun drying and removing other impurities like mud, stones, wood pieces etc. This sawdust substrate was ready for spawn packet preparation.

### 3.6.2 Preparation of spawn packets

The mixed substrates were filled into 9 × 12 inch polypropylene bag @ 500 g. Water was added to the mixture to make the moisture level 60% and $CaCO_3$ was added @0.2% (w/w) of the mixture. The filled polypropylene bags were prepared by using heat resistant plastic neck and plugged the neck with cotton and covered with brown paper placing rubber band to hold it tightly in place. A hole is made of about 2-3 cm deep for better inocula introduction.

### 3.6.2 Preparation of spawn packets with supplements

According to treatments, spawn packets were prepared by sawdust by adding supplements maintaining 500 g with 60% moisture. The spawn packets were transferred to autoclave for sterilization for 2 hours at 121˚C under 1.1kg/cm2 pressure. After sterilization, the packets were cooled and transferred to inoculation chamber. After 24 hours the packets were inoculated while taking out of inoculation chamber according to variety @5gm per packet. The packets were incubated at 22±2˚C.

#### 3.6.2.1 Preparation of spawn packet with wheat bran supplement

Sawdust (SD) substrate with wheat bran (WB) supplement was prepared by sterilization method. Fourteen (16) kg SD + eight (8) kg WB was mixed at 2:1 ratio with 18 liters of water and the mixture was prepared. The mixed SD substrate with WB supplement was filled into 9 × 12 inch polypropylene bag @ 500 g. The spawn packets were transferred to autoclave for sterilization for 2 hours at 121˚C under 1.1kg/cm$^2$ pressure. The above mentioned amount of substrate with supplement (16 kg SD + 8 kg WB) was for 100 spawn packets. With this calculation each spawn packet contained 160 g SD + 80 g WB + 60% moisture.

#### 3.6.2.2 Preparation of spawn packet with maize powder supplement

Sawdust (SD) substrate with maize powder (MP) supplement was prepared by sterilization method. Fourteen (16) kg SD + eight (8) kg MP was mixed with 18 liters of water and the mixture was prepared. The mixed SD substrate with MP supplement was filled into 9 × 12 inch polypropylene bag @ 500 g. Then the spawn packets were transferred to autoclave for sterilization for 2 hours at 121˚C under 1.1 kg/cm$^2$ pressure. The above mentioned amount of substrate with supplement (16 kg SD + 8 kg MP) was for 100 spawn packets. With this calculation each spawn packet contained 160 g SD + 80 g MP + 60% moisture.

#### 3.6.2.3 Preparation of spawn packet with rice straw supplement

Sawdust (SD) substrate with rice straw (RS) supplement was prepared by sterilization method. Fourteen (16) kg SD + eight (8) kg RS was mixed with 18 liters of water. This SD substrate with RS supplement was ready for spawn packet preparation. The mixed SD substrate with RS supplement was filled into 9 × 12 inches polypropylene bag @ 500 g. The spawn packets were transferred to autoclave for sterilization for 2 hours at 121˚C under 1.1kg/cm2 pressure. The above mentioned amount of substrate with supplement (16 kg SD + 8 kg RS) was for 100 spawn packets. With this calculation each spawn packet contained 160 g SD + 80 g RS + 60% moisture.

#### 3.6.2.4 Preparation of spawn packet with wheat bran + maize powder (1:1) supplement

Sawdust (SD) substrate with WB + MP (1:1) supplement was prepared by sterilzation method. Fourteen (16) kg SD + four (4) kg WB + four (4) kg MP was mixed with 18 liters of water. This SD substrate with WB + MP (1:1) supplement was ready for spawn packet preparation. The mixed SD substrate with WB + MP (1:1) supplement was filled into 9 × 12 inch polypropylene bag @ 500 g. The spawn packets were transferred to autoclave for sterilization for 2 hour at 121˚C under 1.1 kg/cm$^2$ pressure. The above mentioned amount of substrate with supplement (16 kg SD + 4 kg WB + 4 kg MP) was for 100 spawn packets. With this calculation each spawn packet contained 160 g SD + 40 g WB + 40 g MP + 60% moisture.

#### 3.6.2.5 Preparation of spawn packet with maize powder + rice straw (1:1) supplement

Sawdust (SD) substrate with MP + RS (1:1) supplement was prepared by sterilization method. Sixteen (16) kg SD + four (4) kg MP + four (4) kg RS was mixed with 18 liters of water. This SD substrate with MP + RS (1:1) supplement was ready for spawn packet preparation. The mixed SD substrate with MP + RS (1:1) supplement was filled into 9 × 12 inch polypropylene bag @ 500 g. The spawn packets were transferred to autoclave for sterilization for 2 hours at 121˚C under 1.1 kg/cm$^2$ pressure. The above mentioned amount of substrate with supplement (16 kg SD + 4 kg MP + 4 kg RS) was for 100 spawn packets. With this calculation each spawn packet contained 160g SD + 40 g MP + 40 g RS + 60% moisture.

#### 3.6.2.6 Preparation of spawn packet with rice straw + wheat bran (1:1) supplement

Sawdust (SD) substrate with RS + WB (1:1) supplement was prepared by sterilization method. Fourteen (16) kg SD + four (4) kg RS + four (4) kg WB was mixed with 18 liters of water. This SD substrate with RS + WB (1:1) supplement was ready for spawn packet preparation. The mixed SD substrate with RS + WB (1:1) supplement was filled into 9 × 12 inch polypropylene bag @ 500 g. The spawn packets were transferred to autoclave for sterilization for 2 hours at 121˚C under 1.1 kg/cm$^2$ pressure. The above mentioned amount of substrate with supplement (16 kg SD + 4 kg RS + 4 kg WB) was for 100 spawn packets. With this calculation each spawn packet contained 160 g SD + 40 g RS + 40g WB + 60% moisture.

#### 3.6.2.7 Preparation of spawn packet with wheat bran + maize powder + rice straw (1:1:1) supplement

Sawdust (SD) substrate with WB + MP + RS (1:1:1) supplement was prepared by sterilization method. Sixteen (16) kg SD + 2.66 kg WB + 2.66 kg MP + 2.66 kg RS was mixed with 18 liters of water. This SD substrate with WB + MP + RS (1:1:1) supplement was ready for spawn packet preparation. The mixed SD substrate with WB + MP + RS (1:1:1) supplement was filled into 9

× 12inch polypropylene bag @ 500 g. The spawn packets were transferred to autoclave for sterilization for 2 hours at 121˚C under 1.1 kg/cm$^2$ pressure. The above mentioned amount of substrate with supplement (16 kg SD + 2.66 kg WB + 2.66 kg MP + 2.66 kg RS) was for 100 spawn packets. With this calculation each spawn packet contained 160g SD + 20 g WB + 20 g MP + 20 g RS + 60% moisture.

### 3.7 Inoculation and mycelium running in spawn packets

The spawn packets were transferred to autoclave for sterilization for 2 hour at 121˚C under 1.1 kg/cm$^2$ pressure. After sterilization, the packets were cooled and transferred to inoculation chamber. After 24 hours the packets were inoculated while taking out of inoculation chamber according to variety @5 gm per packet. The packets were incubated at 22±2˚C. Then the spawn packets were moved to an incubation chamber and kept until mycelium run had completed and the whole packet become white. 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.

### 3.8 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. This improves the primordia initiation. The moisture of the culture room was maintained 80-85% relative humidity by spraying water 2 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.

### 3.9 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.

### 3.10 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.

### 3.11 Data collection

Data were collected on the following parameters:

#### 3.11.1 Growth parameters

1. Mycelium run rate (cm/day)
2. Mycelium run complete (Days)
3. Pin head initiation (Days)
4. Pin head initiation to harvest (days)

#### 3.11.2 Yield contributing parameters

1. Number of fruiting bodies
2. Number of effective fruiting bodies
3. Length of pileus (cm)
4. Diameter of stipe (cm)
5. Diameter of pileus (cm)
6. Thickness of pileus (cm)

### 3.11.3 Yield parameters

1. Biological yield (g)
2. Economic yield (g)
3. Biological efficiency (%)

## 3.12 Procedure of recording data

### 3.12.1 Mycelium run rate (cm/day)

Mycelium running rate (MRR) for each type of treatment was measured after the mycelium colony crossed the shoulder of the packet. The linear length was measured at four different places of packet.

$$MRR = \frac{L}{N} \text{ (cm day}^{-1}\text{)}$$

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

### 3.12.2 Mycelium run complete (days)

Days required from inoculation to completion of mycelium running were recorded. Days required from inoculation and completion of mycelium running, days required from scrapping to primordia initiation, days required from primordia initiation to harvest and days required from scrapping to harvesting on different treatments were recorded.

### 3.12.3 Pin head initiation (days)

Days required from inoculation to 1$^{st}$ pin head initiation of mycelium were recorded.

### 3.12.4 Days required from pin head initiation to 1$^{st}$ harvest

Firstly 1$^{st}$ pin head initiation was observed and days to pin head initiation to 1$^{st}$ harvest was recorded.

### 3.12.5 Total number of fruiting body

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

### 3.12.6 Number of effective fruiting body

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

### 3.12.7 Length of pileus (cm)

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

### 3.12.8 Diameter of stipe (cm)

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

### 3.12.9 Diameter of pileus (cm)

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

### 3.12.10 Thickness of pileus (cm)

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

### 3.12.11 Biological yield (g)

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

### 3.12.12 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.

### 3.12.13 Biological efficiency (%)

Biological efficiency was determined by the following formula:

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

## 3.13 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). 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 data recorded on various characters during the course of investigation entitled “Performance of different supplements and their levels on growth and yield of three oyster mushroom species” have been presented in this chapter along with appropriate tables and figures under the following heads:

## 4.1 Growth parameters

### 4.1.1 Mycelium run rate (cm/day)

Different species of mushroom showed non-significant influence on mycelium run rate (Figure 1 and Appendix II). However, results revealed that the highest mycelium run rate (0.69 cm day$^{-1}$) was recorded from the variety $V_1$ (*Pleurotus djamor*) followed by $V_3$ (*Pleurotus ostreatus* po10) whereas the lowest mycelium run rate (0.64 cm day$^{-1}$) was found from the variety $V_2$ (*Pleurotus florida*).

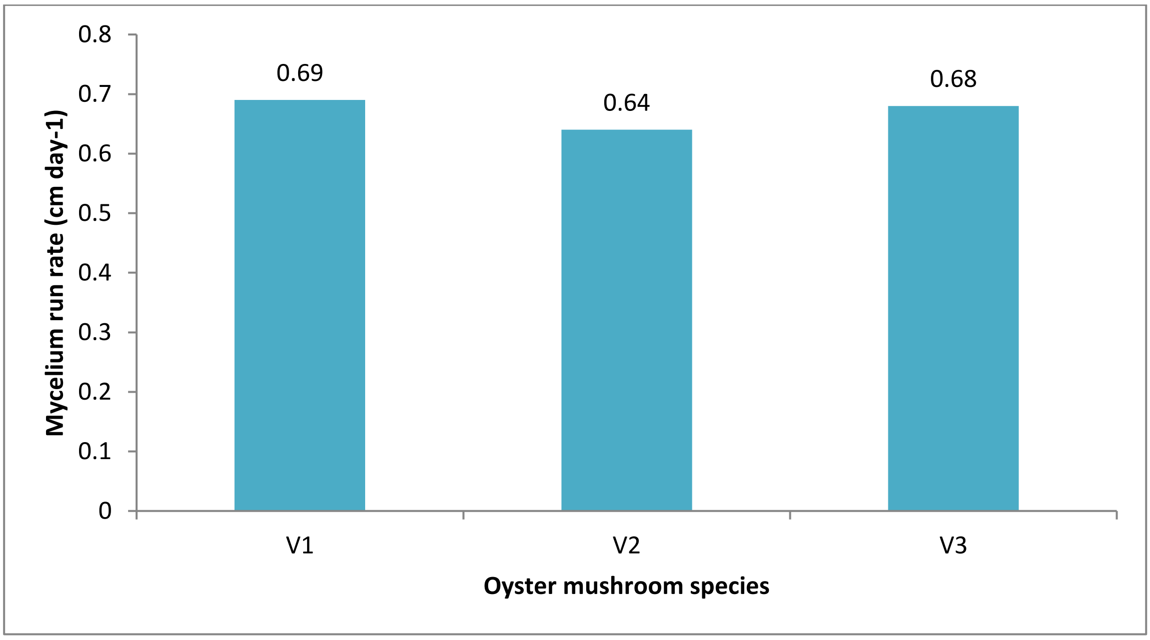


**Figure 1. Mycelium run rate of oyster mushroom as influenced by different species**

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

The present findings corroborated with the findings of Rawte and Diwan (2019) and Zape *et al.* (2006) who found non-significant variation on mycelium running rate among different varieties but Akter *et al*. (2019) found that different spawn seed on different variety showed significant effect on mycelia running rate of Oyster mushroom.

Significant variation was found in mycelium run rate due to the effect of different supplementation to substrates (Figure 2 and Appendix II). However, the highest mycelium run rate (0.79 cm day$^{-1}$) was observed in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was statistically same with $S_4$ (Wheat bran + maize powder; 1:1) and $S_5$ (Maize powder + rice straw; 1:1) whereas the lowest mycelium run rate (0.57 cm day$^{-1}$) was in the supplementation treatment $S_3$ (Rice straw; RS) that was significantly different from other treatments.

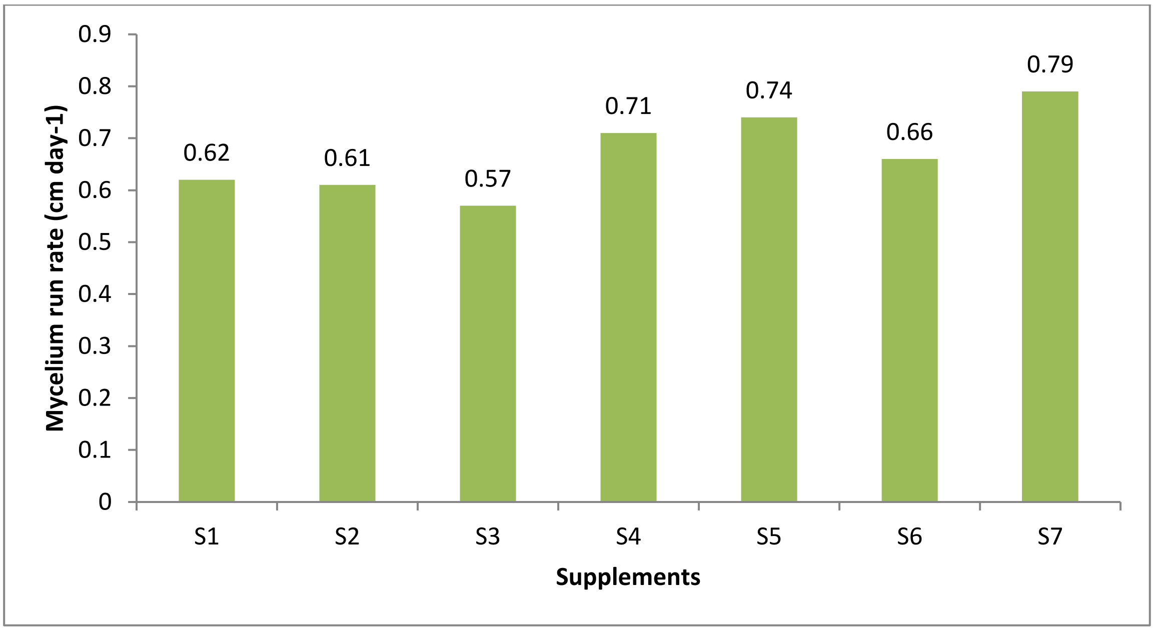


**Figure 2. Mycelium run rate of oyster mushroom as influenced by different supplements**

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

The present findings keep in with the findings of Khan *et al*., 1991, Sarker, 2004, Bhuyan, 2008, Kulsum *et al*., 2009, Mandol *et al.*, 2010 and Hasan *et al*., 2010). Khan *et al*. (1991) reported that sawdust amended with different organic supplement like wheat chaff, wheat bran, paddy straw, cotton waste etc. provided suitable condition for spawn running. Sarker (2004) found that the mycelium running rate of oyster mushroom greatly influenced with the supplement of wheat brans in different levels. Kulsum *et al*. (2009) observed that the highest mycelium running rate was 0.71 cm due to sawdust supplemented with cow dung @ 15% which is more or less similar to the present study. Bhuyan (2008), Mandol *et al.* (2010) and Hasan *et al*. (2010) also found similar result as found in the present experiment.Sinha *et al*. (2021) reported the minimum days for spawn run was observed using supplementation regarding 50% wheat Straw + 50% paddy straw + @ 10 % pulse husk combination.

Treatment combination of different oyster mushroom species and treatments of supplement to substrate showed statistically significant variation on mycelium run rate (Table 1 and Appendix II). Results indicated that the highest mycelium run rate (0.82 cm $day^{-1}$) was recorded from the treatment combination of $V_1S_7$ that was significantly similar with the treatment combination of $V_3S_7$. The lowest mycelium run rate (0.55 cm $day^{-1}$) was recorded from the treatment combination of $V_2S_3$ and this treatment combination was statistically similar to $V_3S_3$.

### 4.1.2 Mycelium run complete (days)

Significant variation was found for mycelium run complete due to different species of mushroom (Figure 3 and Appendix II). However, results revealed that the highest mycelium run complete was recorded as 20.93 days from the variety $V_2$ (*Pleurotus florida*) followed by$V_3$ (*Pleurotus ostreatus* po10) whereas the lowest mycelium run complete (18.75 days) was found from the variety $V_1$ (*Pleurotus djamor*). Similar result was also observed by Patra and

Pani (1995) and they observed lower variation on mycelium run complete among different species of oyster mushroom.

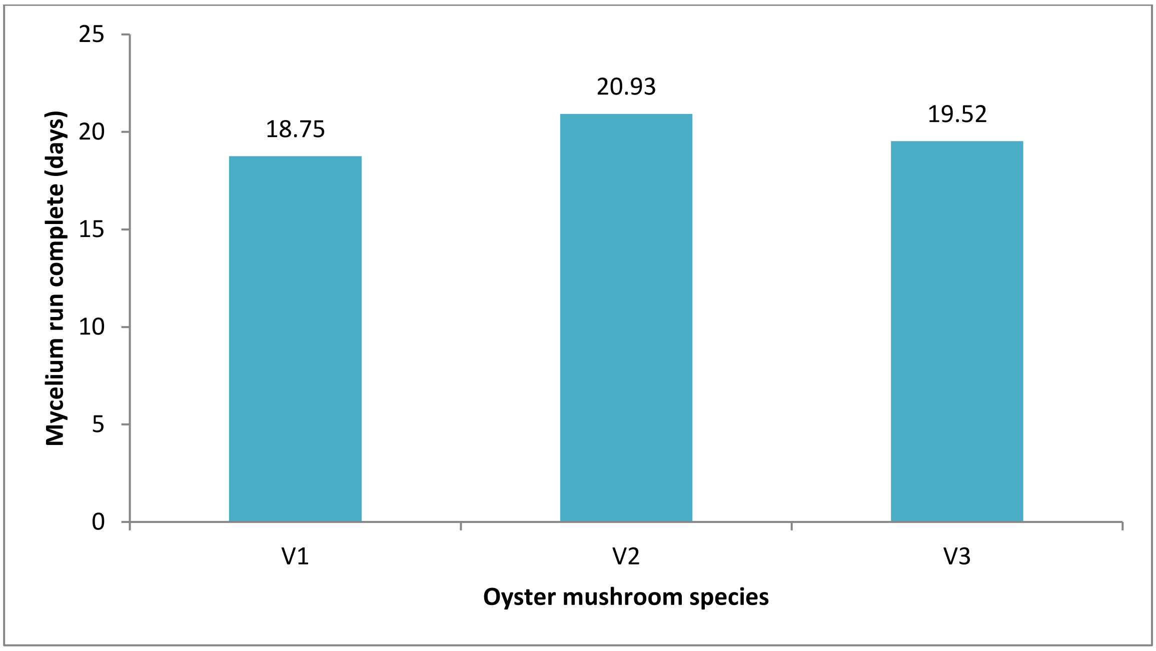


**Figure 3. Mycelium run complete of oyster mushroom as influenced by different species**

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

Significant influence was observed on mycelium run complete as influenced by different supplementation effect to substrates (Figure 4 and Appendix II). Results showed that the highest mycelium run complete (24.96 days) was recorded in the supplementation treatment $S_3$ (Rice straw; RS) which was significantly different from other treatments followed by $S_2$ (Maize powder; MP). The lowest mycelium run complete (15.79 days) was observed from the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) and this was significantly differed to other treatments. The present findings was similar with the findings of Kalita *et al*. (2001) who reported that time taken for completion of spawn running may require from 17 days to 22 days by use of different substrates. Similar result was also observed by Hasan *et al*. (2010) and Bhuyan (2008) who found different supplementation to substrate increased mycelium running rate and reduced time for mycelium running completion.

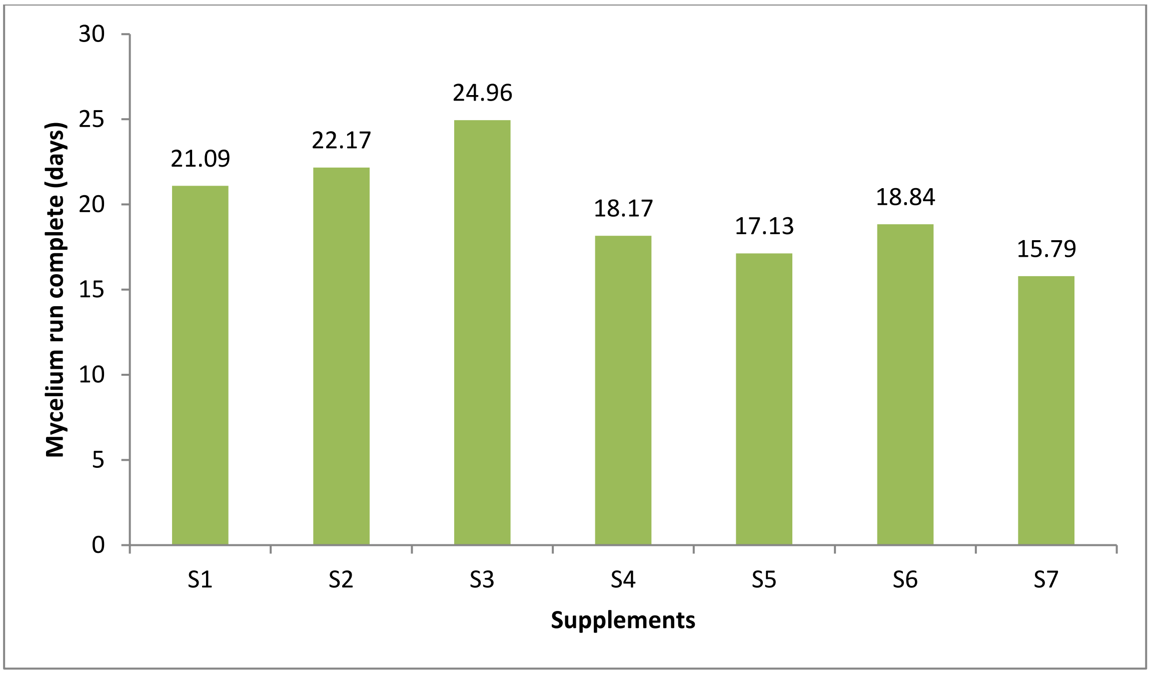


**Figure 4. Mycelium run complete of oyster mushroom as influenced by different supplements**

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

There was a significant influence on mycelium run complete in terms of combined effect of different oyster mushroom species and supplementation treatments to substrate (Table 1 and Appendix II). Results noticed that the highest mycelium run complete (26.13 days) was recorded from the treatment combination of $V_2S_3$ which was significantly same with the treatment combination of $V_3S_3$ followed by $V_1S_3$ and $V_2S_2$. The lowest mycelium run complete (14.25 days) was recorded from the treatment combination of $V_1S_7$ which was statistically similar with $V_3S_7$.

### 4.1.3 Pin head initiation (days)

Days to pin head initiation showed significant difference among different mushroom species (Figure 5 and Appendix II). The highest days to pin head initiation (25.79 days) was obtained from the variety $V_2$ (*Pleurotus florida*) and similarly the lowest days to pin head initiation (24.00 days) was achieved from the variety $V_2$ (*Pleurotus florida*) which was statistically identical with$V_3$

(*Pleurotus ostreatus* po10). Kinge *et al*. (2016) and Zape *et al.* (2006) also found similar result with the present study.

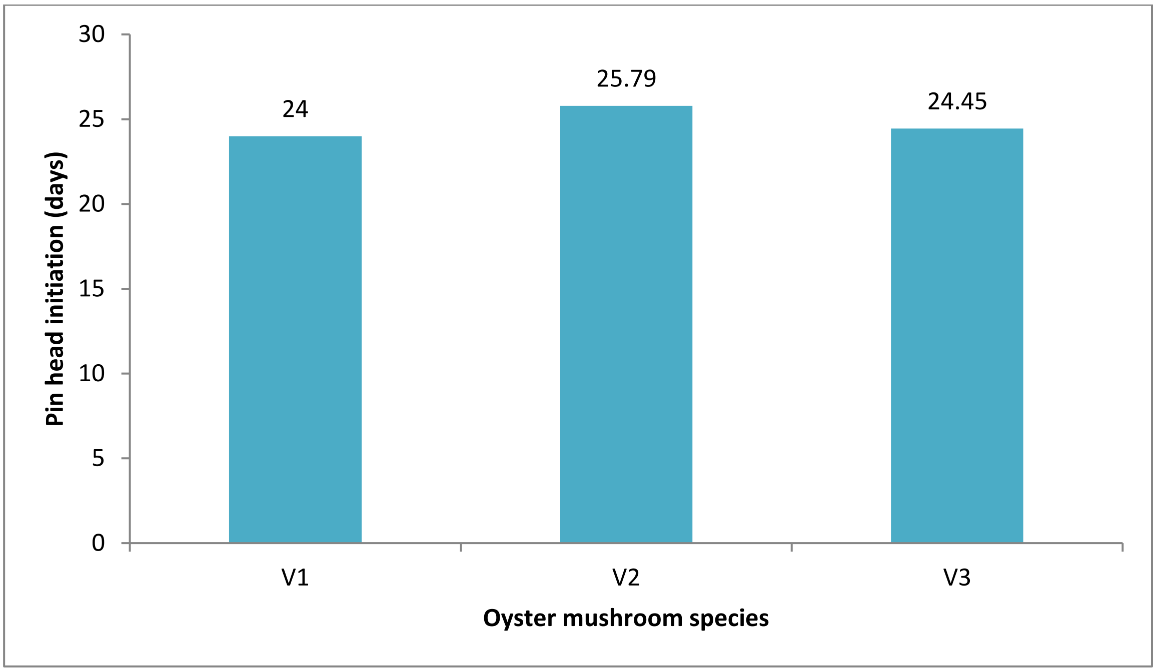


Figure 5. Days to pin head initiation of oyster mushroom as influenced by different species

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

Use of different supplements to substrates showed remarkable variation on days to pin head initiation (Figure 6 and Appendix II). The highest days to pin head initiation (29.09 days) was observed in the supplementation treatment $S_3$ (Rice straw; RS) which was significantly different from other treatments followed by $S_2$ (Maize powder; MP). The lowest days to pin head initiation (21.33 days) was recorded from the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was statistically identical with$S_5$ (Maize powder + rice straw; 1:1). The result obtain from the present study was similar with the findings of Baysal *et al.* (2003), Hasan *et al*. (2010) and Mandol *et al.* (2010) who reported that different supplementation to substrate contribute significantly on pin head initiation and earlier pin head formation was recorded.

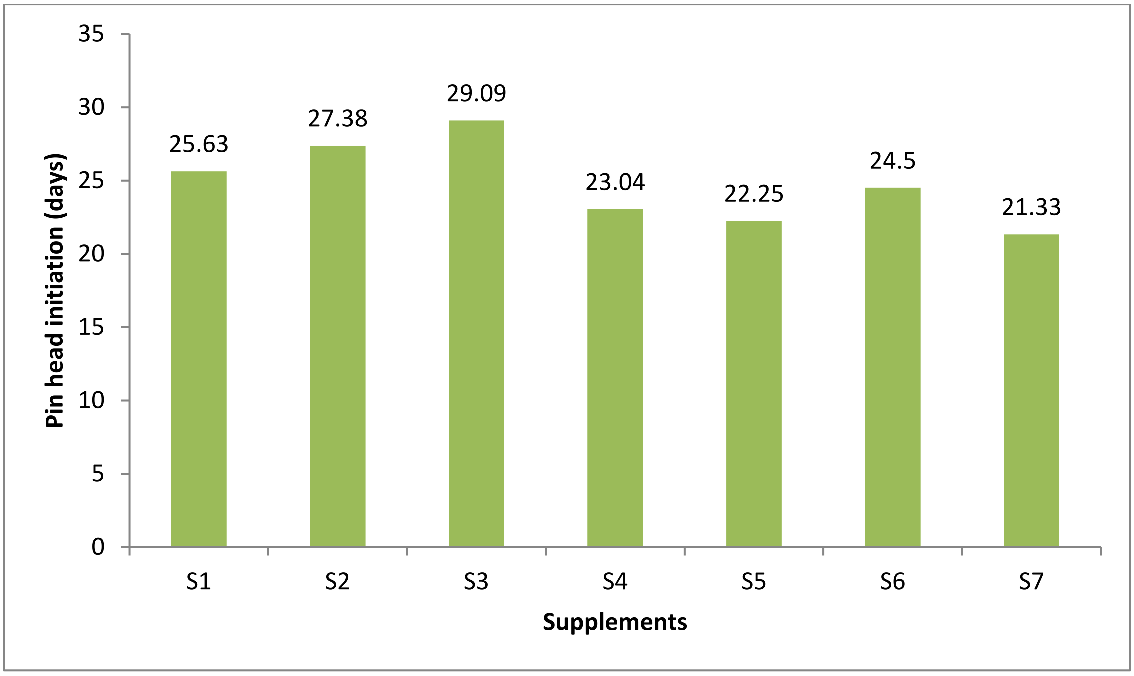


**Figure 6. Days to pin head initiation of oyster mushroom as influenced by different supplements**

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

Days to pin head initiation differed remarkably due to treatment combination of different oyster mushroom species and use of supplements to substrate (Table 1 and Appendix II). Results exhibited that the highest days to pin head initiation (30.38 days) was recorded from the treatment combination of $V_2S_3$which differed significantly from other treatment combinations followed by $V_3S_3$, $V_1S_3$ and $V_2S_2$. The lowest days to pin head initiation (20.50 days) was signified from the treatment combination of $V_1S_7$ and it was statistically identical with the treatment combination of $V_1S_5$ and $V_3S_7$.

### 4.1.4 Pin head initiation to harvest (days)

Different species of mushroom showed significant influence on days to pinhead initiation to harvest (Figure 7 and Appendix II). It was observed that the highest days to pinhead initiation to harvest was taken as 7.89 days from the variety $V_2$ (*Pleurotus florida*) that was significantly different from $V_1$ (*Pleurotus djamor*) and $V_3$ (*Pleurotus ostreatus* po10) whereas the lowest days to pinhead initiation to harvest (5.09 days) was found from the variety $V_1$ (*Pleurotus djamor*). Similar result was also observed by Zape *et al.* (2006).

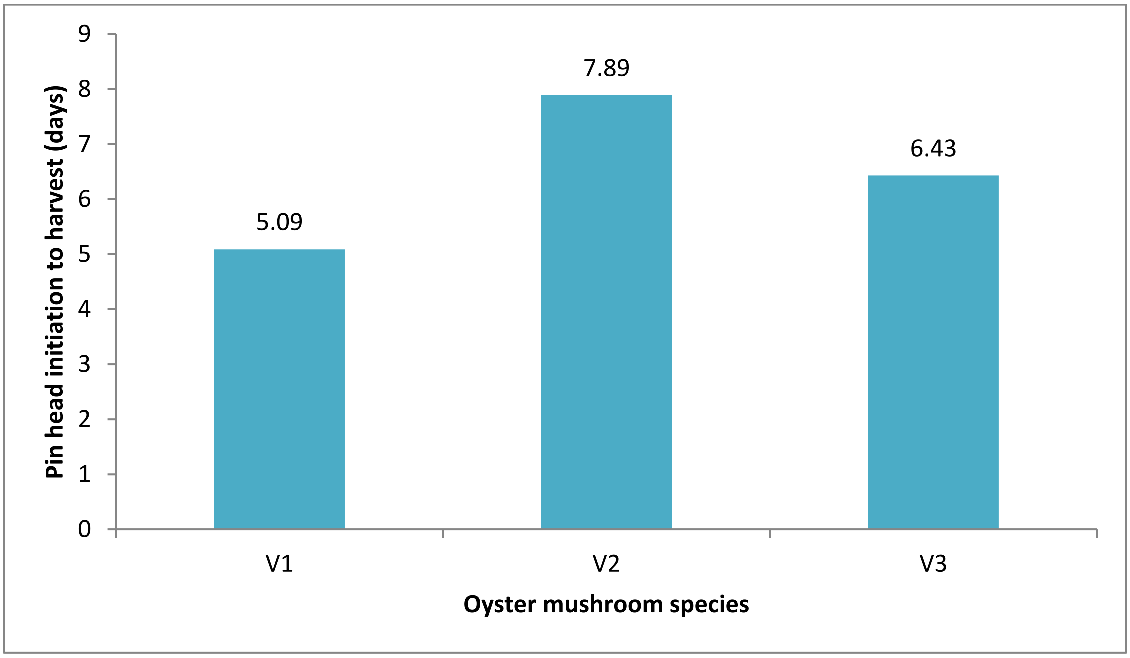


**Figure 7. Days to pinhead initiation to harvestof oyster mushroom as influenced by different species**

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

Significant variation was found in days to pinhead initiation to harvest due to the effect of different supplementation to substrates (Figure 8 and Appendix II). The highest days to pinhead initiation to harvest (8.46 days) was observed in the supplementation treatment $S_3$ (Rice straw; RS) which was statistically identical with $S_2$ (Maize powder; MP) followed by $S_1$ (Wheat bran; WB). The lowest days to pinhead initiation to harvest (4.83 days) was in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which differed significantly to other treatments. Similar result was also observed by Kulsum *et al.* (2009) who reported that the lowest time from primordia initiation to harvest was 3.2 days due to sawdust supplemented with cow dung @ 10%.

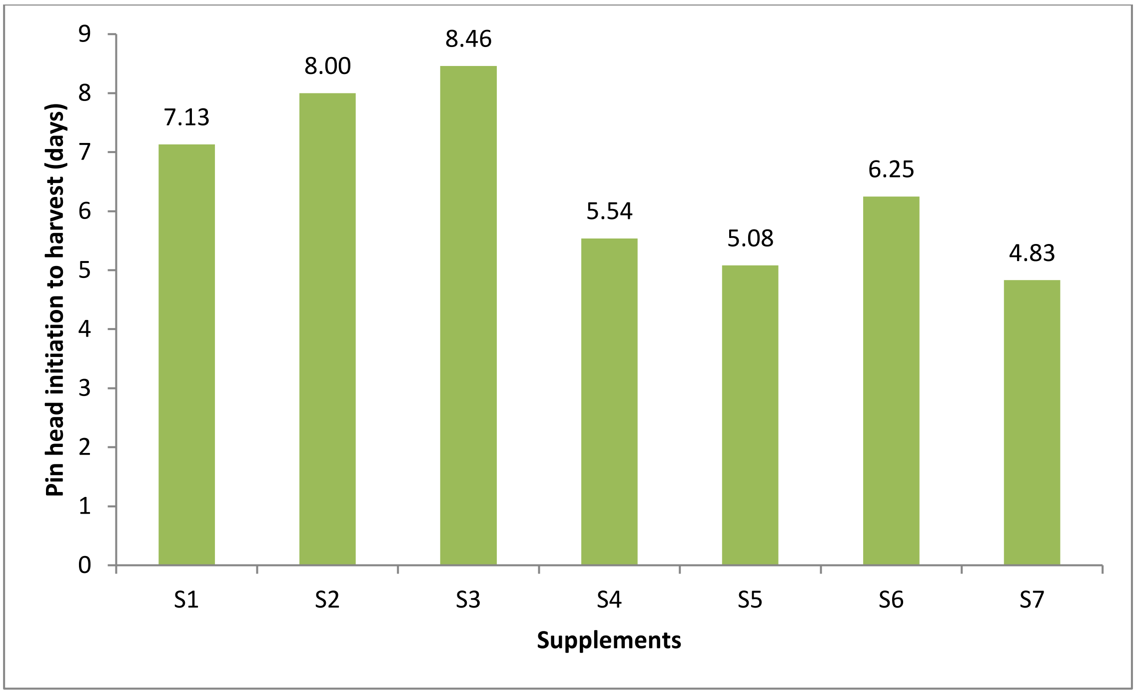


**Figure 8. Days to pinhead initiation to harvestof oyster mushroom as influenced by different supplements**

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

**Table 1. Growth parameters of oyster mushroom as influenced by combined effect of different species and supplements**

| Treatment | Growth parameters | | | |
|---|---|---|---|---|
| | Mycelium run rate (cm day$^{-1}$) | Mycelium run complete (Days) | Pin head initiation (Days) | Pin head initiation to harvest (days) |
| $V_1S_1$ | 0.62 g | 20.50 de | 25.13 ef | 7.00 c |
| $V_1S_2$ | 0.62 g | 21.88 bcd | 26.88 d | 8.00 b |
| $V_1S_3$ | 0.58 hi | 23.13 b | 28.13 bc | 8.13 b |
| $V_1S_4$ | 0.74 d | 17.13 fg | 22.13 h | 5.25 fg |
| $V_1S_5$ | 0.79 bc | 16.25 gh | 21.00 i | 4.25 h |
| $V_1S_6$ | 0.68 e | 18.13 f | 24.25 fg | 6.00 e |
| $V_1S_7$ | 0.82 a | 14.25 i | 20.50 i | 4.00 h |
| $V_2S_1$ | 0.62 g | 21.88 bcd | 26.50 d | 7.38 c |
| $V_2S_2$ | 0.59 hi | 22.50 b | 27.88 bc | 8.00 b |
| $V_2S_3$ | 0.55 j | 26.13 a | 30.38 a | 9.00 a |
| $V_2S_4$ | 0.66 ef | 20.00 e | 24.50 efg | 6.13 de |
| $V_2S_5$ | 0.68 e | 18.13 f | 23.75 g | 6.00 e |
| $V_2S_6$ | 0.64 fg | 20.13 e | 25.00 ef | 6.25 de |
| $V_2S_7$ | 0.73 d | 17.75 f | 22.50 h | 5.50 f |
| $V_3S_1$ | 0.62 g | 20.88 cde | 25.25 e | 7.00 c |
| $V_3S_2$ | 0.61 gh | 22.13 bc | 27.38 cd | 8.00 b |
| $V_3S_3$ | 0.57 ij | 25.63 a | 28.75 b | 8.25 b |
| $V_3S_4$ | 0.74 d | 17.38 fg | 22.50 h | 5.25 fg |
| $V_3S_5$ | 0.76 cd | 17.00 fg | 22.00 h | 5.00 g |
| $V_3S_6$ | 0.66 ef | 18.25 f | 24.25 fg | 6.50 d |
| $V_3S_7$ | 0.81 ab | 15.38 hi | 21.00 i | 5.00 g |
| $LSD_{0.05}$ | 0.031 | 1.415 | 0.977 | 0.455 |
| CV (%) | 10.27 | 5.19 | 3.99 | 7.11 |

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

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

Treatment combination of different oyster mushroom species and supplement to substrate treatments showed statistically significant variation on days to pinhead initiation to harvest (Table 1 and Appendix II). Results indicated that the highest days to pinhead initiation to harvest (9.00 days) was recorded from the treatment combination of $V_2S_3$ that was significantly different from other treatment combinations followed by $V_1S_2$, $V_1S_3$, $V_2S_2$, $V_3S_2$ and $V_3S_3$. The lowest days to pinhead initiation to harvest (4.00 days) was recorded from the treatment combination of $V_1S_7$ and this treatment combination was statistically identical to $V_1S_5$.

## 4.2 Yield contributing parameters

### 4.2.1 Number of fruiting bodies

Significant variation was found for number of fruiting bodies due to different species of mushroom (Figure 9 and Appendix III). Total number of fruiting bodies was counted from 1$^{st}$ and 2$^{nd}$ harvest. Number of fruiting bodies at 1$^{st}$ and 2$^{nd}$ harvest also varied significantly due to varietal performance (Figure 9 and Appendix III). At 1$^{st}$ and 2$^{nd}$ harvest, the highest number of fruiting bodies (9.27 and 6.13, respectively) was recorded from the variety $V_1$ (*Pleurotus djamor*) followed by$V_3$ (*Pleurotus ostreatus* po10) whereas the lowest number of fruiting bodies (7.11 and 4.59, respectively) was found from the variety $V_2$ (*Pleurotus florida*). In terms to total number of fruiting bodies, the highest was also recorded as 15.39 from the variety $V_1$ (*Pleurotus djamor*) which was statistically identical with $V_3$ (*Pleurotus ostreatus* po10) whereas the lowest total number of fruiting bodies (11.70) was found from the variety $V_2$ (*Pleurotus florida*). Supported result was also observed by Ferdousi *et al*. (2019), Kinge *et al*. (2016) and Uddin *et al.* (2011) who observed significant variation on number of fruiting bodies among different species of mushroom.

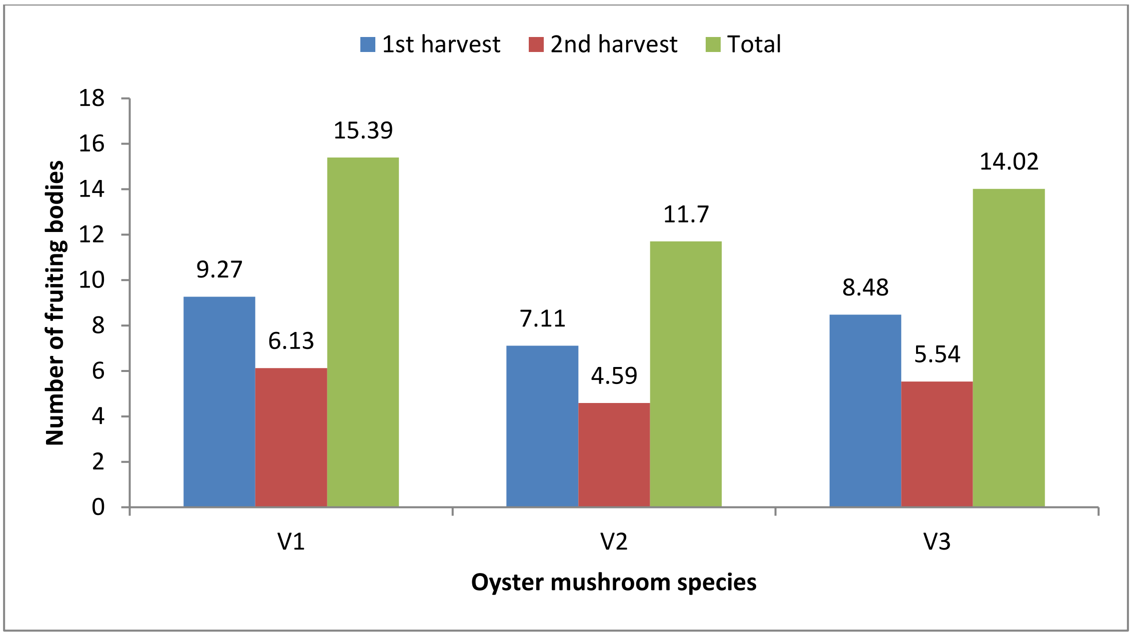


Figure 9. Number of fruiting bodies of oyster mushroom as influenced by different species

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

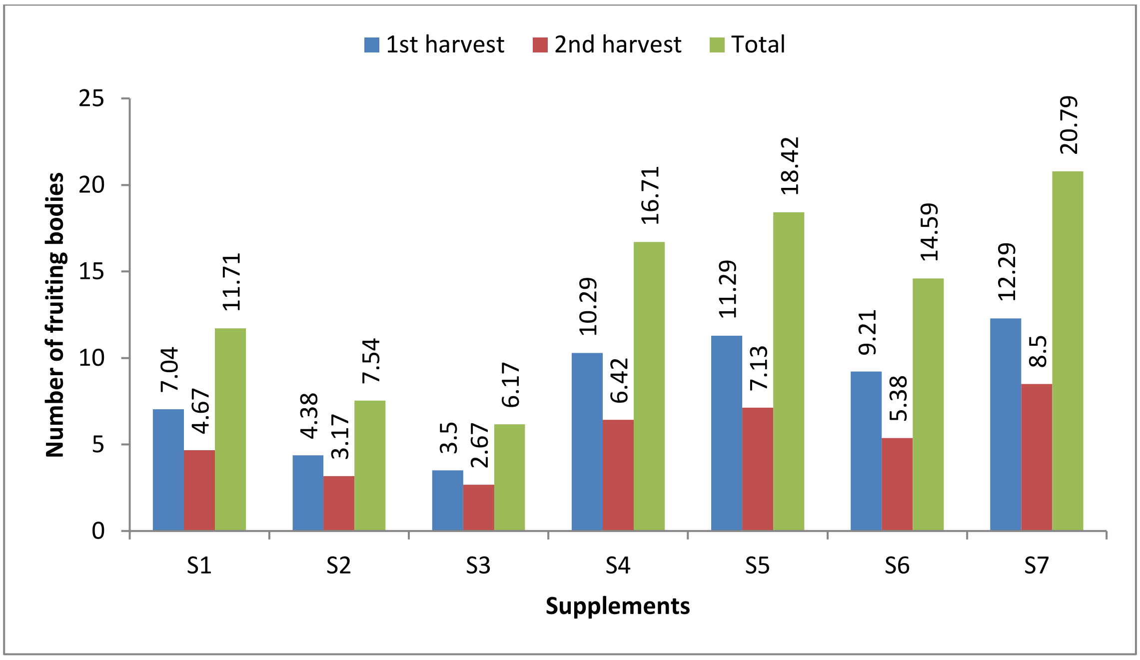


Figure 10. Number of fruiting bodies of oyster mushroom as influenced by different supplements

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

Significant influence was observed on total number of fruiting bodies as influenced by different supplementation effect to substrates (Figure 10 and Appendix III). It had also significant effect at $1^{st}$ and $2^{nd}$ harvest of fruiting bodies (Figure 10 and Appendix III). Results showed that the highest number of fruiting bodies (12.29 and 8.50 at $1^{st}$ and $2^{nd}$ harvest, respectively) was recorded in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) followed by $S_4$ (Wheat bran + maize powder; 1:1) and $S_5$ (Maize powder + rice straw; 1:1) whereas the lowest number of fruiting bodies at $1^{st}$ and $2^{nd}$ harvest (3.50 and 2.67, respectively) was observed from the supplementation treatment $S_3$ (Rice straw; RS) which was statistically similar with $S_2$ (Maize powder; MP). Regarding total number of fruiting bodies, the highest (20.79) was recorded in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was statistically identical with $S_5$ (Maize powder + rice straw; 1:1) whereas the lowest total number of fruiting bodies (6.17) was observed from the supplementation treatment $S_3$ (Rice straw; RS) and this was significantly same to $S_2$ (Maize powder; MP). Sarker (2004) found that the number of primordia increased with the levels of supplement and continued up to a certain range and decline thereafter. 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%.Sinha *et al.* (2021) observed maximum number of fruiting bodies using supplements as 50% wheat Straw + 50 % paddy straw + 10% pulse husk combination.Survase (2012)reported maximum fruiting bodies with supplementation to substrate.

Number of fruiting bodies at $1^{st}$ and $2^{nd}$ harvest as well as total number of fruiting bodies varied significantly in terms of combined effect of different oyster mushroom species and supplementation treatments to substrate (Table 2 and Appendix III). Results noticed that the highest number of fruiting bodies at $1^{st}$ and $2^{nd}$ harvest (14.50 and 10.25, respectively) was recorded from the treatment combination of $V_1S_7$ which differed significantly to other treatment combinations both at $1^{st}$ and $2^{nd}$ harvest followed by $V_3S_7$. The lowest number of fruiting bodies at $1^{st}$ and $2^{nd}$ harvest (3.13 and 2.13, respectively) was recorded from the treatment combination of $V_2S_3$ which was at par with the treatment combination of $V_1S_3$, $V_2S_2$ and $V_3S_3$.

**Table 2. Yield contributing parameters regarding number of fruiting bodies as influenced by combined effect of different species and supplements**

| Treatment | Number of fruiting bodies | | |
|---|---|---|---|
| | 1st harvest | 2nd harvest | Total |
| $V_1S_1$ | 8.00 f | 5.10 g | 13.10 f |
| $V_1S_2$ | 5.00 gh | 3.38 hi | 8.38 gh |
| $V_1S_3$ | 4.00 hi | 3.00 ij | 7.00 hi |
| $V_1S_4$ | 11.38 bc | 7.13 d | 18.50 cd |
| $V_1S_5$ | 12.00 b | 8.13 bc | 20.13 b |
| $V_1S_6$ | 10.00 de | 6.00 ef | 16.00 e |
| $V_1S_7$ | 14.50 a | 10.25 a | 24.75 a |
| $V_2S_1$ | 5.13 g | 4.00 h | 9.13 g |
| $V_2S_2$ | 4.00 hi | 3.00 ij | 7.00 hi |
| $V_2S_3$ | 3.13 i | 2.13 j | 5.25 j |
| $V_2S_4$ | 8.75 f | 5.13 fg | 13.88 f |
| $V_2S_5$ | 10.00 de | 6.00 ef | 16.00 e |
| $V_2S_6$ | 8.63 f | 5.00 g | 13.63 f |
| $V_2S_7$ | 10.13 d | 6.88 de | 17.00 de |
| $V_3S_1$ | 8.00 f | 5.00 g | 13.00 f |
| $V_3S_2$ | 4.13 ghi | 3.13 hi | 7.25 hi |
| $V_3S_3$ | 3.38 i | 2.88 ij | 6.25 ij |
| $V_3S_4$ | 10.75 cd | 7.00 d | 17.75 cd |
| $V_3S_5$ | 11.88 b | 7.25 cd | 19.13 bc |
| $V_3S_6$ | 9.00 ef | 5.13 fg | 14.13 f |
| $V_3S_7$ | 12.25 b | 8.38 b | 20.63 b |
| $LSD_{0.05}$ | 1.104 | 0.904 | 1.511 |
| CV (%) | 6.88 | 9.64 | 8.63 |

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

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

Regarding, total number of fruiting bodies, the highest (24.75) was recorded from the treatment combination of $V_1S_7$ followed by $V_1S_5$ and $V_3S_7$. The lowest total number of fruiting bodies (5.25) was recorded from the treatment combination of $V_2S_3$ which was statistically similar with $V_3S_3$.

### 4.2.2 Number of effective fruiting bodies

Significant variation was found for total number of effective fruiting bodies due to different species of mushroom (Figure 11 and Appendix IV). Total number of effective fruiting bodies was counted with the summation of effective fruiting bodies at $1^{st}$ and $2^{nd}$ harvest. Number of effective fruiting bodies at $1^{st}$ and $2^{nd}$ harvest was also varied significantly due to varietal performance (Figure 11 and Appendix IV). At $1^{st}$ and $2^{nd}$ harvest, the highest number of effective fruiting bodies (6.11 and 3.79, respectively) was recorded from the variety $V_1$ (*Pleurotus djamor*) followed by$V_3$ (*Pleurotus ostreatus* po10) whereas the lowest number of effective fruiting bodies (4.91 and 2.91, respectively) was found from the variety $V_2$ (*Pleurotus florida*). In terms to total number of effective fruiting bodies, the highest (9.90) was also recorded from the variety $V_1$ (*Pleurotus djamor*) that was significantly different from other treatments whereas the lowest total number of effective fruiting bodies (7.82) was found from the variety $V_2$ (*Pleurotus florida*). Uddin *et al.* (2011) found significant variation on number of total fruiting bodies among different mushroom species and from this result it might also be concluded that different mushroom species had significant effect on total number of effective fruiting bodies.

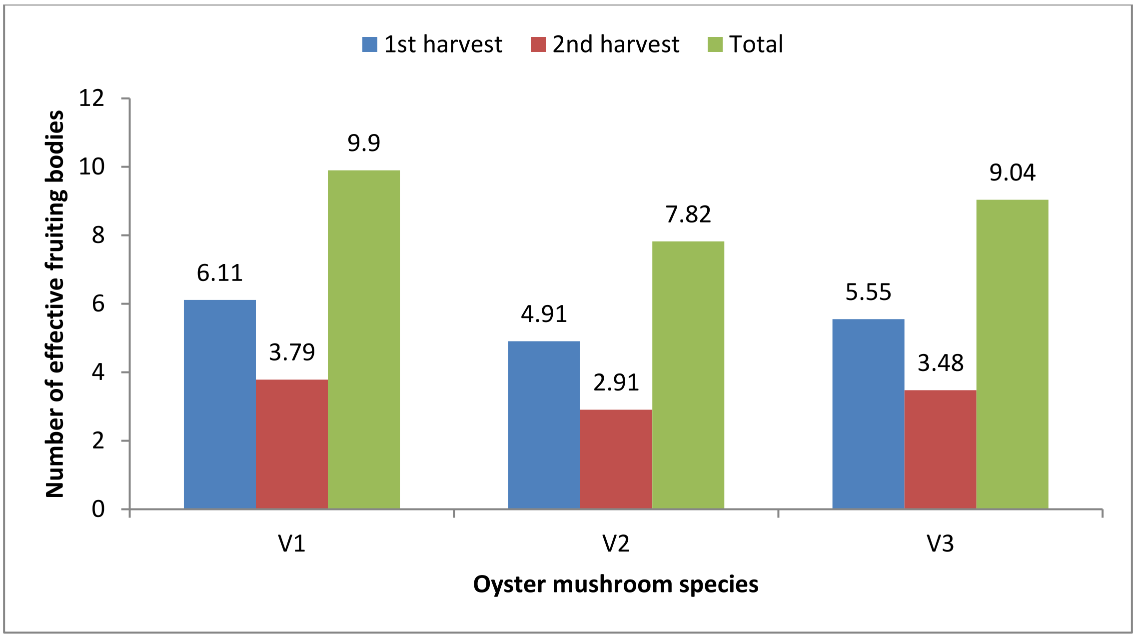


**Figure 11. Number of effective fruiting bodies of oyster mushroom as influenced by different species**

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

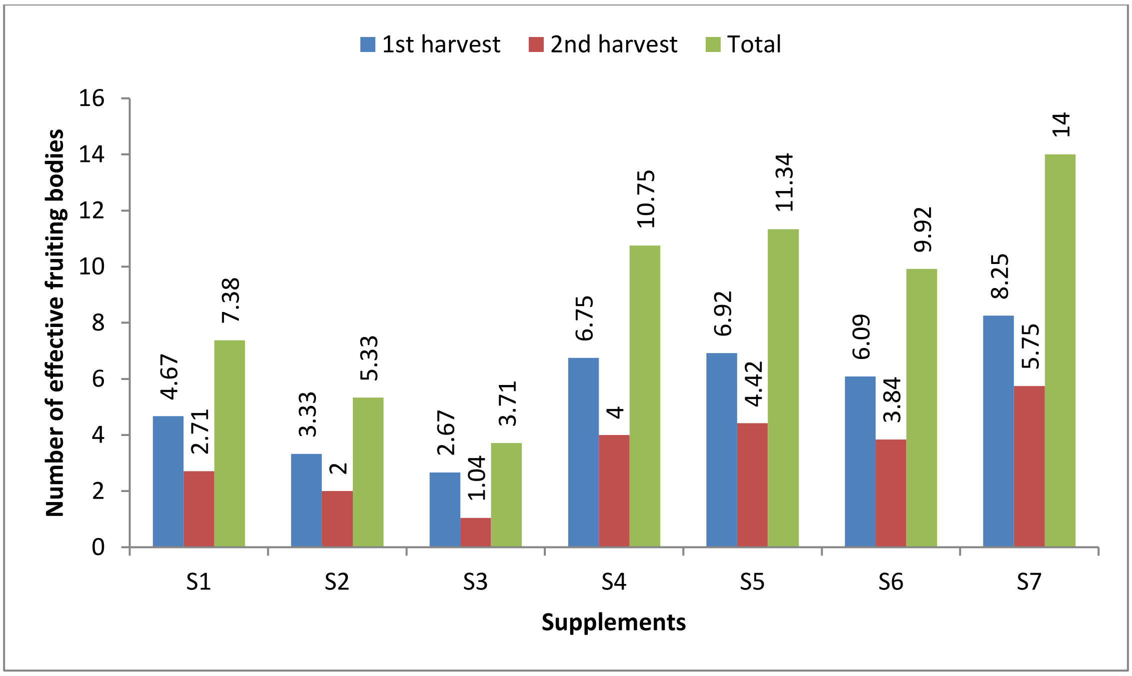


**Figure 12. Number of effective fruiting bodies of oyster mushroom as influenced by different supplements**

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

Significant influence was observed on total number of effective fruiting bodies as influenced by different supplementation effect to substrates (Figure 12 and Appendix IV). It had also significant effect on number of effective fruiting bodies at 1$^{st}$ and 2$^{nd}$ harvest (Figure 12 and Appendix IV). Results showed that the highest number of effective fruiting bodies at 1$^{st}$ and 2$^{nd}$ harvest (8.25 and 5.75, respectively) was recorded in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was significantly different from other treatments followed by $S_5$ (Maize powder + rice straw; 1:1) and $S_4$ (Wheat bran + maize powder; 1:1) whereas the lowest number of effective fruiting bodies at 1$^{st}$ and 2$^{nd}$ harvest (2.67 and 1.04, respectively) was observed from the supplementation treatment $S_3$ (Rice straw; RS). Regarding total number of effective fruiting bodies, the highest (14.00) was recorded in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) followed by $S_4$ (Wheat bran + maize powder; 1:1) and $S_5$ (Maize powder + rice straw; 1:1) whereas the lowest total number of effective fruiting bodies (3.71) was observed from the supplementation treatment $S_3$ (Rice straw; RS) and this was significantly differed to other treatments. Mandol *et al.* (2010), Hasan *et al*. (2010) and Amin *et al*. (2007) also found similar result with the present study and observed that supplementation to substrate increased effective fruiting bodies compared to control.

Number of effective fruiting bodies at 1$^{st}$ and 2$^{nd}$ harvest as well as total number of fruiting bodies varied significantly in terms of combined effect of different oyster mushroom species and supplementation treatments to substrate (Table 3 and Appendix IV). Results noticed that the highest number of effective fruiting bodies at 1$^{st}$ and 2$^{nd}$ harvest (10.00 and 7.13, respectively) was recorded from the treatment combination of $V_1S_7$ which differed significantly to other treatment combinations both at 1$^{st}$ and 2$^{nd}$ harvest followed by $V_3S_7$. The lowest number of effective fruiting bodies at 1$^{st}$ and 2$^{nd}$ harvest (2.00 and 0.88, respectively) was recorded from the treatment combination of $V_2S_3$ which was at par with the treatment combination of $V_1S_9$ and $V_3S_3$.

**Table 3. Yield contributing parameters regarding number of effective fruiting bodies as influenced by combined effect of different species and supplements**

| Treatment | Number of effective fruiting bodies | | |
|---|---|---|---|
| | 1st harvest | 2nd harvest | Total |
| $V_1S_1$ | 5.00 f | 3.13 ef | 8.13 g |
| $V_1S_2$ | 4.00 g | 2.00 g | 6.00 h |
| $V_1S_3$ | 3.00 h | 1.25 gh | 4.25 i |
| $V_1S_4$ | 7.25 bc | 4.13 cd | 11.38 cd |
| $V_1S_5$ | 7.38 bc | 4.88 c | 12.25 c |
| $V_1S_6$ | 6.13 e | 4.00 d | 10.13 ef |
| $V_1S_7$ | 10.00 a | 7.13 a | 17.13 a |
| $V_2S_1$ | 4.00 g | 2.00 g | 6.00 h |
| $V_2S_2$ | 3.00 h | 2.00 g | 5.00 hi |
| $V_2S_3$ | 2.00 i | 0.88 h | 2.88 j |
| $V_2S_4$ | 6.00 e | 3.88 de | 9.88 ef |
| $V_2S_5$ | 6.38 de | 4.00 d | 10.38 def |
| $V_2S_6$ | 6.00 e | 3.63 def | 9.63 f |
| $V_2S_7$ | 7.00 cd | 4.00 d | 11.00 de |
| $V_3S_1$ | 5.00 f | 3.00 f | 8.00 g |
| $V_3S_2$ | 3.00 h | 2.00 g | 5.00 hi |
| $V_3S_3$ | 3.00 h | 1.00 h | 4.00 ij |
| $V_3S_4$ | 7.00 cd | 4.00 d | 11.00 de |
| $V_3S_5$ | 7.00 cd | 4.38 cd | 11.38 cd |
| $V_3S_6$ | 6.13 e | 3.88 de | 10.00 ef |
| $V_3S_7$ | 7.75 b | 6.13 b | 13.88 b |
| $LSD_{0.05}$ | 0.634 | 0.777 | 1.140 |
| CV (%) | 8.11 | 9.48 | 10.37 |

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

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

Regarding, total number of effective fruiting bodies, the highest (17.13) was recorded from the treatment combination of $V_1S_7$ followed by $V_3S_7$ whereas the lowest total number of effective fruiting bodies (2.88) was recorded from the treatment combination of $V_2S_3$ which was statistically similar with $V_3S_3$.

### 4.2.3 Size of fruiting bodies

#### 4.2.3.1 Length of pileus (cm)

Length of pileus showed significant difference among different mushroom species (Table 4 and Appendix V). The highest length of pileus (4.50 cm) was obtained from the variety $V_1$ (*Pleurotus djamor*) which was statistically identical with $V_3$ (*Pleurotus ostreatus* po10) and the lowest pileus length (3.58 cm) was achieved from the variety $V_2$ (*Pleurotus florida*).

Use of different supplements to substrates showed remarkable variation on length of pileus (Table 4 and Appendix V). The highest length of pileus (6.02 cm) was observed in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was significantly different from other treatments followed by $S_4$ (Wheat bran + maize powder; 1:1) and $S_5$ (Maize powder + rice straw; 1:1) whereas the lowest pileus length (1.57 cm) was recorded from the supplementation treatment $S_3$ (Rice straw; RS) which was not differed significantly to $S_2$ (Maize powder; MP). Different supplements added to substrate contributed to increase pileus length also reported by Sitaula *et al*. (2018).

Length of pileus differed remarkably due to treatment combination of different oyster mushroom species and use of supplements to substrate (Table 5 and Appendix V). Results exhibited that the highest length of pileus (6.28 cm) was recorded from the treatment combination of $V_1S_7$ which showed significantly similar result with $V_3S_7$ and $V_1S_5$ followed by $V_1S_4$, $V_3S_4$ and $V_3S_5$. The lowest length of pileus (1.21 cm) was signified from the treatment combination of $V_2S_3$ and it was statistically different with treatment combinations.

**Table 4. Yield contributing parameters regarding size of fruiting bodies as influenced by different species and supplements**

| Treatment | Size of fruiting bodies | | | |
|---|---|---|---|---|
| | Length of pileus (cm) | Diameter of stipe (cm) | Diameter of pileus (cm) | Thickness of pileus (cm) |
| *Effect of variety* | | | | |
| $V_1$ | 4.50 a | 0.93 | 6.81 a | 0.72 |
| $V_2$ | 3.58 b | 0.72 | 6.09 b | 0.62 |
| $V_3$ | 4.36 a | 0.88 | 6.61 a | 0.69 |
| $LSD_{0.05}$ | 0.211 | $0.162^{NS}$ | 0.214 | $0.104^{NS}$ |
| CV (%) | 5.23 | 12.38 | 3.96 | 10.95 |
| *Effect of supplements* | | | | |
| $S_1$ | 3.56 d | 0.68 d | 5.92 c | 0.60 c |
| $S_2$ | 2.01 e | 0.59 d | 5.56 e | 0.57 d |
| $S_3$ | 1.57 e | 0.50 d | 5.26 e | 0.50 d |
| $S_4$ | 5.45 b | 0.96 ab | 7.15 b | 0.73 b |
| $S_5$ | 5.68 b | 1.10 a | 7.52 ab | 0.78 b |
| $S_6$ | 4.73 c | 0.81 c | 6.18 c | 0.66 c |
| $S_7$ | 6.02 a | 1.25 a | 7.95 a | 0.89 a |
| $LSD_{0.05}$ | 0.324 | 0.241 | 0.483 | 0.033 |
| CV (%) | 5.23 | 12.38 | 3.96 | 10.95 |

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

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

### 4.2.3.2 Diameter of stipe (cm)

Different species of mushroom showed non-significant influence on diameter of stipe (Table 4 and Appendix V). However, results revealed that the highest stipe diameterwas taken as 0.93 cm from the variety $V_1$ (*Pleurotus djamor*) followed by $V_3$ (*Pleurotus ostreatus* po10) whereas the lowest stipe diameter (0.72 cm) was found from the variety $V_2$ (*Pleurotus florida*).

Significant variation was found in diameter of stipe due to the effect of different supplementation to substrates (Table 4 and Appendix V). The highest diameter of stipe (1.25 cm) was observed in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was significantly similar to $S_5$ (Maize powder + rice straw; 1:1) and $S_4$ (Wheat bran + maize powder; 1:1). The lowest stipe diameter (0.50 cm) was in the supplementation treatment $S_3$ (Rice straw; RS) and it was significantly same to $S_1$ (Wheat bran; WB) and $S_2$ (Maize powder; MP). Sitaula *et al*. (2018) also found similar result which supported the present study.

Treatment combination of different oyster mushroom species and supplement to substrate treatments showed statistically significant variation on diameter of stipe (Table 5 and Appendix V). Results indicated that the highest stipe diameter (1.41 cm) was recorded from the treatment combination of $V_1S_7$ that was significantly same with the treatment combination of $V_3S_7$ followed by $V_1S_5$ and $V_3S_5$. The lowest stipe diameter (0.48 cm) was recorded from the treatment combination of $V_2S_3$ and this treatment combination was statistically similar to$V_1S_3$, $V_2S_2$ and $V_3S_3$.

#### 4.2.3.3 Diameter of pileus (cm)

Significant variation was found for diameter of pileus due to species difference of mushroom (Table 4 and Appendix V). Results revealed that the highest diameter of pileus (6.81 cm) was recorded from the variety $V_1$ (*Pleurotus djamor*) and that was statistically same with $V_3$ (*Pleurotus ostreatus* po10) whereas the lowest pileus diameter (6.09 cm) was found from the variety $V_2$ (*Pleurotus florida*).

Significant influence was observed on pileus diameter as influenced by different supplementation effect to substrates (Table 4 and Appendix V). Results showed that the highest diameter of pileus (7.95 cm) was recorded in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was significantly similar to $S_5$ (Maize powder + rice straw; 1:1) followed by $S_4$ (Wheat bran + maize powder; 1:1). The lowest pileus diameter (5.26 cm) was observed from the supplementation treatment $S_3$ (Rice straw; RS) and this was significantly same to $S_2$ (Maize powder; MP). The result obtained from the present study was conformity with the findings of Sitaula *et* *al*. (2018) and Khlood and Ahmad (2005) and they obtained higher pileus diameter using supplements to substrate.

There was a significant influence on diameter of pileus in terms of combined effect of different oyster mushroom species and supplementation treatments to substrate (Table 5 and Appendix V). Results noticed that the highest pileus diameter (8.33 cm) was recorded from the treatment combination of $V_1S_7$ which was significantly similar with the treatment combination of $V_1S_5$, $V_3S_7$ and $V_3S_5$. The lowest pileus diameter (5.10 cm) was recorded from the treatment combination of $V_2S_3$ which was statistically similar with the treatment combination of $V_1S_3$, $V_2S_2$ and $V_3S_2$.

### 4.2.3.4 Thickness of pileus (cm)

Thickness of pileus showed non-significant difference among different mushroom species (Table 4 and Appendix V). However, the highest thickness of pileus (0.72 cm) was obtained from the variety $V_1$ (*Pleurotus djamor*) followed by $V_3$ (*Pleurotus ostreatus* po10) and the lowest thickness of pileus (0.62 cm) was achieved from the variety $V_2$ (*Pleurotus florida*).

**Table 5. Yield contributing parameters regarding size of fruiting bodies as influenced by combined effect of different species and supplements**

| Treatment | Size of fruiting bodies | | | |
|---|---|---|---|---|
| | Length of pileus (cm) | Diameter of stipe (cm) | Diameter of pileus (cm) | Thickness of pileus (cm) |
| $V_1S_1$ | 4.29 f | 0.69 fg | 5.99 f | 0.61 hij |
| $V_1S_2$ | 2.04 g | 0.64 gh | 5.68 fg | 0.59 ij |
| $V_1S_3$ | 1.90 gh | 0.53 ij | 5.49 gh | 0.51 k |
| $V_1S_4$ | 5.81 b | 1.13 c | 7.80 bc | 0.78 de |
| $V_1S_5$ | 6.09 ab | 1.21 b | 7.95 ab | 0.85 c |
| $V_1S_6$ | 4.99 d | 0.88 e | 6.44 de | 0.68 f |
| $V_1S_7$ | 6.39 a | 1.41 a | 8.33 a | 1.00 a |
| $V_2S_1$ | 2.19 g | 0.67 g | 5.81 fg | 0.60 ij |
| $V_2S_2$ | 1.99 g | 0.54 ij | 5.50 gh | 0.53 k |
| $V_2S_3$ | 1.21 i | 0.48 j | 5.10 h | 0.49 k |
| $V_2S_4$ | 4.75 de | 0.75 f | 6.06 ef | 0.65 fgh |
| $V_2S_5$ | 5.10 cd | 0.91 e | 6.70 d | 0.69 f |
| $V_2S_6$ | 4.41 ef | 0.70 fg | 6.00 ef | 0.63 ghi |
| $V_2S_7$ | 5.39 c | 1.00 d | 7.49 c | 0.75 e |
| $V_3S_1$ | 4.21 f | 0.68 fg | 5.95 f | 0.60 ij |
| $V_3S_2$ | 2.01 g | 0.58 hi | 5.50 gh | 0.58 j |
| $V_3S_3$ | 1.60 h | 0.50 ij | 5.18 h | 0.50 k |
| $V_3S_4$ | 5.78 b | 1.00 d | 7.59 bc | 0.75 e |
| $V_3S_5$ | 5.84 b | 1.19 bc | 7.91 abc | 0.81 cd |
| $V_3S_6$ | 4.80 d | 0.84 e | 6.11 ef | 0.66 fg |
| $V_3S_7$ | 6.28 a | 1.34 a | 8.03 ab | 0.93 b |
| $LSD_{0.05}$ | 0.379 | 0.083 | 0.449 | 0.044 |
| CV (%) | 5.23 | 12.38 | 3.96 | 10.95 |

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

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

Use of different supplements to substrates showed remarkable variation on thickness of pileus (Table 4 and Appendix V). The highest thickness of pileus (0.89 cm) was observed in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was significantly different from other treatments followed by $S_4$ (Wheat bran + maize powder; 1:1) and $S_5$ (Maize powder + rice straw; 1:1). The lowest thickness of pileus (0.50 cm) was recorded from the supplementation treatment $S_3$ (Rice straw; RS) which was statistically identical with $S_2$ (Maize powder; MP). Supported result was also observed by Mandol *et al.* (2010) and they observed that different supplements added to substrate contributed to increase thickness of pileus.

Thickness of pileus differed remarkably due to treatment combination of different oyster mushroom species and use of supplements to substrate (Table 5 and Appendix V). Results exhibited that the highest thickness of pileus (1.00 cm) was recorded from the treatment combination of $V_1S_7$ which differed significantly from other treatment combinations followed by $V_3S_7$. The lowest thickness of pileus (0.49 cm) was found from the treatment combination of $V_2S_3$ and it was statistically identical with the treatment combination of $V_2S_2$ and $V_3S_3$.

### 4.3 Yield parameters

#### 4.3.1 Biological yield (g)

Different species of mushroom showed non-significant influence on biological yield (Table 6 and Appendix VI). Results indicated that the highest biological yield (159.60 g) was observed from the variety $V_1$ (*Pleurotus djamor*) which was statistically identical with $V_3$ (*Pleurotus ostreatus* po10) whereas the lowest biological yield (147.36 g) was found from the variety $V_2$ (*Pleurotus florida*). Under the present study, non-significant variation was found among the species of mushroom which was supported byZape *et al.* (2006) and they observed that the biological yield did not differ significantly among the species studied but was higher in *P. florida* than *P. flabellatus* and *P. eous.* But Ferdousi *et al*. (2019) and Rawte and Diwan (2019) found signification variation among different species of mushroom.

Significant variation was found in biological yield due to the effect of different supplementation to substrates (Table 6 and Appendix VI). The highest biological yield (174.80 g) was observed in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was significantly different from other treatments followed by $S_5$ (Maize powder + rice straw; 1:1). The lowest biological yield (131.30 g) was in the supplementation treatment $S_3$ (Rice straw; RS) that was significantly different to other treatments. The result obtained from the present study was similar with the findings of Amin *et al*. (2007) and reported that the highest biological yield 247.3g/packet. He also found that the trend of economic yield corresponded with different supplements at different level. Sinha *et al*. (2021) also found similar result with the present study and obtained maximum yield (1180.00 g/kg of a dry substrate with 98.3% biological efficiency), in 50% wheat Straw + 50 % paddy straw + @ 10 % pulse husk combination. Sitaula *et al*. (2018) also found similar result with the present study.

Treatment combination of different oyster mushroom species and supplement to substrate treatments showed statistically significant variation on biological yield (Table 7 and Appendix VI). Results indicated that the highest biological yield (183.10 g) was recorded from the treatment combination of $V_1S_7$ that was significantly different from other treatment combinations followed by $V_3S_7$. The lowest biological yield (115.90 g) was recorded from the treatment combination of $V_2S_3$ and this treatment combination was statistically different to other treatment combinations.

**Table 6. Yield parameters of oyster mushroom as influenced by different species and supplements**

| Treatment | Yield parameters | | |
|---|---|---|---|
| | Biological yield (g) | Economic yield (g) | Biological efficiency (%) |
| *Effect of variety* | | | |
| $V_1$ | 159.60 a | 148.91 a | 63.03 a |
| $V_2$ | 147.36 b | 136.33 b | 58.94 b |
| $V_3$ | 157.34 a | 146.26 a | 62.94 a |
| $LSD_{0.05}$ | 3.024 | 2.712 | 1.077 |
| CV (%) | 3.13 | 3.66 | 3.24 |
| *Effect of supplements* | | | |
| $S_1$ | 144.83 e | 134.03 e | 57.93 c |
| $S_2$ | 141.77 f | 130.60 f | 56.71 c |
| $S_3$ | 131.30 g | 120.17 g | 52.52 d |
| $S_4$ | 163.80 c | 151.50 c | 63.92 b |
| $S_5$ | 169.93 b | 158.57 b | 67.97 a |
| $S_6$ | 156.93 d | 147.87 d | 62.77 b |
| $S_7$ | 174.80 a | 164.10 a | 69.92 a |
| $LSD_{0.05}$ | 2.971 | 1.714 | 2.176 |
| CV (%) | 3.13 | 3.66 | 3.24 |

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

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

### 4.3.2 Economic yield (g)

Significant variation was found for economic yield due to different species of mushroom (Table 6 and Appendix VI). Results revealed that the highest economic yield was recorded as 148.91 g from the variety $V_1$ (*Pleurotus djamor*) which was not significantly differed to $V_3$ (*Pleurotus ostreatus* po10) whereas the lowest economic yield (136.33 g) was found from the variety $V_3$ $V_2$ (*Pleurotus florida*). The present study showed non-significant variation oneconomic yield among the varieties. Zape *et al.* (2006) also found non-significant variation oneconomic yield among different species of mushroom but it was higher in *P. florida* than *P. flabellatus* and *P. eous*. But Rawte and Diwan (2019) and Akter *et al.* (2019) found significant variation oneconomic yield among the varieties. Zape *et al.* (2006) also found non-significant variation oneconomic yield among different species of mushroom.

Significant influence was observed on economic yield as influenced by different supplementation effect to substrates (Table 6 and Appendix VI). Results showed that the highest economic yield (164.10 g) was recorded in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was significantly different from other treatments followed by $S_5$ (Maize powder + rice straw; 1:1) and $S_4$ (Wheat bran + maize powder; 1:1). The lowest economic yield (120.17 g) was observed from the supplementation treatment $S_3$ (Rice straw; RS) and this was significantly differed to other treatments. This result was similar with the findings of Amin *et al.* (2007) and they found the highest biological yield 247.3 g/packet. He also found that the trend of economic yield corresponded with different supplements at different level. Bhuyan (2008) observed that the yield of *Pleurotus ostreatus* increased with increasing the levels of supplements used with sawdust and declined thereafter. Kulsum *et al*. (2009) found that the highest economic yield was 213 g due to sawdust supplemented with cow dung @ 10%. Similar result was also observed by Ashrafi *et al.* (2014) and Mandol *et al.* (2010).

There was a significant influence on economic yield in terms of combined effect of different oyster mushroom species and supplementation treatments to substrate (Table 7 and Appendix VI). Results noticed that the highest economic yield (173.50 g) was recorded from the treatment combination of $V_1S_7$ which was significantly difference with other treatment combinations followed by $V_3S_7$. The lowest economic yield (103.90 g) was recorded from the treatment combination of $V_2S_3$ and no other treatment combination was same or similar with it.

### 4.3.3 Biological efficiency (%)

Biological efficiency showed significant difference among different mushroom species (Table 6 and Appendix VI). Results registered that the highest biological efficiency (63.03%) was obtained from the variety $V_1$ (*Pleurotus djamor*) which was statistically same to $V_3$ (*Pleurotus ostreatus* po10) and similarly the lowest biological efficiency (58.94%) was achieved from the variety $V_2$ (*Pleurotus florida*). The result obtained from the present study was similar with the findings of Zape *et al.* (2006) and they observed that the biological efficiency did not differ significantly among the species studied but was higher in *P. florida* than *P. flabellatus* and *P. eous.*

Use of different supplements to substrates showed remarkable variation on biological efficiency (Table 6 and Appendix VI). The highest biological efficiency (69.92%) was observed in the supplementation treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) which was significantly same to $S_5$ (Maize powder + rice straw; 1:1) whereas the lowest biological efficiency (52.52%) was recorded from the supplementation treatment $S_3$ (Rice straw; RS) that was significantly different from other treatments. Amin *et al*. (2007) found that the trend of economic yield corresponded with different supplements at different level. Similar result was also observed by Sinha *et al*. (2021) and obtained higher biological efficiency with the supplements of paddy straw and pulse husk combination to wheat straw substrate. Muswati *et al*. (2021), Liang *et al*. (2019) and Sitaula *et al*. (2018) were also showed supported results in their findings and obtained higher biological efficiency with different supplementation to substrate.

**Table 7. Yield parameters of oyster mushroom as influenced by combined effect of different species and supplements**

| Treatment | Yield parameters | | |
|---|---|---|---|
| | Biological yield (g) | Economic yield (g) | Biological efficiency (%) |
| $V_1S_1$ | 146.30 g | 134.60 f | 58.52 gh |
| $V_1S_2$ | 143.00 ghi | 130.90 fgh | 57.20 h |
| $V_1S_3$ | 139.00 i | 129.50 gh | 55.60 h |
| $V_1S_4$ | 171.80 c | 160.00 c | 68.72 bc |
| $V_1S_5$ | 174.00 c | 162.90 c | 69.60 b |
| $V_1S_6$ | 160.00 e | 151.00 d | 64.00 de |
| $V_1S_7$ | 183.10 a | 173.50 a | 73.24 a |
| $V_2S_1$ | 144.10 gh | 133.00 fg | 57.64 gh |
| $V_2S_2$ | 140.30 hi | 130.00 gh | 56.12 h |
| $V_2S_3$ | 115.90 j | 103.90 i | 46.36 i |
| $V_2S_4$ | 155.00 f | 143.00 e | 62.00 ef |
| $V_2S_5$ | 162.50 de | 151.00 d | 65.00 de |
| $V_2S_6$ | 150.80 f | 142.00 e | 60.32 fg |
| $V_2S_7$ | 162.90 de | 151.40 d | 65.16 d |
| $V_3S_1$ | 144.10 gh | 134.50 f | 57.64 gh |
| $V_3S_2$ | 142.00 ghi | 130.90 fgh | 56.80 h |
| $V_3S_3$ | 139.00 i | 127.10 h | 55.60 h |
| $V_3S_4$ | 164.60 d | 151.50 d | 65.84 cd |
| $V_3S_5$ | 173.30 c | 161.80 c | 69.32 b |
| $V_3S_6$ | 160.00 e | 150.60 d | 64.00 de |
| $V_3S_7$ | 178.40 b | 167.40 b | 71.36 ab |
| $LSD_{0.05}$ | 4.252 | 4.150 | 3.076 |
| CV (%) | 3.13 | 3.66 | 3.24 |

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

$V_1$ = *Pleurotus djamor*, $V_2$ = *Pleurotus florida*, $V_3$ = *Pleurotus ostreatus* po10

$S_1$ = Wheat bran (WB), $S_2$ = Maize powder (MP), $S_3$ = Rice straw (RS), $S_4$ = Wheat bran+ maize powder (1:1), $S_5$ = Maize powder+ rice straw (1:1), $S_6$ = Rice straw+ wheat bran (1:1), $S_7$ = Wheat bran+ maize powder+ rice straw (1:1:1)

Biological efficiency differed remarkably due to treatment combination of different oyster mushroom species and use of supplements to substrate (Table 7 and Appendix VI). Results exhibited that the highest biological efficiency (73.24%) was recorded from the treatment combination of $V_1S_7$ which was significantly same with the treatment combination of $V_3S_7$ followed by $V_1S_5$ and $V_3S_5$. The lowest biological efficiency (46.36%) was signified from the treatment combination of $V_2S_3$ and it was statistically different with other treatment combinations.

# 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 June-September 2020 to find out the performance of different supplements and their levels on growth and yield of three oyster mushroom species. The experiment consisted of two factors; (1) Three (3) species of oyster mushroom *viz.* (i) $V_1$ (*Pleurotus djamor*), (ii) $V_2$ (*Pleurotus florida*) and (iii) $V_3$ (*Pleurotus ostreatus* po10) and (2) Seven (7) supplements to substrate *viz.* (i) $S_1$ (Wheat bran; WB), (ii) $S_2$ (Maize powder; MP), (iii) $S_3$ (Rice straw; RS), (iv) $S_4$ (Wheat bran + maize powder; 1:1), (v) $S_5$ (Maize powder + rice straw; 1:1), (vi) $S_6$ (Rice straw + wheat bran; 1:1) and (vii) $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1). 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.

Different species of Oyster mushroom showed variation on different parameters which were both significant and non-significant. Results revealed that the highest mycelium run rate (0.69 cm $day^{-1}$) was achieved from $V_1$ (*Pleurotus djamor*) whereas the lowest (0.64 cm $day^{-1}$) was from $V_2$ (*Pleurotus florida*). Similarly, the lowest days to mycelium run complete (18.75 days), days to pin head initiation (24.00 days) and days to pin head initiation to harvest (5.09 days) was found from $V_1$ (*Pleurotus djamor*) whereas the highest (20.93, 25.79 and 5.09 days, respectively) was found from $V_2$ (*Pleurotus florida*). Again, it was observed that the highest total number of fruiting bodies and total number of effective fruiting bodies (15.39 and 9.9.90, respectively) was obtained from $V_1$ (*Pleurotus djamor*) and this variety also showed highest pileus length, diameter of stipe, diameter of pileus and thickness of pileus (4.50, 0.93, 6.81 and 0.72 cm, respectively) whereas the lowest total number of fruiting bodies (11.70), total number of effective fruiting bodies (7.82), length of pileus (3.58 cm), diameter of stipe (0.72 cm), diameter of pileus (6.09 cm) and thickness of pileus (0.62 cm) was recorded from $V_2$ (*Pleurotus florida*). Similarly, the highest biological yield (159.60 g), economic yield (148.91 g) and biological efficiency (63.03%) was achieved from the variety $V_1$ (*Pleurotus djamor*) while the lowest biological yield (147.36 g), economic yield (136.33 g) and biological efficiency (6158.94%) was recorded from the variety $V_2$ (*Pleurotus florida*).

Influence of different treatments of supplements to substrates, maximum parameters studied under the present experiment showed significant variation. Treatment of supplement to substrate, $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) gave the highest mycelium run rate (0.79 cm day$^{-1}$) whereas the lowest (0.57 cm day$^{-1}$) was found from $S_3$ (Rice straw; RS). Similarly, the lowest days to mycelium run complete (15.79 days), days to pin head initiation (21.33 days) and days to pin head initiation to harvest (4.83 days) was found from $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) whereas the highest (24.96, 29.09 and 8.46 days, respectively) was found from $S_3$ (Rice straw; RS). The highest total number of fruiting bodies and total number of effective fruiting bodies (20.79 and 14.00, respectively) was obtained from $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) and the lowest (11.70 and 3.71, respectively) was recorded from $S_3$ (Rice straw; RS). The supplement treatment $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) also showed the highest length of pileus, diameter of stipe, diameter of pileus and thickness of pileus (6.02, 1.25, 7.95 and 0.89 cm, respectively) whereas the lowest (1.57, 0.50, 5.26 and 0.50 cm, respectively) was recorded from $S_3$ (Rice straw; RS). Similarly, the highest biological yield (174.80 g), economic yield (164.10 g) and biological efficiency (69.92%) were found from $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) whereas $S_3$ (Rice straw; RS) gave the lowest biological yield (131.30 g), economic yield (120.17 g) and biological efficiency (52.52%).

Different species of Oyster mushroom in combination with different supplements to substrate showed significant influence on different parameters studied under the present study. Results revealed that the highest mycelium run rate (0.82 cm $day^{-1}$) was found from the treatment combination of $V_1S_7$ whereas the lowest (0.55 cm $day^{-1}$) was found from $V_2S_3$. Similarly, the lowest days to mycelium run complete, days to pin head initiation and days to pin head initiation to harvest (14.25, 20.50 and 4.00 days, respectively) was found from $V_1S_7$ whereas the highest (26.13, 30.38 and 9.00 days, respectively) was found from $V_2S_3$. The highest total number of fruiting bodies and total number of effective fruiting bodies (24.75 and 17.13, respectively) was obtained $V_1S_7$ and the lowest (5.25 and 2.88, respectively) was recorded from $V_2S_3$. The treatment combination of $V_1S_7$ also showed the highest length of pileus, diameter of stipe, diameter of pileus and thickness of pileus (6.39, 1.41, 8.33 and 1.00 cm, respectively) whereas the lowest (1.21, 0.48, 5.10 and 0.49 cm, respectively) was recorded from $V_2S_3$. Likewise, the highest biological yield (183.10 g), economic yield (173.50 g) and biological efficiency (73.24%) were found from $V_1S_7$ whereas the lowest biological yield (115.90 g), economic yield (103.90 g) and biological efficiency (46.36%) were recorded from $V_2S_3$.

From the above results, it can be concluded that the species of Oyster mushroom $V_1$ (*Pleurotus djamor*) gave highest biological yield, economic yield and biological efficiency followed by $V_3$ (*Pleurotus ostreatus* po10) and the lowest was from $V_2$ (*Pleurotus florida*). Regarding supplements treatment to sawdust substrate, $S_7$ (Wheat bran + maize powder + rice straw; 1:1:1) showed best results on growth and yield contributing parameters as well as biological yield, economic yield and biological efficiency. Considering, treatment combination of mushroom species and supplementation to substrate, the highest total biological yield, economic yield and biological efficiency was recorded from $V_1S_7$ (*Pleurotus djamor* with supplement wheat bran + maize powder + rice straw @ 1:1:1 to sawdust substrate). So, this treatment combination ($V_1S_7$) can be considered as best compared to other treatment combinations.

## REFERENCES


Aishah, M.S. and Rosli, W.I. (2013). Effect of Different Drying Techniques on the Nutritional Values of Oyster Mushroom (*Pleurotus sajor-caju*). *Sains Malaysiana*. **42**(7): 937–941.

Akter, F., Ahmed, K.U. and Miah, N. (2019). Effect of different spawn seed on growth and varieties of the Oyster mushrooms (*Pleurotus* spp.). *Res. Agric. Livest. Fish*. **6**(2): 181-192.

Ali, M.R. (2009). Study on supplementation of wheat bran with sugarcane bagasse on yield and proximate composition of Oyster mushroom *(Pleurotus ostreatus).* An M.S. thesis, Department of Biochemistry, SAU, Dhaka-1207.

Amin, S.M.R., Sarker, N.C., Khair, A. and Alam, N. (2007). Detection of novel supplements on paddy straw substrates on Oyster Mushroom cultivation. *Bangladesh J. Mushroom.* **1**(2): 18-22.

Ashrafi, R., Mian, M.H., Rahman, M.M. and Jahiruddin, M. (2014). Recycling of spent mushroom substrate for the production of Oyster Mushroom. *Res. Biotech*. **5**(2): 13-21.

Asraf, J., Ali, M.A., Ahmad, W., Ayub, C.M. and Shafi, J. (2013). Effect of different substrate supplements on Oyster Mushroom (Pleurotus spp.) production. *Food Sci. Technol*. **1**(3): 44–51.

Atila, F. (2017). Evaluation of suitability of various agro-wastes for productivity of *Pleurotus djamor*, *Pleurotus citrinopileatus* and *Pleurotus eryngii* mushrooms. *J. Exp. Agric. Int*. **17**(5): 1–11.

Ayyappan, S., Chandrasehar, G., Gnanasambandan, S. and Kumaran, K. (2000). Utilization of sugarcane trash and coir waste for the cultivation of oyster mushroom (*Pleurotus* sp.). *J. Ecobiol*. **12**(4): 317-319.

Banik, S and Nandi, R. (2004). Effect of supplementation of rice straw with biogas residual slurry manure on the yield, protein and mineral contents of oyster mushroom. *Industrial Crops and Products*. **20**(3): 311-319.

Baysal, E., Peker, H., Yalinkilic, M.K. and Temiz, A. (2003). Cultivation of Oyster mushroom on waste paper with some added supplementary materials. *Bio. Tech.***89**(1): 95-97.

Bhattacharjya, D.K., Paul, R.K., Miah, M.N. and Ahmed, K.U. (2015). Comparative study on nutritional composition of oyster mushroom (*Pleurotus ostreatus* Fr.) cultivated on different sawdust substrates. *Biores Commun*. **1**(2): 93–98.

Bhuyan, M.H.M.B.U. (2008). Study on Preparation of Low Cost Spawn Packets for the Production of Oyster Mushroom (Pleurotus Ostreatus) and its Proximate Analysis. M.S. Thesis, Department of Biochemistry, SAU, Dhaka-1207.

Bird, J.K., Murphy, R.A., Ciappio, E.D. and McBurney, M.I. (2017). Risk of deficiency in multi- ple concurrent micronutrients in children and adults in the United States. *J. Nutr*. **9**(7): 655-656.

Biswas, M.K., Shukla, C.S. and Kumar, S.M. (1997). Method for increasing biological efficiency of oyster mushroom (*Pleurotus florida*) in Madhya Pradesh. *Adv. Plant Sci*. **10**(l): 69-74.

Burton, K., Noble, R., Rogers, S. and Wilson, J. (2015). Understanding mushroom nutrition: project aimed at improving yield, substrate efficiency and utilization and favor. M056 Final Report. Agriculture and Horticulture Development Board (AHDB). p 54-55.

Caral, D.R., Vinay, P., Manasa, P., Kumar, D.V. and Babu, R. (2010). Comparative study of oyster mushroom (*pleurotus ostreatus*) cultivation by physical and chemical method of sterilization using two different substrates. *J. Mycol*. **3**: 12- 17.

Carrasco, J., Zied, D.C., Pardo, J.E., Preston, G.M. and Gimenez, A.P. (2018). Supplementation in mushroom crops and its impact on yield and quality. *AMB Expr*. **8**:146.

Carrol, A.D. and Schisler, L.C.Jr. (1976). Delayed release nutrient supplement for mush- room culture. *Appl. Environ. Microbiol*. **31**: 499–503.

Cheung, P.C.K. (2008). Mushrooms as Functional Foods, John Wiley & Sons, Inc., ISBN 978-0-470-05406-2, M.S., 259.

Chowdhury, A.K., Panja, B.N. and Laha, S.K. (1998). Organic supplements for better yield of oyster mushroom. *India J. Interacademicia B.C.K.V*. **2**(1-2): 116-117.

Das, D.S. and Bora, K.N. (2003). Use of water hyacinth as substrate for cultivation of oyster mushroom in Assam. Deptt. of Botany, Guwahati University, Guwahati 781 014, Assam, *India. J. Eco-Physiol*. **6**(3/4): 119-121.

Desrumaux, B., Seydeyn, P., Werbrouck, A. and Lannoy, P. (1999). Supplémenter dans la culture du champignon de couche: experience comparative avec quelques produits de supplementation du commerce. *Bull. FNSACC*. **81**: 789–802.

Dundar, A., Yildiz, A. (2008). A comparative Study on Pleurotus Ostreatus (Jacq.) P.Kumm. Cultivated on Different Agricultural Lignocellulosic Wastes, *Turk. J. Biol*. **33**: 171-179.

Ferdousi, J., Al-Riyadh, Z. and Hossain, M.I. (2019). Mushroom Production Benefits, Status, Challenges and Opportunities in Bangladesh: A Review. *Ann. Res. Rev. Biol*. **34**(6): 1-13.

Gunde CN, and Cinerman. (1995). *Pleurotus* fruiting bodies contain the inhibitor of 3-hydroxy-3-methylglutaryl-coenzyme a reductase-lovastatin *J. Exp. Mycol*. **19**: 1-6.

Hamza, A.S., Mohammady, T.F. Majcheaczyk, A. and Abou-Hadid, A.F. (2003). Evaluation of five oyster mushroom species grown on corn stalks to be used as animal feed. *Acta- Horticulturae*. **608**: 141-148.

Hasan, M.N., Rahman, M.S., Nigar, S., Bhuiyan, M.Z.A. and Ara, N. (2010) Performance of oyster mushroom (*Pleurotus ostreatus*) on different pretreated substrates. *Int. J. Sustain. Crop Prod*. **5**(4): 16-24.

He, S., Zhao, K., Ma, L., Yang, J. and Chang, Y. (2018). Effects of different cultivation material formulas on the growth and quality of *Morchella spp*. *Saudi J. Biol. Sci*. **25**(4): 719–723.

Hoa, H.T., Wang, C.L. and Wang, C.H. (2015). The effects of different substrates on the growth, yield, and nutritional composition of two oyster mushrooms (*Pleurotus ostreatus* and *Pleurotus cystidiosus*). *J. Mycobiol*. **43**(4): 423–434.

Ingale, A. and Ramteke, A. (2010). Studies on cultivation and biological efficiency of mushrooms grown on different agro-residues. Innov. *Romanian Food Biotechnol*. **6**: 25-28.

Kalita, P., Mazumder, N., Kalita, P. (2001). Performance of Oyster mushroom (Pleurotus spp.) on certain plant wastes. Horticultural Res. Stat. Assam Agricultural University, Assam, India. *J. Agric. Sci. Soc. North East India*. **14**(2): 221-224.

Khan, S.M., Javed, N.and Khan, S.M. (2002). Studies on cultivation of oyster mushroom (Pleurotus spp.) on different forest wastes. Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan. Integrated plant disease management. Proceedings of 3rd National Conference of Plant Pathology, NARC, Islamabad, 1-3 October, 2001-2002. pp. 144-147.

Khan, S.M., Mirza, J.H. and Khan, M.A. (1991). Studies on Shiitake mushroom (*Lentinula edodes*). Proc. 13th Int. Con. Sci. Culti. Edible

Fungi. Dublin, Irish Republic. pp. 503-508.

Khlood, A. and Ahmad, A. (2005). Production of oyster mushroom *(Pleurotus ostreatus)* on olive cake agro-waste. *Dirasat Agril. Sci.***32**(1):64-70.

Kinge, T.R., Djidjou, T.A.M., Nji, T.M., Ache, N.A. and Mih, A.M. (2016). Effect of local substrates on the growth and yield of Pleurotus ostreatus K. in the North West Region, Cameroon. *Cur. Res. Environ. Appl. Mycol*. **6**(1): 11–19.

Kong W. (2004) Oyster Mushroom Cultivation (Descriptions of Commercially Important *Pleurotus* species). Mushroom Growing Handbook-1, Mushworld. pp. 54-61.

Koutrotsios, G., Kalogeropoulos, N., Kaliora, A.C. and Zervakis, G. (2018). Towards an increased functionality in oyster (*Pleurotus*) mushrooms produced on grape marc or olive mill wastes serving as sources of bioactive com- pounds. *J. Agric. Food Chem*. **66**(24): 5971–5983.

Kulsum, U., Hoque, S. and Ahmed, K.U. (2009). Effect of different levels of cowdung with sawdust on yield and proximate composition of oyster mushroom *(Pleurotus ostreatus). Bangladesh J. Mushroom.* **3**(2): 2531.

Liang, C.H., Wu, C.Y., Lu, P.L., Kuo, Y.C. and Liang, Z.C. (2019). Biological efficiency and nutritional value of the culinary-medicinal mushroom Auricularia cultivated on a sawdust basal substrate supplement with different proportions of grass plants. *Saudi J. Biol. Sci*. **26**: 263-269

Mallavadhani, U.V., Sudhakar, A.V.S., Satyanarayana, K.V.S., Mahapatra, A. and Li, W. (2006). Chemical and analytical screening of some edible mushrooms. *Food Chem*. **95**: 58-64.

Mandhare, V.K. (2000). Productivity of Pleurotus spp. on different straws and its effect on nutritional indices of spent straw. Ph.D. (Agri) Thesis submitted to Marathwada Agril. Univ., Parbhani (India).

Manzi, P., Aguzzi, A. and Pizzoferrato, L. (2001). Nutritional value of mushrooms widely consumed in Italy. *Food Chem*. **73**(3): 321-325.

Maria-Florence, E.J., Balasundaran, M., (2000). Mushroom Cultivation Using Forest Litter and Waste Wood. *KFRI Res. Rep*. **195**: 28.

Marimuthu, T., Krishnamoorthy, A.S. and Nallathambi, P. (1994). Nam cake amendment for better yield of Oyster mushroom. *Indian J. Mycol. Plant Path*. **24**(2): 103-106.

Marshall, E. and Nair, N.G, (2009). Make Money by Growing Mushroom, FAO Diversification booklet number. **7**: 53.

Mateus, D., Dias, S. and Nunes, M. (2012). Nitrogen supplementation on the productivity and the chemical composition of oyster mushroom. *J. Food Res*. **1:** 1-3.

Mathew, A.V., Mathai, G. and Suharban, M. (1996). Performance evaluation of five species of *Pleurotus* in Kerela. *Mushroom Res*. **5**(9): 9-12.

Mkhize, S.S., Cloete, J., Basson, A.K. and Zharare, G.E. (2016). Performance of *Pleurotus ostreatus* mushroom grown on maize stalk residues supplemented with various levels of maize flour and wheat bran. *Food Sci. Technol. Campinas*. **36**(4): 598-605.

Mondal, S.R. Rehana, M.J., Noman, M.S. and Adhikary, S.K. (2010). Comparative study on growth and yield performance of oyster mushroom *(Pleurotus florida)* on different substrates. *J. Bangladesh Agril. Univ*. **8**(2): 213-220.

Moonmoon, M., Shelly, N.J., Khan, M.A., Uddin, M.N., Hossain, K., Tania, M. and Ahmed, S. (2011). Effects of different levels of wheat bran, rice bran and maize powder supplementation with saw dust on the production of shiitake mushroom (*Lentinus edodes* (Berk.) Singer). *Saudi. J. Biol. Sci*. **18**(4): 323–328.

Muswati, C., Simango, K., Tapfumaneyi, L., Mutetwa, M. and Ngezimana, W. (2021). The Effects of Different Substrate Combinations on Growth and Yield of Oyster Mushroom (*Pleurotus ostreatus*). *Int. J. Agron*. pp. 249-259.

Nadir, H.A., Ali, A.J. and Muhammed, G.A. (2016). Determination of Yield and Quality of Oyster Mushroom (*Pleurotus florida*) Using Different Substrates in Halabja , Kurdistan. *Plant Production*. **7**: 787–790.

Naraian, R., Sahu, R.K., Kumar, S., Garg, S.K., Singh, C.S. and Kanaujia, RS. (2009). Influence of different nitrogen rich supplements during cultivation of *Pleurotus forida* on corn cob substrate. *Environmentalist*. **29**(1): 1–7.

Ngezimana, (2007). The Use of Organic Supplements and Composted Substrates in Oyster Mushroom (*Pleurotus ostreatus*) Production. *Biresource Technol*. **3**: 13-16.

Ngezimana, T.A., Mtaita, M. Shoko, M. and Tagwira. (2008). Improving biological efficiency of Oyster mushroom, *Pleurotus ostreatus* Fr. (Polyporaceae), through composting and use of organic supplements. *Int. J. Biol. Chem. Sci*. **2**: 37-41.

Nidhi Sinha and Chourasia S. (2021). Effect of Different Substrates with supplementation on the growth and yield of Oyster mushroom species *Pleurotus Florida*. *Int. J. Recent Sci. Res*. **12**(04): 41480-41483.

Pani, B.K. and Mohanty, A.K. (1998). Utilization of water hyacinth as an alternative substrate for Oyster mushroom cultivation. *Crop Res. Hisar*. **15**(2-3): 294-296.

Pardo-Gimenez, A., Carrasco, J., Roncero, J.M., Alvarez-Orti, M., Zied, D.C. and Gonzalez, J.E. (2018). Recycling of the biomass waste defatted almond meal as a novel nutritional supplementation for cultivated edible mushrooms. *Acta. Sci. Agron*. **40**: 39341-39342.

Pardo-Giménez, A., Catalán, L., Carrasco, J., Alvarez-Ortí, M., Zied, D. and Pardo, J. (2016). Effect of supplementing crop substrate with defatted pistachio meal on *Agaricus bisporus* and *Pleurotus ostreatus* production. *J. Sci. Food Agric*. **96**(11): 3838–3845.

Pardo-Gimenez, A., Pardo, J.E. and Zied, D.C. (2017). Supplementation of high nitrogen Agaricus compost: yield and mushroom quality. *J. Agric. Sci. Tech*. **19**: 1589–1601

Patel, Y., Naraian, R. and Singh, V.K. (2012). Medicinal Properties of Pleurotus Species (Oyster Mushroom): A Review. *World J. Fungal Plant Biol*. **3**(1): 1-12

Patil, S.S., Ahmed, S.A., Telang, S.M. and Baig, M.M.V. (2010). The nutritional value of Pleurotus ostreatus (Jacq: Fr.) cultivated on different lignocellulosis agro-wastes. Innovative Romanian Food Biotechnology. **7**: 66-76.

Patil, S.S., Telang, S.M. and Baig, M.M.V. (2010). Substrate evaluation for cultivation and nutritional value of Pleurotus sajor caju. *Int. J. Plant Sci*. **5**(2): 452- 454.

Patra, A.K. and Pani, B.K. (1995). Yield response of different species of Oyster mushroom (Pleurotus spp.) to paddy straw. *Curr. Agril. Res*. **8**: 11-14.

Permana, I.G., Flachowsky, G., Meulen, L., Zadrazil, F., Griensven, L, Van, J.L.D. (2000). Use of sugarcane bagasse for mushroom and animal feed production. Science and cultivation of edible fungi. Proceedings of the 15th International Congress on the Science and Technology of Edible Fungi, Maastricht, Netherlands. **7**: 385-391.

Randive, D.S. (2012). Cultivation and study of growth of oyster mushroom on different agricultural waste substrate and its nutrient analysis. *Adv. Appl. Sci. Res*. **3**: 1938-1949.

Rawte, H. and Diwan, R. (2019). Production Potential and Biological Efficiency of Five *Pleurotus* species. *Cosmos Impact Factor 4.236*. **6**(1): 585-587.

Royse, D.J. (2010). Effects of fragmentation, supplementation and the addition of phase II compost to 2nd break compost on mushroom (*Agaricus bisporus*) yield. *Bioresour. Technol*. **101**(1): 188–192.

Royse, D.J. and Chalupa, W. (2009). Effects of spawn, supplement, and phase II compost additions and time of re-casing second break compost on mushroom (*Agaricus bisporus*) yield and biological efficiency. *Bioresour Technol*. **100**(21): 5277–5282.

Rzymski, P., Mleczek, M., Niedzielski, P., Siwulski, M. and Gąsecka, M. (2017). Cultivation of *Agaricus bisporus* enriched with selenium, zinc and copper. *J. Sci. Food Agric*. **97**(3): 923–928.

Sanchez, C. (2010). Cultivation of *Pleurotus ostreatus* and other edible mush- rooms. *Appl. Microbiol. Biotechnol*. **85**: 1321–1337.

Sarker, N.C. (2004). Oyster mushroom (Pleurotus ostreatus) Production Technology Suitable for Bangladesh and its Nutritional and Postharvest Behavior. PhD Thesis. Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur.

Shah, Z.A., Ashraf, M. and Ishtiaq, M. (2004). Comparative study on cultivation and yield performance of oyster Mushroom (*Pleurotus ostreatus*) on different substrates (Wheat Straw, Leaves, Sawdust). *Pakistan J. Nutr*. **3**(3): 158-160.

Sharma, B.B. (2004). Effect of organic amendments on growth and yield of oyster mushroom Pleurotus spp. *Annals Agric. Res*. **25**(4): 631-632.

Sharma, S., Ram, K.P. Yadav, P. and Chandra, P. (2013). Growth and yield of oyster mushroom *(Pleurotus ostreatus)* on different Substrates. *J. New*

*Biol. Reports.* **2**(1): 3-8.

Shen, Q. and Royse, D.J. (2001). Effects of nutrient supplements on biological efficiency. quality and Crop cycle time of Maitake (*Grifola frondosa*). *Appl. Microbial. Biotechnol*. **57**(1&2): 74-78.

Singh, A.K., (1998). Cultivation of oyster mushroom (Pleurotus spp.) on sugarcane residues. *J. Mycol. Plant Pathol*. **28**: 240-245.

Singh, S.D. and Prasad, G. (2012). Effect of Different Substrate Supplements on the Growth and Yield of two Species of Mushroom *Pleurotus florida* and, *P. Sajor-Caju*. *Int. Multidiscip. Res*. **2**(3): 61-64.

Sinha, N. and Chourasia, S. (2021). Effect of different substrates with supplementation on the growth and yield of oyster mushroom species *Pleurotus florida*. *Int. J. Rec. Sci. Res*. **12**(4B): 41480-41483.

Sitaula, H.P., Dhakal, R., Geetesh, D.C. and Kalauni, D. (2018). Effect of Various Substrates on Growth and Yield Performance of Oyster Mushroom (*Pleurotus ostreatus*) in Chitwan, Nepal. *Int. J. Appl. Sci. Biotechnol*. **6**(3): 215-219.

Song, B.C. (2004). Oyster Mushroom Cultivation. Mushroom Growers' Handbook 1 www. Mush-World_Com.htm.

Stamets, P. (2000). Growing Gourmet and Medicinal Mushrooms, Berkeley/Toronto: Ten Speed Press.

Survase, D.M. 2012. Bioconversion of agro-waste into edible protein rich mushroom by Pleurotus sajor-caju (Fr.) Singer. *Int. Peer Reviewed J.* **1**(1): 60-62.

Thongnaitham, M. (2012). Organic Mushroom Cultivation Manual, Freeland Foundation. **591**: 56-57.

Tsegaye, Z. and Tefera, G. (2017). Cultivation of oyster mushroom (*Pleurotus ostreatus* Kumm, 1871) using agro- industrial residues. *J. Appl. Microb. Res*.**1**: 15-20.

Uddin, M.N., Yesmin, S. Khan, M.A., Tania, M., Moonmoon, M. and Ahmed, S. (2011). Production of oyster mushrooms in different seasonal conditions of Bangladesh. *J. Sci. Res.* **3**(1): 161-167.

Vyas, N.L., Manjit, S. and Singh, M. (2002). Yield performance of *Pleurotus florida* (oyster mushroom) on supplemented substrates in arid zones. *J. Eco. Physiol. India*. **5**(3-4): 149-151.

Werner, A.R. and Beelman, R.B. (2002). Growing high-selenium edible and medicinal button mushrooms (*Agaricus bisporus* (J. Lge) Imbach) as ingredients for functional foods or dietary supplements. *Int. J. Med. Mushrooms*. **4**: 88–94.

Zadrazil, F., Dube, H.C. (1992). The Oyster Mushroom importance and prospects. *Mushroom Res*. **1**(l): 25-32.

Zakia, B., Shashirekha, M.N. and Rajarathnam, S. (1993). Improvement of the bioconversion and biotransformation efficiencies of the oyster mushroom (*Pleurotus sajor-caju*) by supplementation of its rice straw substrate with oil seed cakes. Fmit and Vegetable Technology, Central Food Technological Research Institute, Mysore, India. *Enzyme Microb .Technol*. **15**(11): 985-989.

Zape, A.S., Thakur, M.P., Bainade, P.S. and Nichal, S.S. (2006). Analysis of major chemical constituents and yield of three different species of *Pleurotus* on wheat straw. *J. Plant Disease Sci.* **1**(2): 171-172.

Zied, D.C., Savoie, J.M. and Pardo-Gimenez, A. (2011). Soybean the main nitrogen source in cultivation substrates of edible and medicinal mushrooms. In: El-Shemy HA (ed) Soybean and nutrition. *Int. Tech. Open Access, Rijeka*. pp. 433–452.

## APPENDICES

**Appendix I. Monthly records of air temperature, relative humidity and rainfall during the period from June to September 2020.**

| Year | Month | Air temperature (°C) | | | Relative humidity (%) | Rainfall (mm) |
|---|---|---|---|---|---|---|
| | | *Max* | *Min* | *Mean* | | |
| 2019 | June | 27.40 | 23.44 | 25.42 | 71.28 | 190 |
| 2019 | July | 30.52 | 24.80 | 27.66 | 78.00 | 536 |
| 2019 | August | 31.00 | 25.60 | 28.30 | 80.00 | 348 |
| 2019 | September | 30.8 | 21.80 | 26.30 | 71.50 | 78.52 |

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

**Appendix II. Mean square of growth parameters of oyster mushroom**

| Sources of variation | Degrees of freedom | Mean square of growth parameters | | | |
|---|---|---|---|---|---|
| | | Mycelium run rate (cm day$^{-1}$) | Mycelium run complete (Days) | Pin head initiation (Days) | Pin head initiation to harvest (days) |
| Factor A | 2 | 0.006 $^{NS}$ | 0.929 $^{NS}$ | 9.452 $^{NS}$ | 1.238 $^{NS}$ |
| Factor B | 6 | 0.084 $^{NS}$ | 118.63* | 79.31* | 20.98** |
| AB | 12 | 0.046** | 76.574* | 62.80* | 16.36** |
| Error | 147 | 0.001 | 2.050 | 0.977 | 0.212 |

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

**Appendix III. Mean square of yield contributing parameters regarding number of fruiting bodies**

| Sources of variation | Degrees of freedom | Mean square of number of fruiting bodies | | |
|---|---|---|---|---|
| | | 1st harvest | 2nd harvest | Total |
| Factor A | 2 | 25.786** | 9.327** | 64.149* |
| Factor B | 6 | 117.34* | 53.08* | 327.01* |
| AB | 12 | 92.015* | 33.32** | 232.77* |
| Error | 147 | 1.248 | 0.837 | 2.337 |

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

**Appendix IV. Mean square of yield contributing parameters regarding number of effective fruiting bodies**

| Sources of variation | Degrees of freedom | Mean square of number of effective fruiting bodies | | |
|---|---|---|---|---|
| | | 1st harvest | 2nd harvest | Total |
| Factor A | 2 | 6.792 NS | 0.661 | 11.595** |
| Factor B | 6 | 41.88* | 35.22* | 153.38* |
| AB | 12 | 33.21* | 16.76** | 95.797* |
| Error | 147 | 0.412 | 0.618 | 1.332 |

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

**Appendix V. Mean square of yield contributing parameters regarding size of fruiting bodies**

| Sources of variation | Degrees of freedom | Mean square of size of fruiting bodies | | | |
|---|---|---|---|---|---|
| | | Length of pileus (cm) | Diameter of stipe (cm) | Diameter of pileus (cm) | Thickness of pileus (cm) |
| Factor A | 2 | 7.209* | 0.132 NS | 1.717** | 0.026 NS |
| Factor B | 6 | 23.97* | 1.136** | 12.88* | 0.291** |
| AB | 12 | 29.01* | 0.499** | 8.402* | 0.110** |
| Error | 147 | 0.147 | 0.007 | 0.016 | 0.002 |

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

**Appendix VI. Mean square of yield parameters of oyster mushroom**

| Sources of variation | Degrees of freedom | Mean square of yield parameters | | |
|---|---|---|---|---|
| | | Biological yield (g) | Economic yield (g) | Biological efficiency (%) |
| Factor A | 2 | 110.042 NS | 56.881 NS | 12.114 NS |
| Factor B | 6 | 3341.45* | 3518.91* | 312.536** |
| AB | 12 | 1961.72* | 1928.12* | 148.527** |
| Error | 147 | 18.521 | 17.642 | 3.912 |

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