STUDY ON PERFORMANCE OF OYSTER MUSHROOM (*Pleurotus ostreatus*) GROWN ON SUPPLEMENTED RICE STRAW

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CERTIFICATE

This is to certify that the thesis entitled **"STUDY ON PERFORMANCE OF OYSTER MUSHROOM (*Pleurotus ostreatus*) GROWN ON SUPPLEMENTED RICE STRAW"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN BIOCHEMISTRY**, embodies the result of a piece of *bona fide* research work carried out by **MD. HAFIZUR RAHMAN**, Registration No. **03-01104,** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma in any other institutes.

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

Dated:December,2009
Place: Dhaka, Bangladesh

Professor Dr. Kamal Uddin Ahmed
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Dedicated to
My
Beloved Parents
&
Teachers

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STUDY ON PERFORMANCE OF OYSTER MUSHROOM (*Pleurotus ostreatus*) GROWN ON SUPPLEMENTED RICE STRAW

ABSTRACT

The experiment was carried out to investigate the performance of different levels of cow dung, wheat bran and chemical fertilizer as supplement with rice straw on the yield and proximate composition of oyster mushroom. The highest mycelium running rate (0.73 cm/day) was observed due to rice straw supplemented with chemical fertilizer (N=0.5%, P=0.3% K=0.3%). The highest time from stimulation to primordia initiation (8.37 days) was observed in (Rice straw + 0% chemical fertilizer) treatment. The lowest time from primordia initiation to harvest (3.17 days) and average number of fruiting body/packet (58.02) was observed due to rice straw supplemented with chemical fertilizer (N=0.4%, P=0.3% K=0.3%). The highest average weight of individual fruiting body (4.71g), the highest crude fiber (24.03 %) and the lowest lipid (3.34 %) were found from rice straw supplemented with 10% cow dung. The highest average number of primordia/packet (73.67), the highest biological yield (247.92 g), economic yield (241.65 g), dry yield (26.93 g), biological efficiency (93.56 %), benefit cost ratio (6.02) and the highest dry matter percentage of (9.92 %) were observed from rice straw supplemented with chemical fertilizer (N=0.5%, P=0.3% K=0.3%). The highest moisture content (91.08 %) was observed in (Rice straw + 20% wheat bran) treatment. The highest protein (32.17 %) content was observed in (Rice straw + N=0.6%, P=0.3% K=0.3%) treatment. The highest carbohydrate (56.00 %) was found in (Rice straw + 0% chemical fertilizer) treatment and ash (8.40 %) was found in (Rice straw + N=0.6%, P=0.3% K=0.3%) treatment. Among the treatments, Rice straw + chemical fertilizer (N=0.5%, P=0.3% K=0.3%) can be recommended as an economically effective due to the highest yield. On the other hand Rice straw +10% cow dung or Rice straw + 30% wheat bran treatment may be a fair option.

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LIST OF ABBREVIATIONS

Abbreviation	=	Full word
%	=	Percent
@	=	At the rate
°C	=	Degree Centigrade
Anon.	=	Anonymous
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BBS	=	Bangladesh Bureau of Statistics
CV	=	Coefficient of Variance
cv.	=	Cultivar (s)
DAI	=	Days After Inoculation
DMRT	=	Duncan's Multiple Range Test
e.g.	=	For example
et al.	=	And Others
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram
hr	=	Hour (s)
i.e.	=	That is
IRRI	=	International Rice Research Institute
ISTA	=	International Seed Testing Agency
kg	=	Kilogram
LSD	=	Least Significant Difference
no.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
T	=	Treatment
t/ha	=	Ton per Hectare
UNDP	=	United Nation Development Program
$^{w}/_{v}$	=	Weight per Volume
$^{w}/_{w}$	=	Weight per Weight
wt.	=	Weight
BCR	=	Benefit cost ratio
BE	=	Biological efficiency
MRR	=	Mycelium Running Rate
NMDEC	=	National Mushroom Development and Extension Center
MCC	=	Mushroom Culture Centre
mg	=	Milligram
CHO	=	Carbohydrate
Conc.	=	Concentration

INTRODUCTION

Oyster mushrooms are large reproductive structures of edible fungi belong to the class of Basidiomycetes or Ascomycetes. Approximately 3 lakh varieties of mushroom are identified. Among them which are fully edible and have no toxic effect are to be considered as edible mushroom. Out of 2000 species of prime edible mushrooms about 80 have been grown experimentally, 20 cultivated commercially and 4-5 produced on industrial scale throughout the world (Chang and Miles, 1988). The vegetative part of mushroom consists of thread like long thin mycelium which under suitable condition forms fruiting body or sporocarps. This fruiting body is used as edible mushroom. The vegetative part of mushroom consists of thread like long thin mycelium which under suitable condition form fruiting body. This fruiting body is used as edible mushroom. Mushroom is a highly nutritious, delicious, medicinal and economically potential vegetable.

Mushrooms have been considered as a special kind of food since earliest time. The Greeks believed that mushrooms provided strength for warriors in battle. The Pharoaphs prized mushrooms as a delicacy and the Romans regarded mushrooms as the "Food of the Gods," which served only on festive occasions. The Chinese treasured mushrooms as a health food, the "Elixir of life." The Mexican Indians used mushrooms as hallucinogens in religious ceremonies and in witchcraft as well as for therapeutic purposes (Chang & Miles, 1988). Imam Bukhari (Ra) quoted from the holly verse of Prophet Mohammed (S) that "Mushrooms originated from the extract of Manna (the holy Devine food) and it cures eye diseases".

As a vegetable, Mushroom can play an important role to meet up the nutritional requirements of the population of our country. A healthy person requires 200-250gm vegetable per day (FAO, 1998). But in our country, on an average, we get only 40-50 gm vegetable per day. To get rid of this situation, we have to increase the production of vegetable and huge amount of land is required for this

purpose. But we are in lack of sufficient land to cultivate vegetable. So we should have to cultivate such kind of vegetable that require very small amount of land and as a vegetable mushroom requires very small amount of land.

The low calorie and cholesterol free mushroom diets also display certain medicinal properties. Mushroom reduces the diabetic on regular feeding (Anderson and Ward, 1979). It also reduces the serum cholesterol in human bodies which reduces hypertension (Suzuki and Oshima, 1979). Mushroom inhibits the growth of tumor and cancer (Yoshioka, 1975 and Mori *et al.*, 1986). Edible mushrooms have been treated as important tool in modern medicine for their medicinal values (Kovfeen, 2004). Oyster mushroom contains 19-35% protein on dry weight basis as compared to 7.3% in rice 13.2% in wheat and 25.2% in milk (Chang & Miles, 1988). It contains 4.0% fat having good quantity of unsaturated fatty acids which are essential in our diet (Holman, 1976). It is rich in essential minerals and trace elements (Chandha and Sharma 1995). Mushrooms are source of Niacin (0.3 g) and Riboflavin (0.4 mg). Mushroom is a good source of trypsin enzyme. It is also rich in iron, copper, calcium, potassium, vitamin D and folic acid. Mushrooms are valuable health food, which are low in calories, high in vegetable proteins, zinc, chitin, fiber, vitamins and minerals (Alam and Saboohi, 2001). Mushroom reduces serum cholesterol and high blood pressure (Mori, 1986).

With increasing population and conventional agricultural methods we can not cope with the food problem. Once, our staple food was rice and fish. At that time we could meet our protein need from fish as well as energy from rice. In the last decades the fish production decreased and we had to meet our protein need from vegetable source i.e. pulse. But now a day this is also much costly and now we should find out an alternative source of protein as well as other food materials. Mushroom can help us in this aspect.

There are various types of mushrooms such as oyster mushroom, milky white mushroom, button mushroom etc. which are cultivated in our country. Among

them, oyster mushroom is widely cultivated in our country because the weather and climate of Bangladesh is suitable for its cultivation.

Substrate plays an important role in the yield and nutrient content of oyster mushroom. The substrates on which mushroom spawn (Merely vegetative seed materials) is grown, affects the mushroom production (Klingman, 1950). Oyster mushroom can grow on sawdust, rice and wheat straw and other agro-waste. Sarker *et al*. (2007) observed a remarkable variation in nutritional content of oyster mushroom in different substrates. The National Mushroom Development and Extension Centre (NAMDEC), Savar, grows oyster mushroom using sawdust. Bhuyan (2008) in his study observed that the proximate composition of oyster mushroom is greatly changed due to different supplement used in sawdust based substrates. But, sawdust in our country has been becoming scarce due to its use in huge amount in developing poultry industries and its price is also increasing day by day. Therefore, it is necessary to identify the alternative suitable substrate for mushroom production that will be easily available with low cost and more yielding. Rice straw may be used in this aspect.

A huge amount of rice straw is produced in Bangladesh annually. If we use a small part of this for oyster mushroom production, then we can produce notable amount of mushroom. If rice straw is supplemented with several growth promoting agent like different levels of cow dung, chemical fertilizer and wheat bran then expected yield performance may be achieved. So the investigation is undertaken to fulfill the following aim and objectives:

1. To increase the yield of oyster mushroom.
2. To prepare suitable rice straw based spawn packets.
3. To know the physio-chemical characteristics of oyster mushroom (*Pleurotus ostreatus*) grown on supplemented rice straw.
4. To find out cost benefit ratio of the rice straw based spawn packets.

REVIEW OF LITERATURE

A number of literatures relating to the performance of different substrate on mushroom cultivation were available but performances on same substrate with various supplements were not available. The review of literature given below was based on the present information about the performance of oyster mushroom (*Pleurotus ostreatus*) and the effect of different kinds of substrate on mushroom cultivation. The review includes reports of several investigators which appear pertinent in understanding the problem and which may lead to the explanation and interpretation of results of the present investigation.

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).

Kulsum *et al.* (2009) conducted an experiment to determine the effect of five different levels of cow dung (0%, 5%, 10%, 15% and 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% (3.69g). 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 (21.27g) biological efficiency (75.06%) and cost benefit ratio (8.41) were observed due to sawdust supplemented with cow dung @ 10%. Among the chemical characteristics highest content of protein (31.30%), ash (8.41%), crude fiber (24.07%), the lowest lipid (3.44 %) and carbohydrate (32.85%) were observed due to sawdust supplemented with cow dung @ 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 observed due to sawdust supplemented with cow dung @ 10%.

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 combination (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).

Sarker *et al*. (2007 a) carried out an experiment to find out the performance of different cheap agricultural household by products, grasses and weeds as substrate available in Bangladesh. Mycelium growth rate and time required to complete mycelium running in spawn packet varied significantly in different substrates. The minimum duration to complete mycelium running was 17.75 days in waste paper, which differed significantly from that in all other substrates. Significant variation was found in duration from stimulation to primordial initiation, primordial initiation to first harvest and stimulation to first harvest in different substrates. The minimum duration required from stimulation to first harvest was observed in sugarcane bagasse (6.75 days), which was statistically identical to that in waste paper, wheat straw and sawdust (7.00 days). The number of fruiting body was positively correlated with biological efficiency, biological yield and economic yield of oyster mushroom. The number of fruiting body grown on different substrates differed significantly and the highest number of fruiting body per packet (183.25) was recorded on waste

paper, which was significantly higher as compared to all other substrates. The lowest number of fruiting body (19.25) was observed in water hyacinth. Significant variation in biological efficiency, biological yield and economic yield of oyster mushroom were observed in different substrates. The highest economic yield (225.43 g/packet) was estimated from the waste paper followed by wheat straw (215.72 g/packet).The economic yield on sugarcane bagasse was 191.98g/packet, which was statistically identical to that grown on rice straw (183.28 g/packet), kash (182.93 g/packet) and ulu (175.15g/packet).The economic yield on sawdust was 160.40g/packet, which was statistically identical to that on ulu. The lowest economic yield was observed in water hyacinth (33.59g/packet). No fruiting body and economic yield were obtained from para and nepier grasses. Performances of the substrates were compared based on benefit cost ratio (BCR). The highest BCR (6.50) was estimated when wheat straw was used as substrate followed by sugarcane bagasse (5.90), waste paper (5.65), rice straw (5.58) and kash (5.25) The lowest BCR was obtained from water hyacinth (1.05) followed by ulu (4.74) and sawdust (4.90).

Sarker *et al.* (2007 b) found that remarkable difference in nutrient content of oyster mushroom was observed in respect of different substrates. Wide variation was recorded in the protein content of fruiting body. On dry weight basis, the highest protein content (11.63%) was observed in fruiting body grown on sugarcane bagasse. The 2nd highest protein (11.00%) was observed in that grown on wheat straw and water hyacinth. The lowest protein (7.81%) was observed in that grown on rice straw. Mushrooms are good source of minerals. Maximum of 18400 ppm Ca was found in mushroom which was grown on wheat straw. On other substrates its content varied from 1600 ppm to 18400 ppm. The content of Fe in the mushroom grown on different substrates varied from 92.09 ppm to 118.40 ppm. The highest Fe content was found in waste paper cultured oyster mushroom and lowest on water hyacinth.

Namdev *et al.* (2006) conducted a study to determine the effect of different straw substrates on spawn growth and yield of oyster mushroom. The number of days required for spawn run was significantly less

(14 days) in case of gram straw, parthenium straw, sugarcane straw and wheat straw, compared with 20 days for sunflower stalk, mustard straw and paddy straw. Yield was very poor on parthenium straw (95 g/500 g dry substrates) and it was highest on paddy straw (666 g/500 g), followed by wheat straw and mustard straw (427 and 400 g/500 g respectively).

Ramjan (2006) in his study found that high concentration of IAA is effective for mycelial growth and mustard straw performed best as a substrate for the production of fruiting bodies of oyster mushroom.

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

Zape *et al*. (2006) conducted a study to determine the spawn run, days taken to pin head initiation, yield and biological efficiency of three oyster mushroom species viz. *Pleurotus florida, P. eous* and *P. flabellatus* were grown on wheat straw substrate. Time required for spawn run and pinning was significantly less in *Pleurotus eous* followed by *P. florida*. However, the yield and biological efficiency did not differ significantly but was higher in *P.*

florida than *P. flabellatus* and *P. eous*. In analyzing the physico-chemical composition of dehydrated fruit bodies of *Pleurotus* species revealed that among different species *P. eous* was rich in protein (33.89%), moderate in fat (3.10%), carbohydrate (32.60%) and ash (8%) followed by *P. florida*. However, *P. flabellatus* was rich in crude fibre, carbohydrate and ash but low in protein and fat content as compare to *P. eous* and *P. florida.*

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

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

Khlood and Ahmad (2005) conducted an experiment to study the ability of oyster mushroom (*Pleurotus ostreatus*) P015 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 (T1); 70% straw + 20% olive cake 5% wheat bran + 5% gypsum (T2); 60% straw + 30% olive cake + 5% wheat bran + 5% gypsum (T3); 50% straw + 40% olive cake + 5% wheat bran +.5% gypsum (T4); and 90% olive cake + wheat bran + 5% gypsum (T5). After inoculation and incubation, transparent plastic bags were used for cultivation. The pinheads started to appear 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.

Mousa (2005) conducted an experiment to study the edible oyster mushroom *Pleurotus ostreatus* produced the cellulose and hemicellulose degrading enzymes carboxymethylcellulase (CMCase), cellobiohydrolase, cellobiase and xylanase in liquid medium containing milled rice straw as a carbon source. Optimum CMCase production was obtained in a culture containing 2 % milled rice straw, 0.2 % peptone, initial pH of 4 and incubated for 20 days at 35 ^{0}C. Maximum levels of cellobiohydrolase and cellobiase were achieved in a culture containing 2 % milled rice straw, 0.2 % peptone, initial pH of 5 and after incubation for 15 days at 40 degrees C. The optimum conditions

for xylanase production were obtained after 20 days with 2 % milled rice straw, 0.2 % peptone at pH 5 and 40 degrees C. The purified CMCase was a monomeric protein with a molecular weight of 43 kDa. The optimum pH and temperature for the activity of CMCase were at 5 and 40 degrees C, respectively. The purified enzyme was stable at the pH range from 3 to 7 and temperature up to 45 degrees C.

Amin (2004) in his experiment revealed that the highest number of primordia of oyster mushroom was found in sterilized paddy straw at first flush; whereas the lowest was obtained with saw dust.

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

Moni *et al*. (2004) cultivated the oyster mushroom (*Pleurotus sajor-caju*) on paddy straw, banana leaves, sugarcane baggase, water hyacinth and beetle nut husk. The fruit bodies were sun-dried and analyzed for various nutritional parameters. Considerable variation in the composition of fruit bodies grown on different substrates was observed. Moisture content varied from 88.15 to 91.64%. On dry matter basis, the percentage of nitrogen and crude protein varied from 4.22 to 5.59 and 18.46 to 27.78%, respectively and carbohydrate from 40.54 to 47.68%. The variation in content of crude fat and crude fiber ranged from 1.49 to 1.90 and 11.72 to 14.49% respectively whereas, energy value of fruit bodies was between 310.00 and KCal/100 g of fruit body weight.

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

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 degrees C for spawn running and 17-20 degrees 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.

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.

Obodai *et al.* (2003) evaluated eight lignocellulosic by-products as substrate, for cultivation of the oyster mushroom. *Pleurotus ostreatus* (Jacq. ex. fr.) Kummer. The yields of mushroom on different Substrates were 183.1, 151.8, 111.5, 87.5, 49.5, 23.3, 13.0 and 0.0 g for composted Sawdust of *Triplochiton scleroxylon*, Rice straw, Banana leaves, Maize stover, Corn husk, Rice husk, Fresh Sawdust and Elephant grass respectively. The biological efficiency (BE) followed the same pattern and ranged from 61.0%, for composted Sawdust to 50.0% for elephant grass. The Yield of mushroom was positively correlated to cellulose (r^2 = 0.6). Lignin (r^2 =0.7) and fiber (r^2 = 0.7) contents of the substrates. Based on the yield and BE of the substrates tested, Rice straw appeared to be the best alternate substrate for growing oyster mushroom.

Dhoke *et al.* (2001) studied the effect of different agro-wastes on cropping period and yield of *Pleurotus sajor-caju* the experiments carried out in Prabhani and Maharashtra in India, during 1998-99. Various plant materials, i.e. soybean, paddy, cotton, wheat and jowar (*Sorghum bicolor*) were used. Cropping period on different substrates was recorded for first, second and third picking. The cropping period for third picking varied from 42.25 to 43.50 days in different substrates. The days required for first picking indicated that soybean straw took 22.00 days to produce first crop of harvestable mushroom

while a minimum of 21.25 days were required for paddy and wheat straw. For second picking, jowar and cotton waste took the maximum days of 32.75 days while soybean took the minimum of 31.50days. The final and third picking was completed in 43.50 days in case of soybean straw which was statistically higher compared to paddy and wheat straw (42.25) and cotton and jowar straw (42.75). The highest yield of 993.00 g/kg was obtained from cotton, followed by soybean straw (935.25 g/kg) and paddy straw (816.0 g/kg). The lowest yield of 445.50 g/kg was recorded in jowar straw.

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.

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.

Upamanya and Rathaiah (2000) conducted an experiment to test the effect of fortification of rice straw with rice bran on the yield and quality of oyster mushroom (*Plelrrotus ostrentus*) in Jorhat, Assam, India. Treatments comprised: (i) addition of rice bran at 5% w/w (weight of rice bran/weight of dry substrate) at the time of spawning and (ii) control (without rice bran). Rice straw fortified with rice bran exhibited a higher yield compared to the control. Rice

bran application had no effect on the crude protein content of mushroom but increased the yield by 44% over the control.

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

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

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.

Wani and Sawant (1998) reported that among the various edible fungi, oyster mushroom (*Pleurotus spp.*) has a broad adaptability due to having a wide range of suitable substrates, a simple cultivation technique and minimal cultural requirements. Various substrates on which oyster mushroom can be cultivated are mentioned.

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

Kalita *et al.* (1997) studied the growth of *Pleurotus sajor-caju* in polyethylene bag on different combinations of substrates viz. only rice straw, rice straw plus rice husk mixture (1:1 v/v), water hyacinth, chopped banana leaves, areca nut husk and sugarcane bagasse. They found that only rice straw, rice straw plus rice husk mixture and areca nut husk substrates completed spawn running comparatively within short time (12-14 days) but other substrates took longer time.

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* were investigated in Madhya Pradesh, India. Increasing spawning rates reduced the time required for spawn runs. The highest BEs (66.8-101.25%) was observed after the use of the highest spawning percentages. A 1:1 mixture of paddy straw wheat straw promoted a high BE (106.5%); supplementation of this substrate with 5% rice flour also promoted BE (125.75%).

Krishnamoorthy (1997) cultivated oyster mushrooms *Pleurotus citrinopileatus* and *P. sajor-caju*) on paddy straw with 1 of 15 different organic supplements at 2% of the wet weight of substrate. Neem cake increased the yield of *P. citrinopileatus* and *P. sajor-caju* by 48.7 and 75.0%, respectively compared with the control. Red gram husk, green gram husk and

black gram husk also significantly increased yields compared with the control. Importantly, mushrooms harvested from amended paddy straw did not differ in flavor and taste compared with control.

Patrabansh and Madan (1997) used three different kinds of biomass, namely *Pofulus deltoides, Isuhatoriiun adenophorum* and sericulture waste individually for the cultivation of *Pleurotus sajor-caju*, alone and mixed with paddy straw. *P. sajor-caju*, when used alone, exhibited a very good colonizing ability on these substrates except in sericulture waste.

Jadhav *et al.* (1996) reported that oyster mushroom (*Pleurotus sajor-caju*) was cultivated on wheat straw, paddy straw, talks and leaves of maize or cotton, jowar, soyabean straw, groundnut creepers plus wheat straw (1:1), soyabean straw plus groundnut creepers (1:1), or groundnut creepers alone. Cotton stalks and leaves gave the best results with respect to sporophore number, weight of sporophore (5.12 g) and total yield (914 g/kg of dry straw). Yields obtained on other substrates were: 796 g on paddy straw; 557 g on soyabean straw; and 508 g on soyabean + wheat straw. The lowest yield was recorded on groundnut creeper (258 g).

Mathew *et al.* (1996) investigated that *Pleurotus sajor-caju*, *Pleurotus* citrinopileatus, *Pleurotus florida*, *Pleurotus platypus* and *Pleurotus ostreatus* were evaluated for their yield performance on various substrates, both for spawn production and cultivation, in the plains and in the high ranges of Kerala in studies conducted in the summer and rainy seasons. 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.

Ragunathan *et al.* (1996) investigated that the fruiting bodies of oyster mushroom were rich in nutrients such as carbohydrate, protein, amino nitrogen and minerals and low fat content. The moisture content of the fruit bodies ranged from 84.70 to 91.90 % and the carbohydrate content ranged from 40.6 to 46.3 %, the crude protein content ranged from 31.9 to 42.5 %, 26.92 to 38.8%, and 30.0 to 42.5% in *Pleurotus sajor-caju*, *Pleurotus platypus* and *Pleurotus citrinopileatus* respectively.

Abraham and Pradeep (1995) reported that *C. odorata*, a common weed of the tropics, was examined as a potential substrate for cultivation of *Pleurotus flabellatus*. Performance was evaluated using *C. odorata*, dried or fresh and sterilized or not sterilized, as a sole substrate and in combination with paddy straw (1:1). The results indicate that *C. odorata* residues can be used for the commercial cultivation of *Pleurotus*.

Isik *et al.* (1995) conducted an experiment to find out the best preparation formulas of horse manure and synthetic compost. Horse manure, wheat straw, gypsum as basic materials and wheat bran, cotton seed meal, sunflower meal, malt sprout, chicken food, molasses, ammonium sulphate, urea as activators were used. The nitrogen content of the starting mixture was brought up 2 in all applications. According to the results, the highest yields with horse manure compost were obtained from the combinations of 1000 kg of horse manure, 50 kg of wheat bran, 3.1 kg of ammonium sulphate, 1.5 kg of urea, 35 kg of gypsum and 1000 kg of horse manure, 40 kg of chicken food or malt sprout, 7.5 kg of urea, 35 kg of gypsum. The highest yields with synthetic compost were obtained from the combinations of 1000 kg of wheat straw, 282 kg of wheat bran, 13 kg of urea, 23.5 kg of ammonium nitrate, 40 kg of molasses, 60 kg of gypsum and 1000 kg of wheat straw, 65 kg of cotton seed meal or 100 kg of chicken food, 25 kg of urea, 40 kg of molasses and 0 kg of gypsum.

Murugesan *et al.* (1995) cultivated mushroom P. *sajor-caju* (Fr.) Sing, on water hyacinth (*Elchhorni crassipe*). They compared water

hyacinth with other conventional substrates paddy straw. Total yields for 20 bags of the two substrates were 15.0 and 10.5 kg respectively, although the time taken to reach the pin-head stage was longer on the water hyacinth substrate (17 days in water hyacinth and 10 days in paddy straw). The high yield on water hyacinth was attributed to the C: N ratio (24.3 compared with 53.5) and low lignin content (9% compared with 17%) of this substrate. Use of water hyacinth would provide a cheap substrate and a means of eradicating a troublesome aquatic weed.

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).

Singh *et al.* (1995) reported that the *Pleurotus florida* was cultivated on wheat straw, paddy straw and sugarcane trash (dried leaves) used either separately or in 1:1 ratio, yield and biological efficiency were the highest in paddy straw. The effects of different forest wastes on the radial growth of *Lentinus edodes* Berk were studied. Three types of sawdust from Shishum (*Dalbergia sisso*) 'Kikar' (*Acacia arabica*) and Poplar (*Populus alba*) amended with wheat bran and lime were used for spawn preparation.

Badshah *et al.* (1994) mentioned that *Pleurotus ostreatus* and *P. florida* were grown on wheat straw, sugarcane bagasse, corn cobs or sawdust, by mixing 120-130 g of spawn with 2 kg of substrate and placing the mixture in sterilized polyethylene bags which were kept in the dark at 25°C for 2-3 weeks. Once the bags became full of mycelial growth, they were removed, leaving the substrate uncovered. Watering was carried out 2-3 times a day. Fruiting bodies were harvested at maturity. *P. ostreatus* and *P. florida* yields ranged from 49.8 and 277.7 g/2 kg substrate respectively on sawdust, to 432.8 and 420.5 g/ 2 kg substrate respectively, on wheat straw. Controls (grown in the

field) yielded only 18.5 and 28.5 g/2 kg substrate for *P. ostreatus* and *P, florida*, respectively. In both species, wheat straw and sugarcane bagasse substrates resulted in the highest mushroom ascorbic acid contents and protein, fat and fiber contents were also affected by substrate. *Pleurotus florida* had higher fat but lower protein contents than *P. ostreatus*.

Dhanda *et al.* (1994) conducted an experiment on the use of fermented, semi-fermented and unfermented paddy straw as substrate for *Pleurotus spp*. (oyster mushroom). PAU-4 strain showed early primordia initiation, giving 60% biological efficiency whereas PAU-3 exhibited these effects much earlier with 70% biological efficiency.

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.

Sarawish (1994) found no significant difference in either the growth of mycelium or the yield of straw mushroom on kaptok residue, chopped-dried water hyacinth, chopped-dried banana stem or chopped-dried water hyacinth, chopped-dried banana stem chopped-dried rice straw as a main substrate.

Ijaz and Khan (1992) reported that mushroom has been recently introduced in Pakistan. Different species/strains i.e. *Pleurotus sajor-caju*., *P. ostreatus* strain XI, *P. ostreatus* strain 467 and *P. ostreatus* were cultivated on cotton waste. *P. ostreatus* strain XI gave higher (260 g) basidiocarps out of 750 g of substrates per flush. It had 104 percent biological efficiency and 49 percent sustenance potential. In the same manner cotton waste scored maximum yield, biological efficiency and sustenance potential by defeating paddy straw + 25 percent synthetic compost, paddy straw and wheat straw in descending order.

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

Royse *et al.* (1991) found that yields of *Pleurotus sajor-caju* strain 537 from the substrate supplemented with the commercial nutrient were 1.7-fold higher than yields from non-supplemented substrate. As the supplement level increased from 6 to 12 %, the mushroom yields increased. The yields ranged from 3.56 kg/m^2 for non-supplemented substrates to 7.36 kg/m^2 for substrate supplemented (12% DW) with formaldehyde soybean meal.

Thangamuthu (1990) in an investigation used sugarcane bagasse for growing *Pleurotus spp.* The two species gave similar yields at 500 g substrate, reaching maximum of 506-508 g on pretreated bagasse, 407-411 g on paddy straw and 379-391 g on wheat straw alone.

Gupta (1989) found that the fruiting bodies appeared 12-15 days after the bags were removed, and the first crop was harvested 2-3 days later on wheat straw and *Pleurotus sajor-caju* can be successfully cultivated in both hot and spring seasons.

Patil (1989) cultivated *P. sajor-caju* on six different substrates, i.e. wheat straw, bajra (*Pennisetunz americana*), maize straw, paddy straw, jower and cotton stick. The results indicated that all the substrates could be used for commercial cultivation of the oyster mushroom.

Qin (1989) conducted an experiment to evaluate the performance of five species of *Pleurotus* grown on cotton seed hulls, wheat, rice and maize straw. The crude protein content of the fruiting bodies was varied with different substrates. *Pleurotus sajor-caju* contained 41.26 % crude protein when cultivated on rice straw and 29 % when cultivated on wheat straw. Those cultivated on rice and maize straw contained 17 amino acids but oystin was

lacking in those cultivated on cottonseed husks or wheat straw. The total amino acid and essential amino acid contents in the fruiting bodies grown on the different substrates like rice straw, maize straw and cotton seed husks were also found very significantly.

Chang and Miles (1988) reported that substrate is an important item for growing mushroom. It is a kind of media which supports the growth, development and fruiting of mushroom.

Ramesh and Ansari (1987) evaluated several locally available substrates such as rice straw, banana leaves, saw dust, oil palm refuse, oil palm bunch refuse or grass straw in Andamans to study conversion efficiency of *Pleurotus sajor-caju*. Rice straw and banana leaves were best substrates, with more than 60% conversion efficiency on dry weight basis. The mean weight of the fruiting body was high (7.1 g) on banana leaves compared to other substrates (2.1-5.0 g). The spawn running time was also less with banana leaves, followed by rice straw, grass straw, oil palm bunch refuse, sawdust and oil palm waste. *Pleurotus ostreatus* was successfully grown under local conditions utilizing chopped wheat straw, cotton waste, maize cobs or rice straw as bedding material. Wheat straw and cotton waste gave the highest yields with the shortest incubation period; fruiting bodies were appeared after 15-18 days as compared to 4-5 weeks on the other substrates. The first flush gave the highest yield in all treatments and was a gradual decline in the yield of successive flushes.

Suprapti (1987) measured the mushroom yield and harvesting frequency after cultivation on Rubber wood (*Hevea brasiliensis*) sawdust mixed with 5, 10, 15 or 20 %, of leaves of either turi (*Sesbonia grandiflora*) or lamtoro gung (*Leucaena leucocephala*). Average total yield per treatment was 643.00 g (532.29-744.69) per kg dry wt. of substrate. Addition of 40% lucerne hay (w/w) or 20% rapeseed meal (w/w) to the barley or wheat straw substrate gave the highest yields (275-300 kg/substrate) of *Pleurotus ostreatus*.

Bisht and Harsh (1985) mentioned the use of Lantana, straw and waste paper as substrate for button mushroom cultivation. The substrate was first biodegraded by *Pleurotus ostreatus* (*Jacq.*) Fr, then the sterilized substrate was used for button mushroom cultivation. Thus both mushrooms (*Pleurotus ostreatus* and *Agaricus bisporus*) can he grown economically in succession on the same substrate.

Chang *et al.* (1981) reported that the fruiting bodies of mushrooms contained (82.5-92.2) % moisture, (4.30-50.7) % carbohydrate, (26.6-34.1) % crude protein and (1.1-8.0) % fat.

MATERIALS AND METHODS

The experiment was carried out to find out the yield and proximate composition of oyster mushroom (*Pleurotus ostreatus*) grown on supplemented rice straw. This chapter deals with a brief description on location and design of experiment, experiments and treatments, preparation of substrates, preparation of packets, cultivation of spawn packet, collection of produced mushrooms, proximate analysis of the 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 Biochemistry laboratory and Mushroom Culture House (MCH) of the Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, during the period from January to June 2009. The environmental condition of the experimental location was given in appendix I.

3.2 Experimental materials

Mother culture of oyster mushroom was collected from National Mushroom Development and Extension Center (NAMDEC), Savar, Dhaka.

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 Experiments and treatments

Three different experiments each with five treatments with three replications were conducted to achieve the desired objectives. The experiments were as follows:

Experiment 1: Effect of cow dung supplements with rice straw on the yield and proximate composition of oyster mushroom (*Pleurotus ostreatus*)

Treatments used:

- E_1T_1: Control (Rice straw)
- E_1T_2: Rice straw + 5 % cow dung
- E_1T_3: Rice straw + 10% cow dung
- E_1T_4: Rice straw + 15% cow dung
- E_1T_5: Rice straw + 20% cow dung

Experiment 2: **Effect of mixed chemical fertilizer supplements with rice straw on the yield and proximate composition of oyster mushroom (*Pleurotus ostreatus*)**

Treatments used:

- E_2T_1: Control (Rice straw)
- E_2T_2: Rice straw + chemical fertilizer (N=0.3%, P_2O_5=0.3%, K_2O=0.3%)
- E_2T_3: Rice straw + chemical fertilizer (N=0.4%, P_2O_5=0.3%, K_2O=0.3%)
- E_2T_4: Rice straw + chemical fertilizer (N=0.5%, P_2O_5=0.3%, K_2O=0.3%)
- E_2T_5: Rice straw + chemical fertilizer (N=0.6%, P_2O_5=0.3%, K_2O=0.3%)

Experiment 3: **Effect of wheat bran supplements with rice straw on the yield and proximate composition of oyster mushroom (*Pleurotus ostreatus*)**

Treatments used:

- E_3T_1: Control (Rice straw)
- E_3T_2: Rice straw + 10% wheat bran
- E_3T_3: Rice straw + 20% wheat bran
- E_3T_4: Rice straw + 30% wheat bran
- E_3T_5: Rice straw + 40% wheat bran

3.4.1 Design and layout of the experiment

The experiment was laid out in single factor Completely Randomized Design (CRD). The experiment considered three experiments with five treatment combinations with three replications and three spawn packets in each replication (Appendix II).

3.5 Preparation of substrates

At first weight of dry straw was taken. Then the straw was soaked in water over night. Therefore the straw was taken off from water and left on a perforated sieve for removing the excess water for few hours. Then the supplements were added according to the experiment and treatment (cow dung for experiment-1, chemical fertilizer for experiment-2 and wheat bran for experiment-3 respectively). $CaCO_3$ was also added with spawn preparing substrate @ 1% on dry weight basis. The measured materials were taken in a plastic bowl and mixed thoroughly by hand and moisture was increased by adding water. Moisture was measured by using the moisture meter and adjusted the moisture content at 65%.

3.5.1 Preparation of spawn packets

The mixed substrates were filled into 7×11 inch polypropylene bag @ 500 g. The filled polypropylene bags were prepared by using plastic neck and plugged the neck with cotton and covered with brown paper placing rubber band to hold it tightly in place.

3.5.2 Sterilization, inoculation and mycelium running in spawn packets

Therefore the packets were sterilized about 1 hour and then these were kept for cooling. After cooling, 5 g mother spawn was inoculated into the packets in the laminar airflow cabinet and the packets were kept at 20-22°C temperature until the packets become white with the mushroom mycelium. After completion of the mycelium running the rubber band, brown paper, cotton plug and plastic neck of the mouth of spawn packet were removed and the mouth was wrapped tightly with rubber band. Then these spawn packets were transferred to the culture house.

3.5.3 Cultivation of spawn packet

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

3.5.4 Collection of produced mushrooms

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.

3.6 Data collection

3.6.1 Mycelial growth (%):

Mycelial growth was counted by taking the full packet as a full unit and generally the data was taken at every two days intervals.

3.6.2 Mycelium running rate in spawn packet (cm):

Mycelium running rate (MRR) for each type of substrate was measured after the mycelium colony cross the shoulder of the packet. The linear length was measured at different places of packet using the following formula (Sarker, 2004):

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

Where, L= Average length of mycelium running for different places (cm)

N= Number of days

3.6.3 Days required for completing mycelium running:

Days required from inoculation to completion of mycelium running were recorded.

3.6.4 Average number of fruiting body per packet:

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

3.6.5 Average weight of individual fruiting body per packet:

Average weight of individual fruiting body was calculated by dividing the total weight of fruiting body per packet by the total number of fruiting body per packet.

3.6.6 Biological yield (g):

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

3.6.7 Economic yield:

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

3.6.8 Drying of mushrooms:

The collected fruiting bodies of the mushroom were transferred to the laboratory. Therefore data were collected on different parameter. After collection of the data the fruiting bodies were dried in the sun separately as per treatment. In the time of drying the stipe and the pileus were separated for better drying.

3.6.9 Dry yield:

About 50 g of randomly selected mushroom sample was taken in a paper envelop and was weighed correctly. The mushroom was oven dried at 72ºC temperature for 24 hours and weighed again. The weight of blank envelop was

subtracted from both the initial weight. The dry yield was calculated using the following formula (Sarker, 2004):

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

3.6.10 Biological efficiency:

Biological efficiency was determined by the following formula:

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

3.6.11 Benefit cost ratio:

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

3.6.12 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.

3.7 Proximate analysis of the mushrooms

3.7.1 Collection of the samples:

Mushrooms grown from the spawn were collected packet wise and all the wastes and dusts were removed from the fruiting body. Therefore they were ready to be analyzed.

3.7.2 Moisture:

About 10-20 g of the material of each sample were weighed into separated and weighed petridishes and dried in an oven at 100°C to 105°C till the weight of the petridishes with their contents was constant. The moisture content was expressed as percent of the fresh fruiting bodies.

3.7.3 Dry matter:

A clean container (dish or beaker) was place in an oven at 105ºC overnight. The container was allowed to cool in a desiccator and was weighed. The sample was kept into the container and weighed with the sample. The container was placed in the oven at 105°C for 24 hours. The container was allowed to cool in a desiccator and was weighted. Again, the container was placed in the oven at 105°C for 2 hours. It was cooled in a desiccator and weighed again. Repeat drying, cooling and weighing were continued until the weight became constant. The dried sample was stored in an airtight container. The moisture content of the sample was calculated.

3.7.4. Grinding:

The dried plant materials were cut into small pieces with a knife or scissor. The sample was grinded in a plant grinder fitted with a suitable screen. If the grinding takes a long time, the sample will absorb moisture and it is necessary to dry the sample again in the oven at 105°C overnight.

3.7.5 Determination of crude fiber:

Ten gram of moisture and fat-free sample was taken in a beaker and 200 ml of boiling 0.255 N H_2SO_4 was added. The mixture was boiled for 30 minutes keeping the volume constant by the addition of water at frequent intervals. The mixture was then filtered through a muslin cloth and the residue washed with hot water till free from acid. The material was then transferred to the same beaker and 200 ml of boiling 0.313 N NaOH added. After boiling for 30 minutes (keeping the volume constant as before) the mixture was filtered through a muslin cloth and the residue washed with hot water till free from alkali, followed by washing with some alcohol and ether. It was then transferred to a crucible, dried overnight at 80-100°C and weighed (We) in an electric balance *(KEY: JY-2003; China).* The crucible was heated in a muffle furnace *(Nebertherm: Mod-L9/11/c6; Germany)* at 600°C for 5-6 hours, cooled

and weighed again (Wa). The difference in the weights (We-Wa) represents the weight of crude fiber.

Therefore,

Crude fiber (g/l00g sample) = [100-(moisture + fat)] x (We-Wa) / Wt. of sample (Raghuramulu *et al.*, 2003).

3.7.6 Determination of protein

The Protein contents of the fruiting bodies of the mushrooms were determined by the standard Micro-kjeldhal procedure of AOAC (1975). According to this method total nitrogen contents of the samples were estimated and proteins contents were find out by multiplying by 6.25 to the total nitrogen values. The total nitrogen was determined by the Kjeldahl method, which depends upon the conversion of protein nitrogen into ammonium sulfate, by digestion. ammonia liberated from the ammonium sulfate by making the solution alkaline was distilled into known volume of a standard acid, which was then back titrated.

Reagents

a) Concentrated sulfuric acid
b) Digestion Mixture: Potassium sulfate : Copper sulfate (98 : 2 w/w)
c) 40% Sodium hydroxide in distilled water
d) N/10 Sulfuric acid and N/10 Sodium hydroxide
e) 0.1% methyl red indicator: 0.1 g of the indicator was dissolved in 60 ml of alcohol and the volume was made 100ml with the distilled water

Procedure

Weighed dried sample 2.0g, 5.0g of the digestion mixture, 25 pieces of the glass beads, and 25ml of concentrated sulfuric acid were taken in a Kjeldahl flask. The content of the flask was digested in a flame chamber until the total content became clear. The digested materials were quantitatively transferred into a one liter flat-bottomed flask and the volume was made up to about 400ml with distilled water. Then about 40% NaOH and some pumice stone were added to

prevent bumping, and distilled immediately in the distillation chamber of the Kjeldahl apparatus. The distillation was continued till its volume diminished to one-half of the initial. The distillate was collected in a receiver containing 100ml of N/10 sulfuric acid containing 2/3 drops of methyl red indicator. The liberated ammonia absorbed in the sulfuric acid solution was titrated against standard (N/10) NaOH solution.

Calculation

$$\text{Percentage of nitrogen} = \frac{(A-B)\times 14\times 100}{W\times 1000}$$

Where A = ml of NaOH required in the titration of blank
B = ml of NaOH required in the titration of sample
N = Normality of the NaOH
W = Weight of the sample

The protein content in gram per 100g of the dried sample

$$= \frac{\text{Percentage of nitrogen} \times 6.25 \times \text{D}}{100}$$

Where D = Percentage of dried sample from the fresh sample

3.7.7 Total fat estimation:

Fat was estimated as crude ether extraction of the dry materials. The dried sample (about 5.0 g) was weighted into a conical flask and plugged with fat free cotton. The flask was then placed in an electric shaker and extracted with anhydrous ether for about 16 hours. The ether extract was filtered into another weighed conical flask. The flask containing the original ether extract was washed 4 to 5 times with small quantities of ether and the washings were also transferred to the filter paper. The ether in the conical flask was then removed by evaporation, and the flask with the residual was dried in an oven at 80°C to 100°C, cooled in a dessicator and weighted. The result was expressed as follows:

Fat contents (g) per 100g of dried sample

$$= \frac{\text{Weigh of ether extract} \times \text{Percentage of dried sample}}{\text{Weigh of the dried sample taken}}$$

3.7.8 Determination of total ash:

One gram of the sample was weighed accurately into a crucible. The crucible was placed on a clay pipe triangle and heated first over a low flame till all the material was completely charred, followed by heating in a muffle furnace for about 5-6 hours at 600°C. It was then cooled in a dessicator and weighed. To ensure completion of ashing, the crucible was then heated in the muffle furnace for 1h, cooled and weighed. This was repeated till two consecutive weights were the same and the ash was almost white or grayish white in color. Then total ash was calculated as following equation:

Ash content (g/l00 g sample) = Wt of ash × 100 / Wt of sample taken (Raghuramulu *et al.*, 2003)

3.7.9 Total carbohydrate estimation:

The content of the available carbohydrate was determined by the following equation:

Carbohydrate (g/l00 g sample) = 100 - [(Moisture + Fat + Protein + Ash + Crude Fiber) g/100 g] (Raghuramulu *et al.*, 2003)

3.8 Elementary composition analysis

3.8.1 Equipments:

Electric balance, Grinding machine, Dessicator, Atomic Absorption Spectrometer (AAS), Spectrophotometer, Porcelain crucible, Muffle furnace, Oven, Beaker and Flame Photometer.

3.8.2 Determination of Ca, Mg, K, Fe, Zn and P

The sample was digested with nitric acid to release of Ca, Mg, K, Fe, Zn and P. Ca, Mg, Fe and Zn were determined by atomic absorption spectrophotometer,

K was determined by flame photometry and P was determined by spectrophotometer.

3.8.2.1 Digestion

1. 0.500 g of dried sample was taken into each of 18 nitrogen digestion tubes. The two remaining tubes were kept blanks. 5 ml nitric acid were added to each of all 20 tubes. The tubes were left overnight mixing the contents in the tubes. Covering with the exhaust manifold, the tubes were placed in the digester and the temperature was set to 125°C, turning on the digester, the digestion was continued for 4 hours after boiling started. Every tube was observed to avoid drying.
2. After cooling, the digestion mixture was transferred with distilled water to a 100 ml volumetric flask. Water was added to the flask to make the volume up to the mark.
3. Filtration was performed on a dry filter into a dry bottle, which could be closed with a screw cap. Keeping the filtrate in the closed bottle Ca, Mg, K, Fe, Mn, Zn, Cu and P were determined in the filtrate.

3.8.2.2 Estimation of Ca

20 ml diluted filtrate was transferred into a 50 ml volumetric flask using a pipette. 5 ml $LaC1_3$-solution was added and the volume was made with water and mixed. Then the content of Ca was measured by atomic absorption spectrometer (AAS).

3.8.2.3 Estimation of Mg

20 ml diluted filtrate was transferred into a 50 ml volumetric flask using a pipette. 5 ml $LaC1_3$-solution was added and the volume was made with water and mixed. Then the content of Mg was measured by atomic absorption spectrometer (AAS).

3.8.2.4 Estimation of K

10 ml diluted filtrate was transferred into a 50 ml volumetric flask using a pipette to volume with water and mixed. The content of K was measure by flame photometer.

3.8.2.5 Estimation of P

5 ml diluted filtrate was transferred into a 50 ml volumetric flask using a pipette. 30 ml water was added, mixed and then 10 ml ammonium molybdate-ascorbic acid solution was added to volume with water and mixed. After 15 minutes, the absorbance was measured on a spectrophotometer at 890 nm.

3.8.2.6 Estimation of Fe and Zn

The content of Fe and Zn elements were measure by atomic absorption spectrometer (AAS) directly in the undiluted filtrate.

3.8.2.7 Calculations

For Ca, Mg, K, P

$$\text{mg per kg sample} = \frac{a \times 25000}{b \times c}$$

Where, a= mg/L Ca, Mg, K or P measured on atomic absorption spectrometer, flame photometer or spectrophotometer

b= ml diluted filtrate transferred into the 50 ml volumetric flask for determination of Ca, Mg, K or P

c = g sample weighed into the digestion tube

If an additional dilution is made before the transfer to the 50 ml volumetric flask, the result is multiplied with the dilution factor. But the above elements were in trace. So addition of dilution was not to be performed.

For Zn and Fe

$$\text{mg per kg sample} = \frac{d \times 100}{c}$$

Where, d = mg/L Zn and Fe measured on atomic absorption spectrophotometer

c = g sample weighed into the digestion tube

3.9 Statistical analysis of data

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

RESULTS AND DISCUSSION

Experiment 1: Effect of cow dung supplements with rice straw on the yield and proximate composition of oyster mushroom (*Pleurotus ostreatus*)

4.1.1 Effect on mycelium running rate (Days)

Mycelium running rate per day (MRR) for each type of substrates was measured after the mycelium colony crossed the shoulder of the packet. The linear length was measured at different places of packet. Mycelium running rate in spawn packet was found to be differed due to different supplements used. The highest running rate was observed in E_1T_3 (0.70 cm) and the lowest running rate of mycelium was observed in E_1T_1 (0.52 cm). The other treatments were statistically similar (Table 1 and Appendix III). The present findings corroborated with the findings of previous workers (Khan *et al.*, 1991; Kalita *et al.*, 2001 and Kulsum *et al.*, 2009). 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. Kalita *et al.* (2001) reported that time taken for completion of spawn running may required from 17 days to 22 days by use of different substrates. 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.

4.1.2 Effect on time from stimulation to primordia initiation (Days)

The time from stimulation to primordia initiation ranged from 6.03 days to 7.23 days. The highest time from stimulation to primordia initiation was observed in E_1T_1 (7.23 days). The lowest time from stimulation to primordia initiation was in the treatment E_1T_4 & E_1T_5 (6.03 days). The other treatments varied significantly in terms of time from stimulation to primordia initiation (Table 1 and Appendix III). The result of the present study keeps in with the findings of

previous workers (Sarker, 2004; Amin, 2007; Bhuyan, 2008 and Ali, 2009). Sarker (2004) observed that duration from primordia initiation to first harvest of oyster mushroom was significantly lower as compared to control where no supplement was used and the duration required for total harvest of oyster mushroom increased with the level of supplement used. In the present study, the time required for total harvest decreased with the levels of supplements increased compared to rice straw alone. Amin *et al.* (2007) found significant differences among the level of supplements used for preparing the substrates. Bhuyan (2008) also found similar effect as found in the present study. Ali (2009) observed that the highest time from stimulation to primordia initiation was (11.5 days) due to sugarcane bagasse supplemented with wheat bran @ 10%.

4.1.3 Effect on time from primordia initiation to harvest (days)

The lowest time from primordia initiation to harvest was in the treatment E_1T_3 (3.63 days) and the highest time from primordia initiation to harvest was observed in the treatment E_1T_1 (5.06 days). The other treatments were statistically similar (Table 1 and Appendix III). The result of the present study keeps in with the findings of several workers (Khan *et al.*, 2001; Dhoke *et al.*, 2001 and Kulsum *et al.*, 2009). Khan *et al.* (2001) reported that after spawn running pinhead formation took 7-8 days and fruiting body formed after 3-5 days, sporocarps may be harvested after 10-12 days. Dhoke *et al.* (2001) found significant effect of different agro-wastes on yield of oyster mushroom. The days required for first picking varied from 11.25-12.00 and the final picking complete from 42.25 to 43.50 days depending on different substrates. Kulsum *et al.* (2009) observed that the lowest time from primordia initiation to harvest was 3.2 days due to sawdust supplemented with cow dung @ 10%.

4.1.4 Effect on average number of primordia

The highest average number of primordia/packet was observed in the treatment E_1T_2 (70.63) followed by E_1T_4 (66.67) and the lowest average number of primordia/packet was in the treatment E_1T_1 (57.35). The other treatments were

statistically similar (Table 1 and Appendix III). The result of the present findings keeps in with the findings of previous scientists (Ahmed, 1998; Dey, 2006; Bhuyan, 2008 and Kulsum *et al.* 2009). Ahmed (1998) reported significantly different number of primordia on different substrates. Dey (2006) found that the number of primordia and the average yield significantly varied with the substrates used in production of oyster mushroom. Bhuyan (2008) found similar findings due to saw dust supplemented with different levels of cow dung. Kulsum *et al.* (2009) observed that the highest average number of primordia/packet was 73.21 due to sawdust supplemented with cow dung @ 10%.

4.1.5 Effect on average number of fruiting body

The highest average number of fruiting body/packet was observed in the treatment E_1T_2 (51.92) and the lowest average number of fruiting body /packet was in the treatment E_1T_1 (39.67). The other treatments significantly varied over control in terms of average number of primordia/packet (Table 1 and Appendix III). The result of the present findings keeps in with the findings of previous scientists (Yoshida *et al.,* 1993; Amin, 2004 and Kulsum *et al.,* 2009). Yoshida *et al.* (1993) reported that the number of fruiting bodies was lower but increased when the substrates was mixed with different supplements. Amin (2004) reported that the number of primordia grown on different substrates differed significantly. 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%.

4.1.6 Effect on average weight of individual fruiting body (g)

Supplementation of rice straw with different levels of cow dung had great effect on average weight of individual fruiting body. The average weight of individual fruiting body in different treatment ranged from 3.73 g to 4.71 g. The highest average weight of individual fruiting body was observed in the treatment E_1T_3 (4.71 g) and the lowest average weight of individual fruiting body was in the

treatment E_1T_1 (3.73 g). The other treatments varied significantly over control in terms of average weight of individual fruiting body (Table 1 and Appendix III). The present study conforms to the study of the previous scientists (Sarker, 2004; Sarker *et al*., 2007; Bhuyan, 2008 and Kulsum *et al.*, 2009). Sarker (2004) found significant increase in weight of fruiting body in gram per sporocarps over control in spawn packet containing different supplement in compared with rice straw alone. Sarker *et al.* (2007) reported the individual weigh of fruiting body ranged from 1.33-1.59g. Bhuyan (2008) found significant effect of supplementation on the weight of fruiting body but he found comparatively higher weight of individual fruiting body ranged from (5.02 g to 7.01 g). Kulsum *et al.* (2009) observed that the highest average weight of individual fruiting body was 2.99 g due to sawdust supplemented with cow dung @ 15%.

Table 1. Effect of different levels of cow dung with rice straw on mycelium growth and yield contributing characters of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Mycelium running rate in spawn packets (cm)	Time from stimulation to primordial initiation (days)	Time from primordial initiation to harvest (days)	Average number of primordia /packet	Average number of fruiting body /packet	Average weight of individual fruiting body (g)
E_1T_1	0.52 d	7.23 a	5.06 a	57.35 d	39.67 d	3.73 b
E_1T_2	0.64 b	6.50 b	4.40 b	70.63 a	51.92 a	3.80 b
E_1T_3	0.70 a	6.13 bc	3.63 c	63.33 b	48.33 b	4.71 a
E_1T_4	0.65 b	6.03 c	4.30 b	66.67 b	45.67 c	4.61 a
E_1T_5	0.61 c	6.03 c	4.36 b	61.00 c	49.50 b	3.78 b
LSD(0.05)	0.019	0.372	0.449	2.630	2.170	0.516
CV (%)	2.92	3.08	5.48	3.73	4.50	4.90

In a column the figures having a common letter(s) do not differ significantly.

Note: E_1T_1: Rice straw (Controlled), E_1T_2: Rice straw + 5% Cow dung, E_1T_3: Rice straw + 10%Cow dung, E_1T_4: Rice straw +15% Cow dung, E_1T_5: Rice straw + 20% Cow dung.

4.1.7 Effect on biological yield (g)

The supplementation of rice straw with cow dung had great effect on biological yield. The highest biological yield was recorded under treatment E_1T_3 (234.24 g) and the lowest biological yield was recorded under E_1T_1 (157.36 g). The other treatments varied significantly as compared with control in terms of biological yield (Table 2 and Appendix IV).Chowdhury *et al.* (1998) examined the effects of adding different supplements to substrates for growing oyster mushrooms (*Pleurotus sajor-caju*) and found adding 5% supplements gave the highest yield of oyster mushroom. Baysal *et al.* (2003) found the highest yield of oyster mushroom (*Pleurotus ostreatus*) with the substrate composed of 20% rice husk in weigh. Amin *et al.* (2007) found that the highest biological yield 247.3 g/packet was obtained due to paddy straw supplemented with 10% wheat broken which is more or less similar to the present study.

4.1.8 Effect on economic yield (g)

In the present study, the economic yield was increased with the levels of supplements increased up to 10% cow dung with rice straw and declined thereafter. The highest economic yield was recorded under treatment E_1T_3 (227.72 g) and the lowest economic yield was recorded under E_1T_1 (148.21 g). The other treatments varied significantly over control (Table 2 and Appendix IV). Payapanon *et al.* (1994) mentioned that suitable amount of supplements added to rice straw medium, maximized economic yield of oyster mushroom at optimum production cost. 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%.

4.1.9 Effect on dry yield

The dry yield of the oyster mushroom grown on rice straw responded significantly with the different levels of supplement (cow dung). The dry yield of mushroom was maximum under the treatment E_1T_3 (22.83 g) and the lowest dry yield was recorded under E_1T_1 (14.19 g). The other treatments varied significantly over control (Table 2 and Appendix IV). Ahmed (1998) observed significant effects of various substrates on diameter and length of stalk, also diameter and thickness of pileus. He also found that lower diameter of pileus produced the lowest yield and concluded that the diameter of pileus increased the quality and yield of mushroom and highest dry yield from mango sawdust. Sarker *et al.* (2007) found that the range of dry yield was 4.28 to 29.98 g/packet of *Pleurotus ostreatus* grown on different substrate which was more or less similar to this study. Kulsum *et al.* (2009) found that the highest dry yield was 21.27 g due to sawdust supplemented with cow dung @ 10%.

4.1.10 Effect on biological efficiency

The highest biological efficiency (140.26 %) was calculated in treatment E_1T_3 and the lowest biological efficiency (100.54 %) was calculated from E_1T_1 (Table 2 and Appendix IV). The other treatments varied significantly over control. The present findings keep in with the findings of previous workers (Biswas *et al.*, 1997; Kalita *et al.*, 1997; Obodai *et al.*, 2003 and Sarker *et al*., 2007). Biswas *et al.* (1997) found that supplementation of substrate promoted biologycal efficiency (125.75%). Kalita *et al.* (1997) observed that biological efficiency for different substrates was ranged from 35.2 to 60.9 %. Obodai *et al.* (2003) found that biological efficiency (BE) followed a pattern and ranged from 61.0% to 80.0%. Sarker *et al*. (2007) found that the biological efficiency was ranged from 20.89 to 145.66 % for *Pleurotus ostreatus* grown on different substrates.

4.1.11 Effect on benefit cost ratio

The highest benefit cost ratio was calculated in treatment E_1T_3 (5.69) and the lowest benefit cost ratio 3.70 was calculated from E_1T_1. The other treatments differed significantly in terms of benefit cost ratio (Table 2 and Appendix IV).

The present findings keep in with the findings of previous workers (Lim *et al.*, 1997; Sarker *et al.*, 2007 and Kulsum *et al.*, 2009). Lim *et al.* (1997) analyzed the cost and return of *Volvariella* and *Pleurotus* mushroom production and found the ROI 8.9 and 5.1 respectively. Sarker *et al*. (2007) mentioned the performances of substrates were significantly differed based on benefit cost ratio. They reported the highest cost benefit ratio (6.51) with wheat straw substrate. Kulsum *et al.* (2009) found that the benefit cost ratio was ranged from 3.80 to 8.41 due to sawdust supplemented with different levels of cow dung.

Table 2. Effect of different levels of cow dung with rice straw on the yield, biological efficiency and benefit cost ratio of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Biological yield (gm)	Economic yield (gm)	Dry yield (gm)	Biological efficiency (%)	Benefit cost ratio
E_1T_1	157.36 e	148.21 e	14.19 e	100.54 d	3.70 d
E_1T_2	204.52 c	196.43 c	19.80 c	126.64 b	4.91 c
E_1T_3	234.24 a	227.72 a	22.83 a	140.26 a	5.69 a
E_1T_4	218.35 b	210.55 b	20.80 b	126.94 b	5.26 b
E_1T_5	196.63 d	187.02 d	18.03 d	111.41 c	4.67 c
LSD (0.05)	2.893	2.328	0.449	1.090	0.279
CV (%)	0.79	0.65	1.29	0.79	0.78

In a column the figures having a common letter(s) do not differ significantly.

Note: E_1T_1: Rice straw (Controlled), E_1T_2: Rice straw + 5% Cow dung, E_1T_3: Rice straw + 10%Cow dung, E_1T_4: Rice straw +15% Cow dung, E_1T_5: Rice straw + 20% Cow dung.

4.1.12 Effect on proximate composition

4.1.12.1 Effect on moisture

The moisture content of the fruiting body shows significant differences. The moisture percent ranged from 90.64 to 90.15. The highest moisture percent was observed in treatment E_1T_5 (90.60) followed by E_1T_4 (90.51). The other treatments were statistically similar but the lowest moisture was in E_1T_1 (90.01)

(Table 3 and Appendix V). The results of the present study keep in with the findings of previous workers (Rahman, 1994; Moni, 2004; Alam *et al.*, 2007 and Bhuyan, 2008). Rahman (1994) observed more or less 90% moisture in the mushroom *Pleurotus ostreatus*. Moni *et al.* (2004) found 88.15 to 91.64% moisture. Alam *et al.* (2007) reported 87 to 87.5 % moisture in oyster mushroom grown on different substrates. Bhuyan (2008) found no significant differences in moisture content among the mushrooms produced in sawdust supplemented with cow dung.

4.1.12.2 Effect on dry matter

The dry matter percentage of the fruiting body shows significant differences. The dry matter percent of fruiting body ranged from 9.36 to 9.85. The highest dry matter percentage was observed in treatment E_1T_1 (9.85) which was followed by E_1T_3 (9.76) and E_1T_2 (9.63). The other treatments were statistically similar but the lowest dry matter percentage was in E_1T_5 (9.36) (Table 3 and Appendix V). The result of the present study matches with the findings of previous researcher Kulsum *et al.* (2009) who found that the dry matter percentage of the fruiting body was ranged from 9.40 to 9.98 due to sawdust supplemented with different levels of cow dung.

4.1.12.3 Effect on protein

All the treatments contain a considerable amount of protein. The content of protein varied from 18.43 to 30.90 % (w/w) in the mushroom grown on rice straw with different levels of cow dung. The highest content of protein was found in treatment E_1T_3 (30.90 %) which was followed by E_1T_4 (27.53) and the lowest protein was found in E_1T_1 (18.43 %). The other treatments statistically similar but varied significantly over control in respect to protein content (Table 3 and Appendix V). The result of the present study corroborates with the study of Chang *et al.* (1981) who reported that the fruit bodies of oyster mushrooms contained 26.6-34.1% protein. Zhang-Ruihong *et al.* (1998) found that the protein content of oyster mushroom was 27.2% on an average. Kulsum *et al.*

(2009) found that the highest content of protein was 31.30 % due to sawdust supplemented with cow dung @ 10%.

4.1.12.4 Effect on lipid

The lowest lipid percentage was recorded under treatment E_1T_3 (3.34) followed by E_1T_2 (3.70) and the highest lipid percentage was recorded under E_1T_1 (5.13). The rest of the treatments were statistically similar (Table 3 and Appendix V). The result of the present study keep in with the findings of Alam *et al.* (2007) who reported 4.30 to 4.41% lipids in oyster mushroom grown on different substrates. Kulsum *et al.* (2009) also found that lipid content was ranged from 3.44 to 5.43% due to sawdust supplemented with different levels of cow dung which is more or less similar to the present study.

4.1.12.5 Effect on ash

The result of the present study showed that the ash content of the mushroom was the highest at 5% cow dung but decreased as the supplements added with the substrates. The highest percentage of ash was observed in the treatment E_1T_2 (8.40) and the lowest percentage of ash was in the treatment E_1T_1 (6.33) (Table 3 and Appendix V). The findings of the present study are supported by the study of Kulsum *et al.* (2009) who found that ash content was ranged from 6.58 to 8.41% due to sawdust supplemented with different levels of cow dung. Khlood-Ananbeh *et al.* (2005) reported that ash contents were moderate in the fruiting bodies. Alam *et al.* (2007) reported 8.28 to 9.02% ash in *Pleurotus spp.*

4.1.12.6 Effect on carbohydrate

The lowest percentage of carbohydrate was recorded under treatment E_1T_3 (33.50) and the highest carbohydrate percentage was recorded under E_1T_1 (49.58). The rest of the treatments were statistically similar but differed over control in respect to percent carbohydrate content (Table 3 and Appendix V). The findings of the present study match with the study of Kulsum *et al.* (2009) who found that carbohydrate content was ranged from 32.85 to 56.38 % due to

sawdust supplemented with different levels of cow dung. Chang *et al.* (1981) reported that the fruit bodies of mushrooms contained 40.30-50.7% carbohydrates. Alam *et al.* (2007) found 39.82 to 42.83% carbohydrates in *Pleurotus spp.*

4.1.12.7 Effect on crude fiber

The highest percentage of crude fiber was recorded under treatment E_1T_3 (24.03) followed by E_1T_2 (23.27) and the lowest crude fiber percentage was recorded under E_1T_1 (20.53). The rest of the treatments were statistically similar but varied over control in respect to percent crude fiber content (Table 3 and Appendix V). The findings of the present study corroborate with the study of Kulsum *et al.* (2009) who found that crude fiber content was ranged from 20.31 to 24.01% due to sawdust supplemented with different levels of cow dung. Alam *et al.* (2007) reported 0.87g/100g to 23.29g/100g fiber in *Pleurotus spp.*

Cow dung supplements with rice straw had an effect (Fig. 1) on the approximate composition of oyster mushroom which was shown in the following figure.

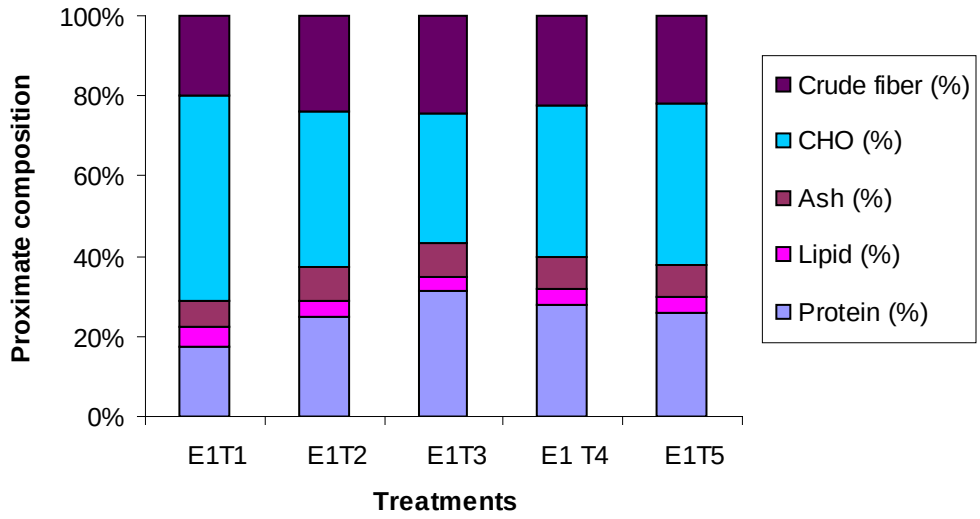

Fig.1: Effect of cow dung supplements with rice straw on the proximate composition of oyster mushroom (Dry weight basis)

Table 3. Effect of different levels of cow dung with rice straw on chemical composition of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Moisture (%)	Dry matter (%)	Protein (%)	Lipid (%)	Ash (%)	CHO (%)	Crude fiber (%)
E_1T_1	90.15 c	9.85 a	18.43 d	5.13 a	6.33 d	49.58 a	20.53 e
E_1T_2	90.37 bc	9.63 ab	24.61 c	3.70 d	8.40 a	40.02 b	23.27 b
E_1T_3	90.24 c	9.76 a	30.90 a	3.34 e	8.23 ab	33.50 c	24.03 a
E_1T_4	90.51 ab	9.49 bc	27.53 b	4.23 b	8.07 bc	37.80 b	22.37 c
E_1T_5	90.64 ab	9.36 c	25.65 c	4.01 c	7.95 c	40.56 b	21.83 d
LSD (0.05)	0.253	0.253	1.145	0.206	0.245	3.654	0.179
CV (%)	0.15	1.41	2.51	2.65	1.69	4.81	0.42

In a column the figures having a common letter(s) do not differ significantly.

Note: E_1T_1: Rice straw (Controlled), E_1T_2: Rice straw + 5% Cow dung, E_1T_3: Rice straw + 10%Cow dung, E_1T_4: Rice straw +15% Cow dung, E_1T_5: Rice straw + 20% Cow dung.

4.1.13 Effect on mineral content

4.1.13.1 Effect on nitrogen

The result of the present study showed that nitrogen content of the mushroom was the highest at 10% cow dung but decreased as the supplements added with the substrates. The highest percentage of nitrogen was measured under treatment E_1T_3 (4.944) followed by E_1T_4 (4.404) and the lowest nitrogen percentage was measured under E_1T_1 (2.948) (Table 4 and Appendix VI). The findings of the present study matches with the study of Moni *et al.* (2004) who analyzed for various nutritional parameters and found 4.22 to 5.59 % nitrogen on dry matter basis in fruiting bodies of oyster mushroom. Kulsum *et al.* (2009) found that nitrogen content was ranged from 1.81 to 5.01% due to sawdust supplemented with different levels of cow dung.

4.1.13.2 Effect on phosphorus

The highest percentage of phosphorus was measured under treatment E_1T_1 (0.926) and the lowest phosphorus percentage was measured under E_1T_3 (0.82). The rest of the treatments differed statistically in respect to percent phosphorus content (Table 4 and Appendix VI). The findings of the present study match with the study of Sarker *et al.* (2007) who found 0.97% phosphorus in oyster mushroom grown on sawdust based substrates. Kulsum *et al.* (2009) also found that phosphorus content was ranged from 0.84 to 0.92 % due to sawdust supplemented with different levels of cow dung.

4.1.13.3 Effect on potassium

The highest percentage of potassium was measured under treatment E_1T_2 (1.353) and the lowest potassium percentage was measured under E_1T_1 (1.137). The rest of the treatments were statistically different and varied significantly in respect to percent potassium content (Table 4 and Appendix VI). The findings of the

present study confirms by the study of Chang *et al.* (1981) who reported that the fruiting bodies of *Pleurotus* contained 1.432 to 1.88 mg/g of K on dry weigh of fruiting bodies. Sarker *et al.* (2007) also found 1.3% potassium in oyster mushroom grown on sawdust based substrates.

4.1.13.4 Effect on calcium

The highest amount of calcium was measured under treatment E_1T_3 (23.50 mg/100g) and the lowest amount was measured under E_1T_1 (21.47) mg/100g. The rest of the treatments were statistically similar but differed significantly over control in respect to calcium content (Table 4 and Appendix VI). The findings of the present study matches with the study of Alam *et al.* (2007) who found 22.15 to 33.7 mg/100 g of calcium in different oyster mushroom varieties. Sarker *et al.* (2007) found 2400ppm calcium in oyster mushroom grown on sawdust based substrates.

4.1.13.5 Effect on magnesium

The highest amount of magnesium was measured under treatment E_1T_3 (18.70 mg/100g) and the lowest amount was measured under E_1T_1 (13.60 mg/100g). The rest of the treatments were statistically similar but differed significantly over control in respect to magnesium content (Table 4 and Appendix VI). The findings of the present study corroborates with the study of Alam *et al.* (2007) who found 13.4 to 20.22 mg/100g of magnesium in different oyster mushroom varieties.

4.1.13.6 Effect on iron

The highest amount of iron was measured under treatment E_1T_3 (44.20 mg/100g) and the lowest amount was measured under E_1T_1 (40.33 mg/100g). The rest of the treatments were statistically different over control in respect to iron content (Table 4 and Appendix VI). The findings of the present study matches with the findings of Alam *et al.* (2007) who found 33.45 to 43.2 mg/100g iron in different oyster mushroom varieties. Sarker *et al.* (2007) found

92.09 ppm to 118.40 ppm iron in oyster mushroom grown on sawdust based substrates.

4.1.13.7 Effect on zinc (mg)

The highest amount (mg) of zinc was recorded under treatment E_1T_3 (16.53) and the lowest amount was recorded under E_1T_1 (13.57). The rest of the treatments were statistically similar in respect to zinc content (Table 4 and Appendix VI). The result of the present study matches with the study of Alam *et al.* (2007) who found 16 to 20.9 mg/100g zinc in different oyster mushroom varieties. Sarker *et al.* (2007) found 30.92ppm zinc in oyster mushroom grown on sawdust based substrates.

Table 4. Effect of different levels of cow dung with rice straw on mineral contents of oyster mushroom (*Pleurotus ostreatus*)

Treatments	N (%)	P (%)	K (%)	Ca (mg/ 100g)	Mg (mg/ 100g)	Fe (mg/ 100g)	Zn (mg/ 100g)
E_1T_1	2.948 e	0.926 a	1.137 e	21.47 e	13.60 e	40.33 c	13.57 e
E_1T_2	3.937 d	0.883 b	1.353 a	22.73 b	15.67 d	43.50 ab	14.87 d
E_1T_3	4.944 a	0.82 d	1.310 b	23.50 a	18.70 a	44.20 a	16.53 a
E_1T_4	4.404 b	0.853 c	1.240 c	22.30 d	17.50 b	43.50 ab	15.77 b
E_1T_5	4.104 c	0.866 bc	1.160 d	22.50 c	16.70 c	42.87 b	15.23 c
LSD (0.05)	0.0188	0.0266	0.0188	0.1975	0.2147	0.9693	0.2663
CV (%)	1.25	1.03	1.01	0.27	0.67	0.23	0.51

In a column the figures having a common letter(s) do not differ significantly.

Note: E_1T_1: Rice straw (Controlled), E_1T_2: Rice straw + 5% Cow dung, E_1T_3: Rice straw + 10%Cow dung, E_1T_4: Rice straw +15% Cow dung, E_1T_5: Rice straw + 20% Cow dung.

Correlation study:

A highly significant correlation between average number of fruiting body and biological yield was observed when rice straw was supplemented with different levels of cow dung (Fig. 2). The relationship showed a quadratic equation as $y = -1.0565x^2 + 100.13x - 2151.5$ ($R^2 = 0.8155^{**}$). Where y = biological yield and x = average number of fruiting body. The majority of total variation in biological yield of the oyster mushroom can be explained by this equation. The R^2 value indicated that 81.55% of biological yield of oyster mushroom (*Pleurotus ostreatus*) was attributed to the average number of fruiting body.

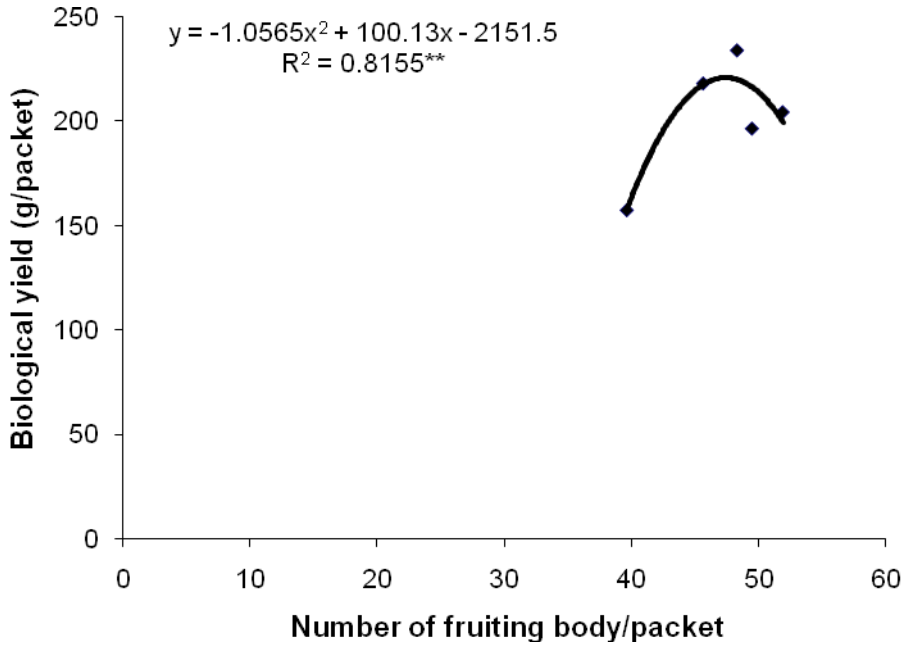

Fig. 2: Relationship between average number of fruiting body with biological yield as influenced by different levels of cow dung as supplement with rice straw

A significant and positive correlation between average weight of individual fruiting body and economic yield was observed when rice straw was supplemented with different levels of cow dung (Fig. 3). The relationship between average weight of individual fruiting body and economic yield could be expressed by the equation y = 49.53x – 10.38 (R^2 = 0.659*) where y = biological yield and x = average weight of individual fruiting body. The R^2 value indicated that 65.90% of economic yield of oyster mushroom (*Pleurotus ostreatus*) was attributed to the average weight of individual fruiting body.

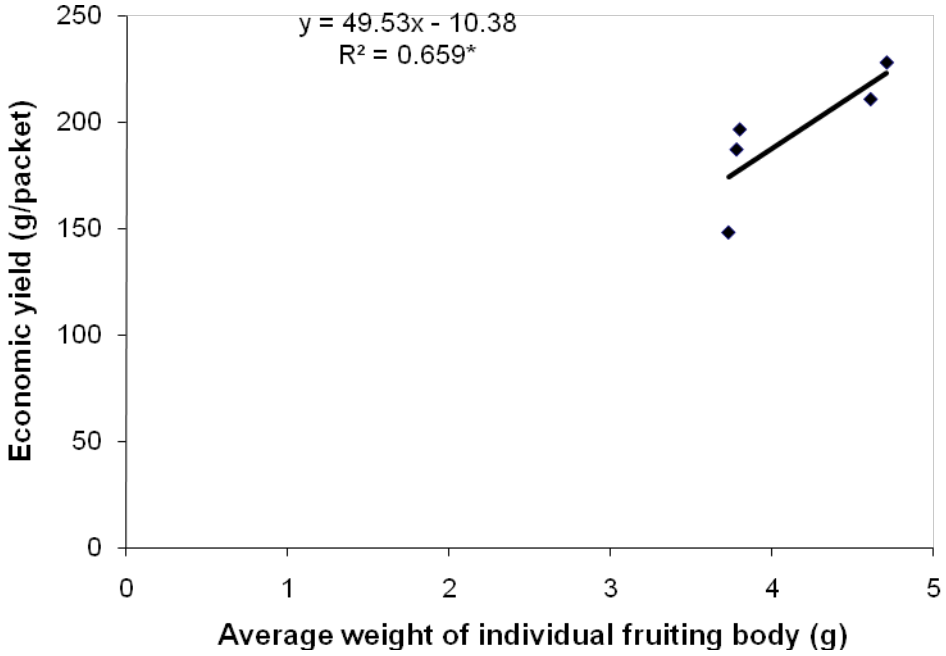

Fig. 3: Relationship between average weight of individual fruiting body and economic yield as influenced by different levels of cow dung as supplement with rice straw

Experiment 2: Effect of chemical fertilizer supplements with rice straw on the yield and proximate composition of oyster mushroom (*Pleurotus ostreatus*)

4.2.1 Effect on mycelium running rate (Days)

Mycelium running rate per day (MRR) for each type of substrates was measured after the mycelium colony crossed the shoulder of the packet. Mycelium running rate in spawn packet was found to be different due to different levels of supplement used. The highest running rate was observed in E_2T_4 (0.73 cm) and the lowest running rate of mycelium (0.53 cm) was observed in E_2T_1 (Table 5 and Appendix VII).The present findings corroborated with the findings of previous workers (Khan *et al.*, 1991; Kalita *et al.*, 2001 and Namdev *et al.*, 2006). 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. Kalita *et al.* (2001) reported that time taken for completion of spawn running may required from 17 days to 22 days by use of different substrates. Namdev *et al.* (2006) conducted a study to determine the effect of different straw substrates on spawn growth and he observed that the number of days required for spawn run was significantly less (14 days) in the case of gram straw, pantheism straw, sugarcane straw and wheat straw compared with 20 days for sunflower stalk, mustard straw and paddy straw.

4.2.2 Effect on time from stimulation to primordial initiation (Days)

The lowest time from stimulation to primordial initiation was observed in the treatment E_2T_4 (6.10 days) followed by E_2T_5 (6.30 days) and the highest time from stimulation to primordial initiation was observed in the treatment E_2T_1 (8.37 days). The other treatments were statistically similar (Table 5 and Appendix VII). The results of the present findings keep in with the findings of previous scientists (Gupta, 1989; Khan *et al.*, 2001; Royse, 2002; Sarker, 2004 and Amin *et al.* 2007). Gupta (1989) found that the fruiting bodies appeared 12-

15 days after the bags were removed. Khan *et al.* (2001) reported that after spawn running pinhead formation took 7-8 days and fruiting body formed after 3-5 days, sporocarps may be harvested after 10-12 days. Royse (2002) found, as the spawn rate increased the number of days to production decreased. In the present study, the time required for total harvest also decreased with the levels of supplements increased compared to sawdust alone. Amin *et al.* (2007) found significant differences among the level of supplements used for preparing the substrates.

4.2.3 Effect on time from primordial initiation to harvest (days)

The lowest time from primordial initiation to harvest was in the treatment E_2T_3 (3.17 days) and the highest time from primordial initiation to harvest was observed in the treatment E_2T_1 (4.43 days) (Table 5 and Appendix VII). Gupta (1989) found that the first crop harvest was required 2-3 days after primordial initiation. Dhoke *et al.* (2001) found that the days required for first picking varied from 11.25-12.00 and the final picking complete from 42.25 to 43.50 days depending on different substrates. Sarker (2004) observed that duration from primordial initiation to first harvest of oyster mushroom was significantly lower as compared to control where no supplement was used and the duration required for total harvest of oyster mushroom increased with the level of supplement used.

4.2.4 Effect on average number of primordia/packet

The lowest average number of primordia/packet was in the treatment E_2T_1 (54.67) and the highest average number of primordia /packet was observed in the treatment E_2T_4 (73.67) (Table 5 and Appendix VII). The result of the present study corroborates with the study of previous researchers (Amin, 2004; Sarker, 2004 and Dey, 2006). Amin (2004) in his experiment revealed that the highest number of primordia of oyster mushroom was found in sterilized paddy straw at first flush whereas the lowest was obtained with saw dust. Sarker (2004) found that the number of primordia increased with the levels of supplement and

continued up to a certain range and decline thereafter. Dey (2006) found that the number of primordia and the average yield of oyster mushroom significantly varied with the substrates used.

4.2.5 Effect on average number of fruiting body/packet

The highest average number of fruiting body/packet was observed in the treatment E_2T_3 (58.02) and the lowest average number of fruiting body/packet was in the treatment E_2T_1 (41.67) (Table 5 and Appendix VII).The result of the present study corroborates with the study of previous researchers (Yoshida *et al.*, 1993 and Veena-Savalgi *et al.,* 1998).Yoshida *et al.* (1993) reported that the number of fruiting bodies was lower, but increased when the substrates was mixed with different supplements. Veena-Savalgi *et al.* (1998) found that the feasibility of growing *Pleurotus* on dried aerial parts of *Cassia hirsuta* (collected in India) in combination with different levels of bagasse gave the highest fruiting bodies as well as the highest bio-efficiency

4.2.6 Effect on average weight of individual fruiting body (g)

The highest average weight of individual fruiting body was observed in the treatment E_2T_4 (4.56) which was followed by treatment E_2T_5 (4.43) and the lowest average weight of individual fruiting body was in the treatment E_2T_1 (3.17).The other treatments differed significantly in terms of average weight of individual fruiting body (Table 5 and Appendix VII). Sarker *et al.* (2007) reported the individual weight of fruiting body ranged from 1.33-1.59 g but in the present study, the weight of individual fruiting body ranged from 3.17 to 4.56 g. This might be due to different levels of supplements used or due to environmental condition.

Table 5. Effect of different levels of chemical fertilizer with rice straw on mycelium growth and yield contributing characters of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Mycelium running rate in spawn packets (cm)	Time from stimulation to primordial initiation (days)	Time from primordial initiation to harvest (days)	Average number of primordia /packet	Average number of fruiting body /packet	Average weight of individual fruiting body (g)
E_2T_1	0.53e	8.37a	4.43a	54.67e	41.67d	3.17c
E_2T_2	0.65c	7.73b	3.93ab	67.67c	52.67b	3.76b
E_2T_3	0.68b	6.90c	3.17c	70.01b	58.02a	3.80b
E_2T_4	0.73a	6.10d	3.63bc	73.67a	53.33b	4.56a
E_2T_5	0.59d	6.30 d	3.97ab	61.03d	47.33c	4.43a
LSD (0.05)	0.012	0.472	0.545	3.206	2.048	0.326
CV (%)	2.72	3.44	7.60	3.48	3.16	2.96

In a column the figures having a common letter(s) do not differ significantly.

Note: E_2T_1: Rice straw (Controlled), E_2T_2: Rice straw + chemical fertilizer (N=0.3%, P_2O_5=0.3%, K_2O=0.3%), E_2T_3: Rice straw + chemical fertilizer (N=0.4%, P_2O_5=0.3%, K_2O=0.3%), E_2T_4: Rice straw + chemical fertilizer (N=0.5%, P_2O_5=0.3%, K_2O=0.3%), E_2T_5: Rice straw + Mixed chemical fertilizer (N=0.6%, P_2O_5=0.3%, K_2O=0.3%).

4.2.7 Effect on biological yield (g)

The highest biological yield was recorded under treatment E_2T_4 (247.92 g) and the lowest biological yield was recorded under E_2T_1 (161.31 g). The rest of the treatments differed significantly in compared to control (Table and Appendix VIII).The result of the present study corroborates with the study of previous researchers (Chowdhury *et al.*, 1998; Amin *et al.*, 2007 and Dhoke *et al.*, 2001). Amin *et al.* (2004) found the highest biological yield 247.3 g/packet. Chowdhury *et al.* (1998) examined the effects of adding different supplements to substrates

for growing oyster mushrooms (*Pleurotus sajor-caju*) and found adding 5% supplements gave the highest yield of oyster mushroom. Dhoke *et al.* (2001) found significant effect of different agro-wastes on yield of oyster mushroom.

4.2.8 Effect on economic yield (g)

The highest economic yield was recorded under treatment E_2T_4 (241.65 g) and the lowest economic yield was recorded under E_2T_1 (152.48 g). The economic yield of the rest of the treatments differed statistically compared to control (Table 6 and Appendix VIII).The result of the present study corroborates with the study of previous researchers (Baysal *et al.,* 2003 and Amin *et al.,* 2007). Amin *et al.* (2007) found that the trend of economic yield corresponded with different supplements at different level. Baysal *et al.* (2003) found the highest yield of oyster mushroom (*Pleurotus ostreatus*) with the substrate composed of 20% rice husk in weight. Appreciable variations in economic yield also observed at different levels of supplements under different substrate-supplement combinations.

4.2.9 Effect on dry yield

The maximum dry yield of mushroom was recorded under the treatment E_2T_4 (26.93 g). The lowest dry yield was recorded under E_2T_1 (18.12 g). The other treatments differed statistically compared to control (Table 6 and Appendix VIII). The result of the present study corroborates with the study of previous researcher Sarker *et al*. (2007) who found the range of dry yield ranged from 4.28 to 29.98 g/packet of *Pleurotus ostreatus* grown on different substrate. Kulsum *et al.* (2009) found that the highest dry yield was 21.27 g due to sawdust supplemented with cow dung @ 10%.

4.2.10 Effect on biological efficiency

The highest biological efficiency 156.32% was observed in the treatment E_2T_4 and the lowest biological efficiency 103.07% was observed from E_2T_1. The rest of the treatments varied significantly over control (Table 6 and Appendix VIII).The present findings keep in with the findings of previous workers (Biswas

et al., 1997; Kalita *et al.*, 1997; Obodai *et al.*, 2003). Biswas *et al.* (1997) found supplementation of substrate promoted biological efficiency (125.75%). Kalita *et al.* (1997) observed biological efficiency for different substrates ranged from 35.2 to 60.9 %. Obodai *et al.* (2003) found biological efficiency (BE) followed a pattern and ranged from 61.0% to 80.0%.

4.2.11 Effect on benefit cost ratio

The highest benefit cost ratio 6.02 was calculated in treatment E_2T_4 which was followed by E_2T_3 (5.53) and the lowest benefit cost ratio 3.91 was calculated from E_2T_1. The rest of the treatments varied significantly over control (Table 6 and Appendix VIII). The present findings keep in with the findings of previous workers (Lim *et al.*, 1997; Sarker *et al.*, 2007). Sarker *et al.* (2007) mentioned the performances of substrates were significantly differed based on benefit cost ratio. They reported the highest cost benefit ratio 6.51 with wheat straw which was more or less similar to the present study. Lim *et al.* (1997) analyzed the cost and return of *Volvariella* and *Pleurotus* mushroom production and found the ROI 8.9 and 5.1 respectively.

Table 6. Effect of different levels of chemical fertilizer with rice straw on the yield, biological efficiency and benefit cost ratio of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Biological yield (gm)	Economic yield (gm)	Dry yield (gm)	Biological efficiency (%)	Benefit cost ratio
E_2T_1	161.31e	152.48e	18.12e	103.07e	3.91e
E_2T_2	204.90d	196.39d	22.91d	129.54d	5.01d
E_2T_3	227.51b	220.78b	24.97b	143.64 b	5.53b
E_2T_4	247.92a	241.65a	26.93a	156.32 a	6.02a
E_2T_5	215.19c	208.92c	23.74c	135.51c	5.23c
LSD (0.05)	6.520	5.566	0.911	2.458	0.223
CV (%)	1.70	1.48	2.47	1.70	1.70

In a column the figures having a common letter(s) do not differ significantly.

Note: E_2T_1: Rice straw (Controlled), E_2T_2: Rice straw + chemical fertilizer (N=0.3%, P_2O_5=0.3%, K_2O=0.3%), E_2T_3: Rice straw + chemical fertilizer (N=0.4%, P_2O_5=0.3%, K_2O=0.3%), E_2T_4: Rice straw + chemical fertilizer (N=0.5%, P_2O_5=0.3%, K_2O=0.3%), E_2T_5: Rice straw + Mixed chemical fertilizer (N=0.6%, P_2O_5=0.3%, K_2O=0.3%).

4.2.12 Effect on proximate composition

4.2.12.1 Effect on moisture

The moisture content of the fruiting body shows no significantly difference. The moisture percent ranged from 90.08 to 90.44. The highest moisture percent was observed in treatment E_2T_5 (90.44) and the lowest was in E_2T_4 (90.08) (Table 7 and Appendix IX). The result of the present study corroborates with the study of previous researchers (Moni *et al*., 2004; Alam *et al.*, 2007 and Rahman, 1994). Moni *et al*. (2004) cultivated the oyster mushroom (*Pleurotus sajor-caju*) on paddy straw, banana leaves, sugarcane baggase, water hyacinth, beetle nut husk and he found moisture content varied from 88.15 to 91.64%. Alam *et al.* (2007) reported that 87 to 87.5% moisture present in oyster mushroom. Rahman (1994) observed more or less 90% moisture in the mushroom *Pleurotus ostreatus*.

4.2.12.2 Effect on dry matter

The dry matter percentage of the fruiting body shows no significant difference. The dry matter percent of fruiting body ranged from 9.56 to 9.92. The highest moisture percent was observed in treatment E_2T_4 (9.92) and the lowest was in E_2T_5 (9.56) (Table 7 and Appendix IX). The result of the present study matches with the findings of previous researcher Kulsum *et al.* (2009) who found that the dry matter percentage of the fruiting body was ranged from 9.40 to 9.98 due to sawdust supplemented with different levels of cow dung.

4.2.12.3 Effect on protein

Protein is the most important constituent of food material. All the treatments contain a great amount of protein. The content of protein varied from 18.98-31.17 % (w/w) in the mushroom grown on rice straw supplemented with different levels of chemical fertilizer. The highest content of protein was found

in treatment E_2T_5 (31.17) and the lowest protein was found in E_2T_1 (18.98). The other treatments varied significantly over control in respect to protein content (Table 7 and Appendix IX). The results of the present study keep in with the findings of previous workers (Chang *et al.*, 1981; Moni *et al*., 2004 and Zhang-Ruihong *et al.*, 1998). Chang *et al.* (1981) reported that the fruit bodies of mushrooms contained 26.6-34.1% crude protein. Moni *et al*. (2004) cultivated the oyster mushroom (*Pleurotus sajor-caju*) on paddy straw, banana leaves, sugarcane baggase, water hyacinth, beetle nut husk and he found that the percentage of crude protein varied from 18.46 to 27.78% respectively. Zhang-Ruihong *et al.* (1998.) found the protein content of mushroom was 27.2% on an average.

4.2.12.4 Effect on lipid

The highest lipid percentage was found under treatment E_2T_1 (5.33). The rest of the treatments were statistically similar but the lowest lipid percentage was found under E_2T_3 (3.70) (Table 7 and Appendix IX). The result of the present study keep in with the findings of Alam *et al.* (2007) who reported 4.30 to 4.41% lipids in oyster mushroom grown on different substrates. Kulsum *et al.* (2009) also found that lipid content was ranged from 3.44 to 5.43% due to sawdust supplemented with different levels of cow dung which is more or less similar to the present study.

4.2.12.5 Effect on ash

The highest percentage of ash was observed in the treatment E_2T_2 (8.24) followed by E_2T_4 (7.79) and the lowest percentage of ash was in the treatment E_2T_1 (6.23). The other treatments were statistically similar but differed significantly in terms of percentage ash content (Table 7 and Appendix IX). The findings of the present study are supported by the study of Kulsum *et al.* (2009) who found that ash content was ranged from 6.58 to 8.41% due to sawdust supplemented with different levels of cow dung. Khlood-Ananbeh *et al.* (2005)

reported that ash contents were moderate in the fruiting bodies. Alam *et al.* (2007) reported 8.28 to 9.02% ash in *Pleurotus spp.*

4.2.12.6 Effect on carbohydrate

The highest percentage of carbohydrate was found under treatment E_2T_1 (48.83) and the lowest carbohydrate percentage was found under E_2T_4 (35.36). The rest of the treatments were statistically different over control in respect to percent carbohydrate content (Table 7 and Appendix IX). The findings of the present study are supported by the study of Kulsum *et al.* (2009) who found that carbohydrate content was ranged from 32.85 to 56.38 % due to sawdust supplemented with different levels of cow dung. Chang *et al.* (1981) reported that the fruit bodies of mushrooms contained 40.30-50.7% carbohydrates.

4.2.12.7 Effect on crude fiber

There were no statistical differences among the treatments in respect to percent crude fiber content (Table 7 and Appendix IX). The highest percentage of crude fiber was found under treatment E_2T_4 (22.58) and the lowest crude fiber percentage was found under E_2T_1 (20.63) followed by T_1 (20.37).

From the graph (Fig. 4) it was observed that percentage of CHO was decreased along with the increasing of the level of chemical fertilizer. On the other hand percentage of protein was increased along with the increasing of the level of chemical fertilizer. The crude fiber, ash and lipid percentage were remain more or less unchanged.

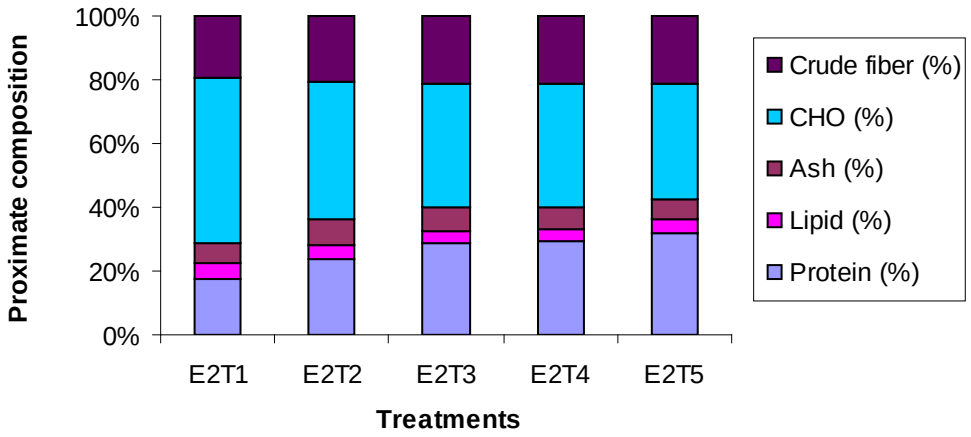

Fig.4: Effect of chemical fertilizer supplements with rice straw on the proximate composition of oyster mushroom (Dry weight basis)

Table 7. Effect of different levels of chemical fertilizer with rice straw on chemical composition of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Moisture (%)	Dry matter (%)	Protein (%)	Lipid (%)	Ash (%)	CHO (%)	Crude fiber (%)
E_2T_1	90.18c	9.82b	18.98e	5.33a	6.23d	48.83a	20.63
E_2T_2	90.27b	9.73c	25.57cd	4.87b	8.24a	39.62b	21.70
E_2T_3	90.39a	9.61d	27.23c	3.70d	7.60b	40.17b	21.30
E_2T_4	90.08d	9.92a	30.37ab	3.90cd	7.79ab	35.36c	22.58
E_2T_5	90.44a	9.56d	31.17a	4.20c	6.88c	35.88c	21.87
LSD (0.05)	0.084	0.084	2.767	0.449	0.442	4.665	0.966
CV (%)	0.05	0.51	9.11	5.45	3.20	5.67	6.24

In a column the figures having a common letter(s) do not differ significantly.

Note: E_2T_1: Rice straw (Controlled), E_2T_2: Rice straw + chemical fertilizer (N=0.3%, P_2O_5=0.3%, K_2O=0.3%), E_2T_3: Rice straw + chemical fertilizer (N=0.4%, P_2O_5=0.3%, K_2O=0.3%), E_2T_4: Rice straw + chemical fertilizer (N=0.5%, P_2O_5=0.3%, K_2O=0.3%), E_2T_5: Rice straw + Mixed chemical fertilizer (N=0.6%, P_2O_5=0.3%, K_2O=0.3%).

4.2.13 Effect on mineral content

4.2.13.1 Effect on nitrogen

The highest percentage of nitrogen was recorded under treatment E_2T_5 (4.987) followed by E_2T_4 (4.859) and the lowest nitrogen percentage was counted under E_2T_1 (2.948). The rest of the treatments were statistically similar but varied significantly over control in terms of percent nitrogen content (Table 8 and Appendix X). The result of the present study matches with the study of Moni *et al.* (2004) who analyzed for various nutritional parameters and found 4.22 to 5.59 % nitrogen on dry matter basis in fruiting bodies of oyster mushroom.

4.2.13.2 Effect on phosphorus

The highest percentage of phosphorus was measured under treatment E_2T_5 (1.07) and the lowest phosphorus percentage was measured under E_2T_1 (0.91). The rest of the treatments differed statistically in respect to percent phosphorus content (Table 8 and Appendix X). The findings of the present study do not match with the study of Sarker *et al.* (2007) who found 0.97% phosphorus in oyster mushroom grown on sawdust based substrates. Kulsum *et al.* (2009) also found that phosphorus content was ranged from 0.84 to 0.92 % due to sawdust supplemented with different levels of cow dung. Phosphorus content variation in this study may be due to different levels of chemical fertilizer used.

4.2.13.3 Effect on potassium

The highest percentage of potassium was measured under treatment E_2T_3 (1.53) and the lowest potassium percentage was measured under E_2T_1 (1.09). The rest of the treatments were statistically different and varied significantly in respect to percent potassium content (Table 8 and Appendix X). The findings of the present study confirm by the study of Chang *et al.* (1981) who reported that the fruiting bodies of *Pleurotus* contained 1.432 to 1.88 mg/g of K on dry weigh of fruiting

bodies. Sarker *et al.* (2007) also found 1.3% potassium in oyster mushroom grown on sawdust based substrates

4.2.13.4 Effect on calcium

The highest amount of calcium was observed under treatment E_2T_3 (24.23 mg/100g) and the lowest amount was observed under E_2T_1 (21.80 mg/100g). The rest of the treatments were statistically similar but differed significantly over control in respect to percent calcium content (Table 8 and Appendix X). The findings of the present study match with the study of Alam *et al.* (2007) who found 22.15 to 33.7 mg/100 g calcium in different oyster mushroom varieties. Sarker *et al.* (2007) also found 2400 ppm calcium in oyster mushroom grown on sawdust based substrates.

4.2.13.5 Effect on magnesium

The highest amount of magnesium was observed under treatment E_2T_3 (15.80 mg/100g) and the lowest amount was observed under E_2T_1 (12.90 mg/100g). The rest of the treatments were statistically similar but differed significantly over control in respect to magnesium content (Table 8 and Appendix X). The result of the present study corroborates with the study of Alam *et al.* (2007) who found 13.4 to 20.22 mg/100g magnesium in different oyster mushroom varieties. Sarker *et al.* (2004) also found 0.21% magnesium in oyster mushroom grown on sawdust based substrates.

4.2.13.6 Effect on iron

The highest amount of iron was observed under treatment E_2T_3 (44.20 mg/100g) followed by E_2T_2 (43.83 mg/100g) and E_2T_5 (43.57 mg/100g) and the lowest amount was observed under E_2T_1 (40.50 mg/100g) (Table 8 and Appendix X). The result of the present study matches with the findings of Alam *et al.* (2007) who found that iron content of different oyster mushroom varieties ranged from 33.45 to 43.2 mg/100g. Kulsum *et al.* (2009) also found that iron content was

ranged from 40.5 to 43.4 mg/100g due to sawdust supplemented with different levels of cow dung.

4.2.13.7 Effect on zinc (mg)

The highest amount (mg) of zinc was observed under treatment E_2T_3 (16.17) and the lowest amount was observed under E_2T_1 (13.27). The rest of the treatments were statistically similar in respect to zinc content (Table 8 and Appendix X). The result of the present study matches with the study of Alam *et al.* (2007) who found that zinc content of different oyster mushroom varieties ranged from 16 to 20.9 mg/100g. Sarker *et al.* (2007) found 30.92ppm zinc in oyster mushroom grown on sawdust based substrates.

Table 8. Effect of different levels of chemical fertilizer with rice straw on mineral contents of oyster mushroom (*Pleurotus ostreatus*)

Treatments	N (%)	P (%)	K (%)	Ca (mg/ 100g)	Mg (mg/ 100g)	Fe (mg/ 100g)	Zn (mg/ 100g)
E_2T_1	3.037e	0.91b	1.09b	21.80d	12.90d	40.50c	13.27e
E_2T_2	4.091d	1.05a	1.45a	23.50b	14.30c	43.83a	14.80c
E_2T_3	4.357c	1.02a	1.53a	24.23a	15.80a	44.01a	16.17a
E_2T_4	4.859b	1.06a	1.42a	22.70c	15.20ab	42.90b	15.77b
E_2T_5	4.987a	1.07a	1.39a	23.10bc	14.93b	43.57a	14.23d
LSD (0.05)	0.129	0.059	0.157	0.638	0.632	0.627	0.363
CV (%)	1.05	0.83	1.08	1.24	1.37	0.42	0.61

In a column the figures having a common letter(s) do not differ significantly.

Note: E_2T_1: Rice straw (Controlled), E_2T_2: Rice straw + chemical fertilizer (N=0.3%, P_2O_5=0.3%, K_2O=0.3%), E_2T_3: Rice straw + chemical fertilizer (N=0.4%, P_2O_5=0.3%, K_2O=0.3%), E_2T_4: Rice straw + chemical fertilizer (N=0.5%, P_2O_5=0.3%, K_2O=0.3%), E_2T_5: Rice straw + Mixed chemical fertilizer (N=0.6%, P_2O_5=0.3%, K_2O=0.3%).

Correlation study:

A significant and negative correlation between average number of fruiting body and biological yield was observed when rice straw was supplemented with different levels of chemical fertilizer (Fig. 5). The relationship showed a quadratic equation as $y = -0.3863x^2 + 42.406x – 933.21$ ($R^2 = 0.7721$*), where y = biological yield and x = average number of fruiting body. The majority of total variation in biological yield of the oyster mushroom can be explained by this equation. The R^2 value indicated that 77.21% of biological yield of oyster mushroom (*Pleurotus ostreatus*) was attributed to the average number of fruiting body.

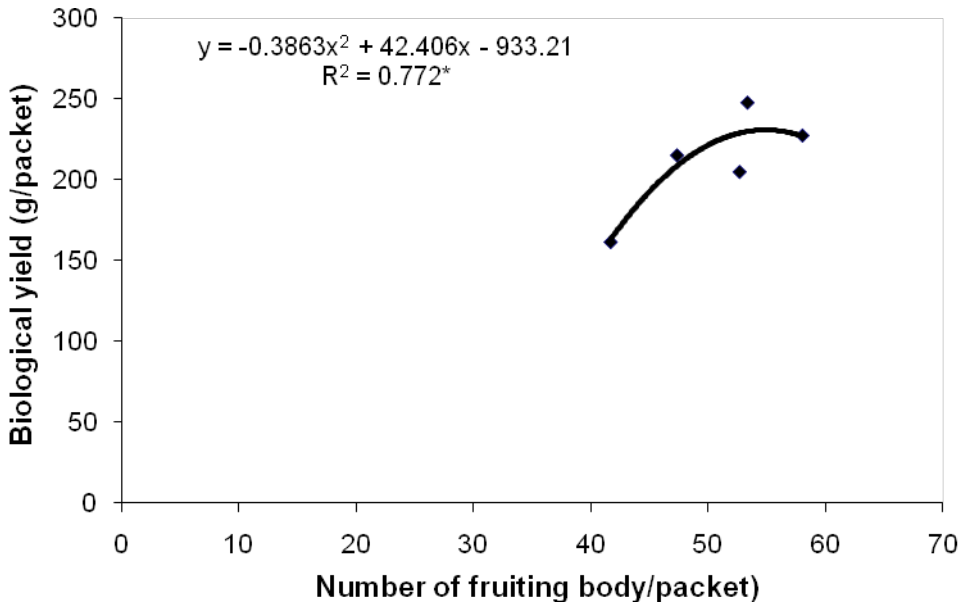

Fig. 5: Relationship between average number of fruiting body with biological yield as influenced by different levels of chemical fertilizer as supplement with rice straw

A highly significant but negative correlation between average weight of individual fruiting body and economic yield was observed when rice straw was supplemented with different levels of chemical fertilizer (Fig. 6). The relationship between average weight of individual fruiting body and economic yield showed a quadratic equation as $y = -40.156x^2 + 363.5x - 595.0$ ($R^2 = 0.819^{**}$) where y = biological yield and x = average weight of individual fruiting body. The R^2 value indicated that 81.90% of economic yield of oyster mushroom (*Pleurotus ostreatus*) was attributed to the average weight of individual fruiting body.

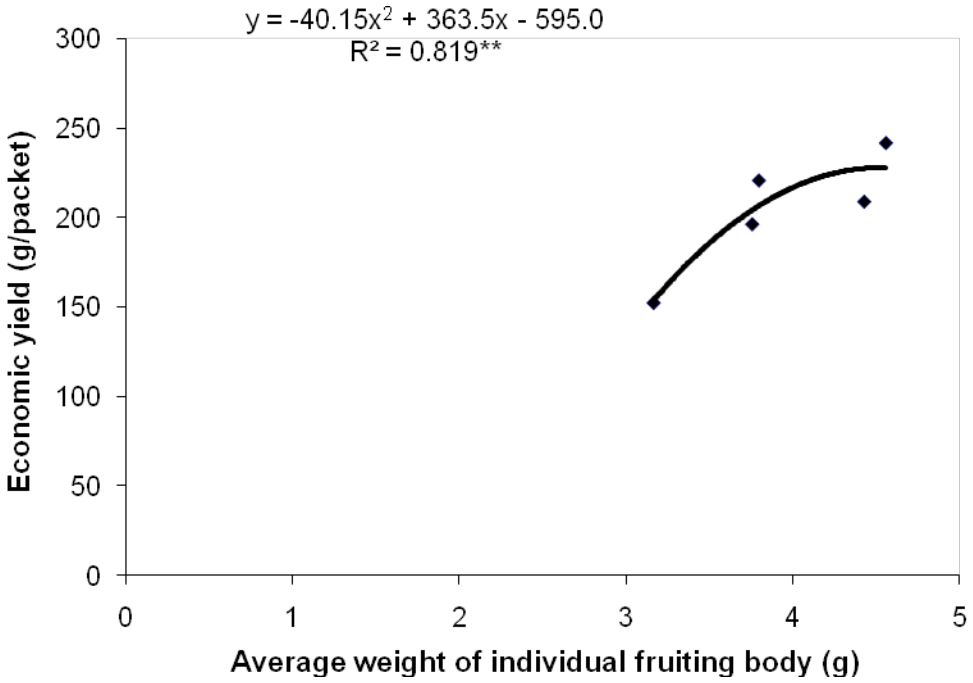

Fig. 6: Relationship between average weight of individual fruiting body and economic yield as influenced by different levels of chemical fertilizer as supplement with rice straw

Experiment 3: Effect of wheat bran supplements with rice straw on the yield and proximate composition of oyster mushroom (*Pleurotus ostreatus*).

4.3.1 Effect on mycelium running rate (cm)

Mycelium running rate per day (MRR) for each type of substrates was measured after the mycelium colony crossed the shoulder of the packet. The linear length was measured at different places of packet. Mycelium running rate in spawn packet was found to be differed due to different levels of supplements used. The highest running rate (0.70 cm) was observed in E_3T_3 and E_3T_4 and the lowest running rate of mycelium was observed in T_1 (0.72 cm). The other treatments varied significantly over control (Table 9 and Appendix XI). The present findings corroborated with the findings of previous workers (Kalita *et al.*, 2001; Sarker, 2004 and Ali, 2009). Kalita *et al.* (2001) reported that time taken for completion of spawn running may required to 17 days from 22 days by use of different substrates. Sarker (2004) found that the mycelium running rate of oyster mushroom greatly influenced with the supplement of wheat brans in different levels. Ali (2009) observed that the highest mycelium running rate was 0.96 cm due to sugarcane bagasse supplemented with wheat bran @ 40%.

4.3.2 Effect on time from stimulation to primordial initiation (Days)

The time from stimulation to primordial initiation was ranged from 6.70 days to 8.18 days. The highest time from stimulation to primordial initiation was observed in E_3T_1 (8.18 days). The other treatments varied significantly in terms of time from stimulation to primordial initiation (Table 9 and Appendix XI). But the lowest time from stimulation to primordial initiation was in the treatment E_3T_3 (6.70 days). The result of the present findings keeps in with the findings of previous scientists (Sarker, 2004, Amin *et al.*, 2007 and Ali, 2009). Sarker (2004) observed that duration from primordial initiation to first harvest of oyster mushroom was significantly lower as compared to control where no supplement was used and the duration required for total harvest of oyster mushroom increased with the level of supplement used. In the present study, the time

required for total harvest also decreased with the levels of supplements increased compared to rice straw alone. Amin *et al.* (2007) found significant differences among the level of supplements used for preparing the substrates. Ali (2009) observed that the highest time from stimulation to primordia initiation was 11.5 days due to sugarcane bagasse supplemented with wheat bran @ 10%.

4.3.3 Effect on time from primordial initiation to harvest (days)

The lowest time from primordial initiation to harvest was observed in the treatment E_3T_2 (3.96 days) and the highest time from primordial initiation to harvest was observed in the treatment E_3T_5 (5.07days). The other treatments were statistically similar (Table 9 and Appendix XI). The result of the present findings keeps in with the findings of previous scientists (Khan *et al.*, 2001; Royse, 2002 and Ali, 2009). Khan *et al.* (2001) reported that after spawn running pinhead formation took 7-8 days and fruiting body formed after 3-5 days, sporocarps may be harvested after 10-12 days. Royse (2002) found, as the spawn rate increased the number of days to production decreased. Ali (2009) observed that the lowest time from primordia initiation to harvest was 3.23 days due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.4 Effect on average number of primordia/packet

The highest average number of primordia/packet was in the treatment E_3T_3 (63.33) and the lowest average number of primordia/packet was in the treatment E_3T_1 (51.00) (Table 9 and Appendix XI). The result of the present findings keeps in with the findings of previous scientists (Ahmed, 1998; Dey, 2006 and Ali, 2009). Ahmed (1998) reported significantly different number of primordia on different substrates. Dey (2006) found that the number of primordia and the average yield significantly varied with the substrates used in production of oyster mushroom. Ali (2009) observed that the highest average number of primordia/packet was 70.67 due to sugarcane bagasse supplemented with wheat bran @ 40%.

4.3.5 Effect on average number of fruiting body

The highest average number of fruiting body/packet was observed in the treatment E_3T_4 (48.70) followed by E_3T_3 (47.33) and the lowest average number of fruiting body /packet was in the treatment E_3T_1 (38.33). The other treatments were statistically and significantly varied over control in terms of average number of primordia/packet (Table 9 and Appendix XI). The result of the present findings keeps in with the findings of previous scientists (Yoshida *et al.*, 1993; Amin, 2004; Sarker, 2004 and Ali, 2009). Yoshida *et al.* (1993) reported that the number of fruiting bodies was lower, but increased when the substrates was mixed with different supplements. Amin (2004) reported that the number of primordia grown on different substrates differed significantly. Sarker (2004) found that the number of primordia increased with the levels of supplement and continued up to a certain range and decline there after. In the present study the average number of fruiting body increased up to 30 % wheat bran used as supplement and decreased there after. Ali (2009) observed that the highest average number of fruiting body/packet was 61.00 due to sugarcane bagasse supplemented with wheat bran @ 40%.

4.3.6 Effect on average weight of individual fruiting body (g)

Supplementation of rice straw with different levels of wheat bran had great effect on average weight of individual fruiting body. The average weight of individual fruiting body in different treatment ranged from 3.36 g to 4.67 g. The highest average weight of individual fruiting body was observed in the treatment E_3T_4 (4.67 g) and the lowest average weight of individual fruiting body was in the treatment E_3T_1 (3.36 g). The other treatments varied significantly over control in terms of average weight of individual fruiting body (Table 9 and Appendix XI). The present study matches with the study of the previous scientists (Sarker, 2004; Sarker *et al*., 2007; Bhuyan, 2008 and Ali, 2009). Sarker (2004) found significant increase in weight of fruiting body in gram per sporocarps over control in spawn packet containing different supplement in compared with sawdust alone. Sarker *et al.* (2007) reported the individual

weight of fruiting body ranged from 1.33-1.59 g. Bhuyan (2008) found significant effect of supplementation on the weight of fruiting body but he found comparatively higher weight of individual fruiting body ranged from (5.02g to 7.01g), which may be due to environmental conditions or growing season. Ali (2009) observed that the highest average weight of individual fruiting body was 3.69 g due to sugarcane bagasse supplemented with wheat bran @ 30%.

Table 9. Effect of different levels of wheat bran with rice straw on mycelium growth and yield contributing characters of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Mycelium running rate in spawn packets (cm)	Time from stimulation to primordial initiation (days)	Time from primordial initiation to harvest (days)	Average number of primordia /packet	Average number of fruiting body /packet	Average weight of individual fruiting body (g)
E_3T_1	0.56d	8.18a	4.33b	51.40e	38.33d	3.36d
E_3T_2	0.60c	7.67b	3.96c	61.25c	45.00c	3.89c
E_3T_3	0.70a	6.70d	4.31b	63.33a	47.33a	4.15b
E_3T_4	0.70a	6.87d	4.52b	62.20b	48.70a	4.67a
E_3T_5	0.66b	7.14c	5.07a	58.33d	46.67b	4.02b
LSD (0.05)	0.006	0.253	0.337	3.151	3.333	0.292
CV (%)	1.30	1.82	4.04	3.27	4.91	2.96

In a column the figures having a common letter(s) do not differ significantly.

Note: E_3T_1: Rice straw (Controlled), E_3T_2: Rice straw + 10 % wheat bran, E_3T_3: Rice straw + 20 % wheat bran, E_3T_4: Rice straw + 30 % wheat bran, E_3T_5: Rice straw + 40 % wheat bran.

4.3.7 Effect on biological yield (g)

Supplementation of rice straw with wheat bran had great effect on biological yield. The highest biological yield was observed under treatment E_3T_4 (218.86 g) and the lowest biological yield was observed under E_3T_1 (154.62 g). The other treatments varied significantly as compared with control in terms of biological yield (Table 10 and Appendix XII). The present findings corroborated with the findings of previous worker Amin *et al.* (2007) who found that the highest biological yield was 247.3 g/packet. He also found that the trend of economic yield corresponded with different supplements at different level. Ali (2009) also observed that the highest biological yield was 254.7 g due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.8 Effect on economic yield (g)

Supplementation of rice straw with wheat bran increases the economic yield over control. The highest economic yield was recorded under treatment E_3T_4 (210.61 g) and the lowest economic yield was counted under E_3T_1 (145.26 g). The other treatments varied significantly over control (Table 10 and Appendix XII). In this study it was observed that the economic yield was increased up to treatment E_3T_4 with the increasing of levels of wheat bran and then decreased at the next higher level. Payapanon *et al.* (1994) mentioned that suitable amount of supplements added to rice straw medium maximized economic yield of oyster mushroom at optimum production cost. Sarker (2004) found appreciable variations in economic yield also observed at different levels of supplements under different substrate-supplement combinations. Ali (2009) observed that the highest economic yield was 243.3 g due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.9 Effect on dry yield

The dry yield of the oyster mushroom, grown on rice straw responded significantly in terms of dry yield with the different levels of supplement (wheat

bran). The dry yield of mushroom was observed maximum under the treatment E_3T_4 (23.15 g) and the lowest dry yield was observed under E_3T_1 (16.29 g). The other treatments varied significantly over control (Table 10 and Appendix XII). The result of the present study corroborates with Sarker *et al*. (2007) who found that the range of dry yield was varied from 4.28 g to 29.98 g. Ali (2009) also observed that the highest dry matter was 23.40 g due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.10 Effect on biological efficiency

The highest biological efficiency (117.85 %) was calculated in treatment E_3T_4 and the lowest biological efficiency (98.97 %) was calculated from E_3T_5 (Table 10 and Appendix XII). The other treatments varied significantly over control. The present findings keep in with the findings of previous workers (Biswas *et al.*, 1997; Kalita *et al.*, 1997; Obodai *et al.*, 2003 and Ali, 2009). Biswas *et al.* (1997) found supplementation of substrate promoted biological efficiency (125.75%). Kalita *et al.* (1997) observed biological efficiency for different substrates ranged from 35.2 to 60.9 %. Obodai *et al.* (2003) found biological efficiency (BE) followed a pattern and ranged from 61.0% to 80.0%. Ali (2009) observed that the highest biological efficiency was 87.82 % due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.11 Effect on benefit cost ratio

The highest benefit cost ratio was calculated in treatment E_3T_4 (5.14) and the lowest benefit cost ratio 3.53 was calculated from E_3T_1. The other treatments differed significantly in terms of benefit cost ratio (Table 10 and Appendix XII). The present findings keep in with the findings of previous workers (Lim *et al.*, 1997; Sarker *et al*, 2007 and Ali, 2009). Sarker *et al*. (2007) mentioned the performances of substrates were significantly differed based on benefit cost ratio. They reported the highest cost benefit ratio 6.51 with wheat straw which was more or less similar to the present study. Lim *et al.* (1997) analyzed the cost and return of *Volvariella* and *Pleurotus* mushroom production and found the

ROI 8.9 and 5.1 respectively. Ali (2009) observed that the highest cost benefit ratio was 8.29 due to sugarcane bagasse supplemented with wheat bran @ 30%.

Table 10. Effect of different levels of wheat bran with rice straw on the yield, biological efficiency and benefit cost ratio of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Biological yield (gm)	Economic yield (gm)	Dry yield (gm)	Biological efficiency (%)	Benefit cost ratio
E_3T_1	154.62d	145.26d	16.29 d	99.79d	3.53d
E_3T_2	183.73c	175.83c	19.20c	110.02c	4.27c
E_3T_3	203.41b	195.12b	21.17b	115.24ab	4.61b
E_3T_4	218.86a	210.61a	23.15a	117.85a	5.14a
E_3T_5	192.44b	185.58b	20.61b	98.97d	4.67b
LSD (0.05)	8.370	8.257	0.776	3.157	0.286
CV (%)	2.49	2.48	2.36	2.45	2.38

In a column the figures having a common letter(s) do not differ significantly.

Note: E_3T_1: Rice straw (Controlled), E_3T_2: Rice straw + 10 % wheat bran, E_3T_3: Rice straw + 20 % wheat bran, E_3T_4: Rice straw + 30 % wheat bran, E_3T_5: Rice straw + 40 % wheat bran.

4.3.12. Effect on proximate composition

4.3.12.1 Effect on moisture

The moisture content of the fruiting body shows significant difference. The moisture percent ranged from 90.15 % to 91.08 %. The highest moisture percent was observed in treatment E_3T_3 (91.08 %). The other treatment was varied significantly over control. But the lowest moisture percent was observed in E_3T_5 (90.15 %) followed by E_3T_4 (90.26 %) (Table 11 and Appendix XIII). The result of the present study corroborates with the study of previous researchers (Moni *et al*., 2004; Alam *et al.*, 2007; Rahman, 1994 and Ali, 2009). Moni *et al*. (2004)

cultivated the oyster mushroom (*Pleurotus sajor-caju*) on paddy straw, banana leaves, sugarcane baggase, water hyacinth, beetle nut husk and he found moisture content varied from 88.15 to 91.64%. Alam *et al.* (2007) reported that 87 to 87.5% moisture present in oyster mushroom. Rahman (1994) observed more or less 90% moisture in the mushroom *Pleurotus ostreatus*. Ali (2009) observed that the highest moisture content was 90.45 % due to sugarcane bagasse supplemented with wheat bran @ 40%.

4.3.12.2 Effect on dry matter

The dry matter percentage of the fruiting body showed significant difference. The dry matter percent of fruiting body ranged from 8.92 % to 9.85 %. The highest dry matter percentage was observed in treatment E_3T_5 (9.85 %) which was followed by E_3T_4 (9.74 %). The other treatment was varied significantly over control but the lowest dry matter percentage was in E_3T_3 (8.92 %) (Table 11 and Appendix XIII). The result of the present study matches with the findings of previous researcher Kulsum *et al.* (2009) who found that the dry matter percentage of the fruiting body was ranged from 9.40 to 9.98 due to sawdust supplemented with different levels of cow dung.Ali (2009) also observed that the highest dry matter percentage was 10.07 % due to sugarcane bagasse supplemented with wheat bran @ 10%.

4.3.12.3 Effect on protein

All the treatments contain a considerable amount of protein. The content of protein varied from 19.82-25.77% (w/w) in the mushroom grown on rice straw with different levels of wheat bran. The highest content of protein was found in treatment E_3T_4 (25.77 %) and the lowest protein was found in E_3T_1 (19.82 %). The other treatments varied significantly over control in respect to protein content (Table 11 and Appendix XIII). The result of the present study corroborates with the study of Chang *et al.* (1981) who reported that the fruit bodies of oyster mushrooms contained 26.6-34.1% protein. Zhang-Ruihong *et al.* (1998) found the protein content of oyster mushroom was 27.2% on an

average. Ali (2009) observed that the highest protein content was 30.31 % due to sugarcane bagasse supplemented with wheat bran @ 10%.

4.3.12.4 Effect on lipid

The lowest lipid percentage was measured under treatment E_3T_4 (3.64 %) and the highest lipid percentage was measured under E_3T_1 (5.08 %). The rest of the treatments varied significantly over control (Table 11 and Appendix XIII). The result of the present study showed that the lipid content of the mushroom decreased as the supplements added with the substrates. The result of the present study keeps in with the findings of Alam *et al.* (2007) who reported 4.30 to 4.41% lipids in oyster mushroom grown on different substrates. Kulsum *et al.* (2009) found that lipid content was ranged from 3.44 to 5.43% due to sawdust supplemented with different levels of cow dung which is more or less similar to the present study. Ali (2009) observed that the lowest lipid was 3.90 % due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.12.5 Effect on ash

The highest percentage of ash was observed in the treatment E_3T_2 (8.12) and the lowest percentage of ash was in the treatment E_3T_1 (6.38). The other treatments were statistically different and differed significantly in terms of percentage ash content (Table 11 and Appendix XIII). The findings of the present study are supported by the study of Kulsum *et al.* (2009) who found that ash content was ranged from 6.58 to 8.41% due to sawdust supplemented with different levels of cow dung. Khlood-Ananbeh *et al.* (2005) reported that ash contents were moderate in the fruiting bodies. Alam *et al.* (2007) reported 8.28 to 9.02% ash in *Pleurotus spp.* Ali (2009) observed that the highest ash was 9.15 % due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.12.6 Effect on carbohydrate

The lowest percentage of carbohydrate was counted under treatment E_3T_4 (40.44) and the highest carbohydrate percentage was counted under E_3T_1 (48.45). The rest of the treatments were statistically different and differed

significantly over control in respect to percent carbohydrate content (Table 11 and Appendix XIII). The findings of the present study are supported by the study of Kulsum *et al.* (2009) who found that carbohydrate content was ranged from 32.85 to 56.38 % due to sawdust supplemented with different levels of cow dung. Chang *et al.* (1981) reported that the fruit bodies of mushrooms contained 40.30-50.7% carbohydrates. Ali (2009) observed that the lowest carbohydrate was 32.57 % due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.12.7 Effect on crude fiber

There were no statistical differences among the treatments in respect to percent crude fiber content (Table 11 and Appendix XIII).The highest percentage of crude fiber was counted under treatment E_3T_2 (23.38) and the lowest crude fiber percentage was counted under E_3T_1 (20.27). The findings of the present study corroborate with the study of Alam *et al.* (2007) who reported 22.87g/100g to 23.29g/100g of fiber in *Pleurotus spp.* Ali (2009) also observed that the highest crude fiber was 24.07 % due to sugarcane bagasse supplemented with wheat bran @ 30%.

Wheat bran supplements with rice straw had an effect (Fig. 7) on the approximate composition of oyster mushroom which was shown in the following figure.

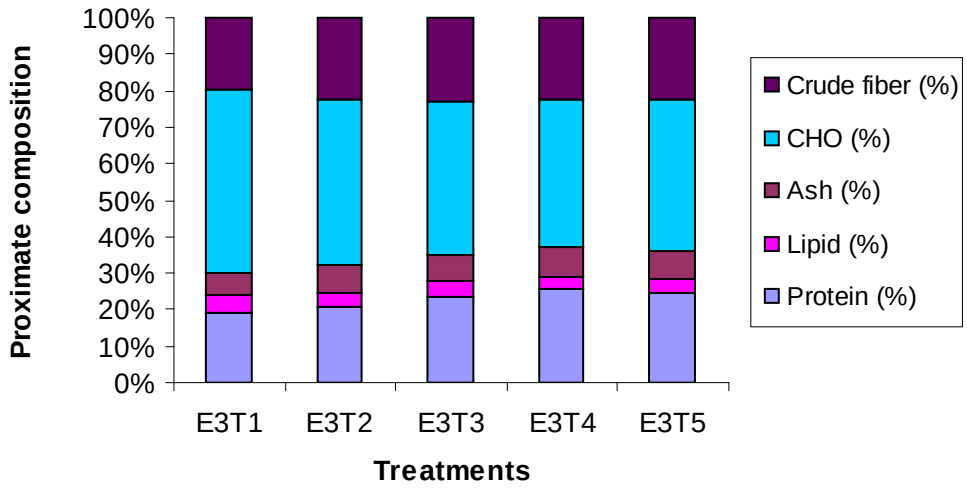

Fig.7: Effect of wheat bran supplements with rice straw on the proximate composition of oyster mushroom (Dry weight basis)

Table 11. Effect of different levels of wheat bran with rice straw on chemical composition of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Moisture (%)	Dry matter (%)	Protein (%)	Lipid (%)	Ash (%)	CHO (%)	Crude fiber (%)
E_3T_1	90.34c	9.66b	19.82e	5.08a	6.38e	48.45a	20.27
E_3T_2	90.58b	9.42c	21.56d	3.92bc	8.12a	43.20b	23.38
E_3T_3	91.08a	8.92d	23.48c	4.18b	7.57c	42.02b	22.75
E_3T_4	90.26cd	9.74ab	25.77a	3.64c	7.82b	40.44bc	22.33
E_3T_5	90.15d	9.85a	24.08b	3.73c	7.39d	42.88b	21.92
LSD (0.05)	0.188	0.188	0.461	0.390	0.133	1.855	2.043
CV (%)	0.11	1.04	1.14	5.03	0.95	2.19	4.90

In a column the figures having a common letter(s) do not differ significantly.

Note: E_3T_1: Rice straw (Controlled), E_3T_2: Rice straw + 10 % wheat bran, E_3T_3: Rice straw + 20 % wheat bran, E_3T_4: Rice straw + 30 % wheat bran, E_3T_5: Rice straw + 40 % wheat bran.

4.3.13 Effect on mineral content

4.3.13.1 Effect on nitrogen

The highest percentage of nitrogen was measured under treatment E_3T_4 (4.123) and the lowest nitrogen percentage was measured under E_3T_1 (3.171). The rest of the treatments were statistically and significantly varied over control in terms of percent nitrogen content (Table 12 and Appendix XIV). The findings of the present study matches with the study of Moni *et al.* (2004) who analyzed for various nutritional parameters and found 4.22 to 5.59 % of nitrogen on dry matter basis in fruiting bodies of oyster mushroom. Ali (2009) observed that the highest nitrogen was 4.85 % due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.13.2 Effect on phosphorus

The highest percentage of phosphorus was measured under treatment E_3T_4 (0.986) which was followed by E_3T_3 (0.954). The rest of the treatments were statistically similar (Table 12 and Appendix XIV) but the lowest phosphorus percentage was measured under E_3T_2 (0.897). The findings of the present study do not match with the study of Chang *et al.* (1981) who reported that the fruiting bodies of *Pleurotus* contained 5.87 to 8.40 mg/g of P on dry weigh of fruiting bodies. This may be due to the system of measurement. But Sarker *et al.* (2007) found 0.97% phosphorus in oyster mushroom grown on sugarcane bagasse based substrates. Ali (2009) observed that the highest phosphorus was 0.92 % due to sugarcane bagasse supplemented with wheat bran @ 0% (control).

4.3.13.3 Effect on potassium

The highest percentage of potassium was measured under treatment E_3T_4 (1.37) which was followed by E_3T_5 (1.34) and the lowest potassium percentage was measured under E_3T_1 (1.10). The rest of the treatments were statistically similar but varied significantly in respect to percent potassium content (Table 12 and Appendix XIV). The findings of the present study confirms by the study of

Chang *et al.* (1981) who reported that the fruiting bodies of *Pleurotus* contained 1.432 to 1.88 mg/g of K on dry weigh of fruiting bodies. Sarker *et al*. (2007) also found 1.3% potassium in oyster mushroom grown on sawdust based substrates. Ali (2009) observed that the highest potassium was 1.39 % due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.13.4 Effect on calcium

The highest amount of calcium was measured under treatment E_3T_4 (26.58 mg/100g) and the lowest amount was measured under E_3T_1 (20.20 mg/100g).The rest of the treatments were statistically similar but differed significantly over control in respect to percent calcium content (Table 12 and Appendix XIV). The findings of the present study matches with the study of Alam *et al.* (2007) who found 22.15 to 33.7 mg/100g of calcium in different oyster mushroom varieties. Sarker *et al.* (2007) found 2400ppm calcium in oyster mushroom grown on sawdust based substrates. Ali (2009) observed that the highest calcium was 22.08 % due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.13.5 Effect on magnesium

The highest amount of magnesium was measured under treatment E_3T_5 (13.68 mg/100g) and the lowest amount was measured under E_3T_1 (12.83 mg/100g) which was followed by E_3T_4 (12.97 mg/100g). The rest of the treatments were statistically similar but differed significantly over control in respect to percent magnesium content (Table 12 and Appendix XIV). The findings of the present study corroborates with the study of Alam *et al.* (2007) who found 13.4 to 20.22 mg/100g of magnesium in different oyster mushroom varieties. Ali (2009) also observed that the highest magnesium was 20.21 % due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.13.6 Effect on iron

The highest amount of iron was measured under treatment E_3T_3 (44.54 mg/100g) which was followed by E_3T_2 (43.87 mg/100g) and the lowest amount was measured under E_3T_1 (40.13 mg/100g). The rest of the treatments were statistically similar in respect to percent iron content (Table 12 and Appendix XIV). The findings of the present study matches with the findings of Alam *et al.* (2007) found 33.45 to 43.2 mg/100g iron in different oyster mushroom varieties. Sarker *et al.* (2007) found 92.09 ppm to 118.40 ppm iron, in oyster mushroom grown on sawdust based substrates. Ali (2009) observed that the highest iron was 43.11 mg due to sugarcane bagasse supplemented with wheat bran @ 30%.

4.3.13.7 Effect on zinc (mg)

The highest amount (mg) of zinc was measured under treatment E_3T_3 (15.17) which was followed by E_3T_2 (14.92) and the lowest amount was measured under E_3T_1 (13.35). The rest of the treatments were statistically similar in respect to zinc content (Table 12 and Appendix XIV). The result of the present study matches with the study of Alam *et al.* (2007) who found that zinc content of different oyster mushroom varieties ranged from 16 to 20.9 mg/100g. Sarker *et al.* (2007) found 30.92ppm zinc in oyster mushroom grown on sawdust based substrates.

Table 12. Effect of different levels of wheat bran with rice straw on mineral contents of oyster mushroom (*Pleurotus ostreatus*)

Treatments	N (%)	P (%)	K (%)	Ca (mg/ 100g)	Mg (mg/ 100g)	Fe (mg/ 100g)	Zn (mg/ 100g)
E_3T_1	3.171e	0.921b	1.10d	22.78e	12.83d	40.13e	13.35d
E_3T_2	3.449d	0.897b	1.25bc	24.38d	13.36b	43.87b	14.92ab
E_3T_3	3.756c	0.954ab	1.18cd	25.43b	13.08c	44.54a	15.17a
E_3T_4	4.123a	0.986a	1.37a	26.58a	12.97cd	42.89d	14.58b
E_3T_5	3.852b	0.928ab	1.34ab	24.87c	13.68a	43.18c	13.89c
LSD (0.05)	0.103	0.059	0.103	0.473	0.245	0.084	0.352

CV (%)	1.69	2.41	4.39	1.01	0.96	0.12	1.30

In a column the figures having a common letter(s) do not differ significantly.

Note: E_3T_1: Rice straw (Controlled), E_3T_2: Rice straw + 10 % wheat bran, E_3T_3: Rice straw + 20 % wheat bran, E_3T_4: Rice straw + 30 % wheat bran, E_3T_5: Rice straw + 40 % wheat bran.

Correlation study:

A highly significant and positive correlation between average number of fruiting body and biological yield was observed when rice straw was supplemented with different levels of wheat bran (Fig. 8). The relationship between average number of fruiting body and biological yield could be expressed by the equation y = 5.703x –67.20 (R^2 = 0.932**). Where y = biological yield and x = average number of fruiting body. The R^2 value indicated that 93.20% of biological yield of oyster mushroom (*Pleurotus ostreatus*) was attributed to the average number of fruiting body.

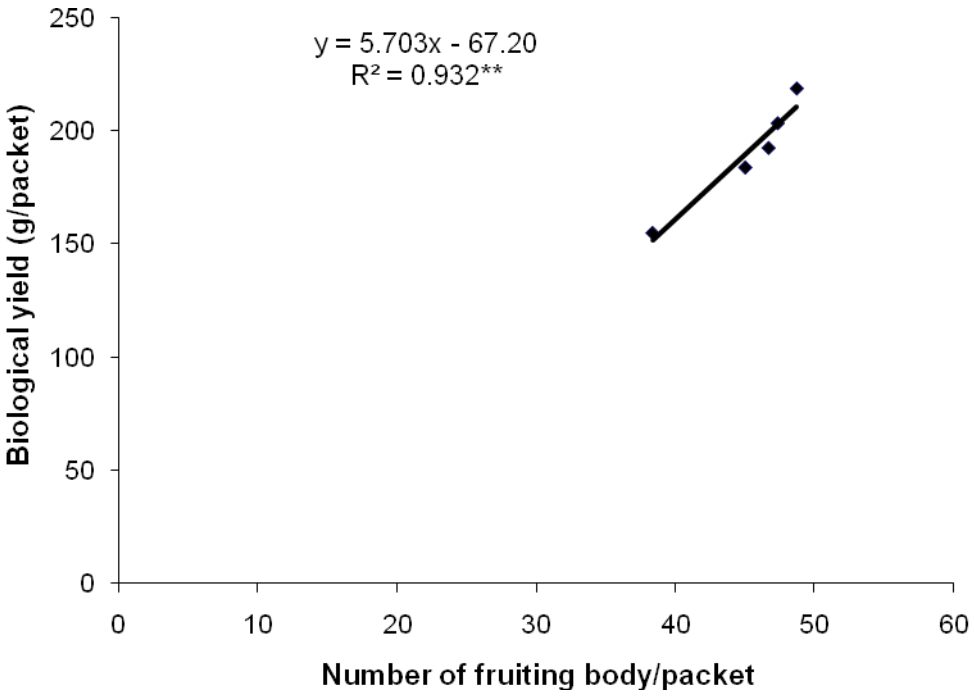

Fig. 8: Relationship between average number of fruiting body with biological yield as influenced by different levels of wheat bran as supplement with rice straw

A significant and linear positive correlation between average weight of individual fruiting body and economic yield was observed when rice straw was supplemented with different levels of wheat bran (Fig. 9). The relationship between average weight of individual fruiting body and economic yield could be expressed by the regression equation, y = 50.85x - 21.85 (R^2 = 0. 965**) where y = economic yield and x = average weight of individual fruiting body. The R^2 value indicated that 96.50% of economic yield of oyster mushroom (*Pleurotus ostreatus*) was attributed to the average weight of individual fruiting body.

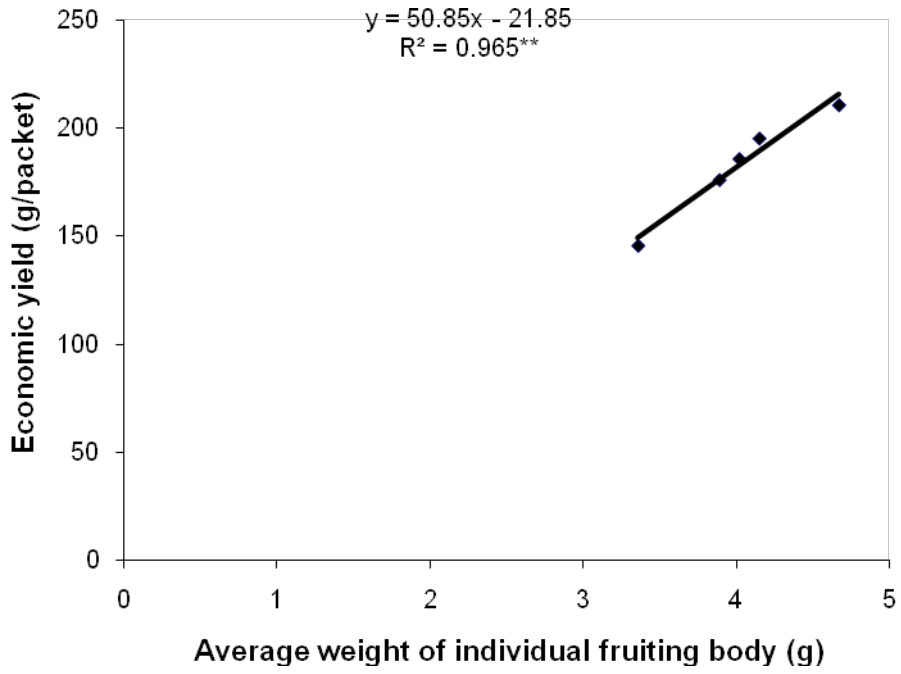

Fig. 9: Relationship between average weight of individual fruiting body and economic yield as influenced by different levels of wheat bran as supplement with rice straw.

SUMMARY

The present study was conducted with three different experiments each with five treatments and each treatment with three replications to investigate the performance of different levels of cow dung, chemical fertilizer and wheat bran as supplement with rice straw on the production and proximate composition of oyster mushroom (*Pleurotus ostreatus*).

The effect of cow dung as supplement with rice straw showed significant effect on mycelial running rate of oyster mushroom that reduced the required days to complete mycelium running in the spawn packet compared to the rice straw alone. The supplementation of cow dung with rice straw found to be significant in yield and yield contributing characters of oyster mushroom with some extent. Average number of primordia and average number of fruiting body was higher in case of rice straw supplemented with cow dung @ 5%. Rice straw supplemented with cow dung @ 10% gave the best result with the highest average weight of individual fruiting body, yield, biological efficiency and benefit cost ratio (BCR). Cow dung as supplement with rice straw also had a great effect on proximate composition and mineral content of *Pleurotus ostreatus*. Rice straw supplemented with cow dung @ 10% performed best in terms of percent protein and crude fiber content while percent lipid and carbohydrate content was higher in rice straw alone. Rice straw supplemented with cow dung @ 10% gave the best result with highest amount of N, Ca, Mg, Fe and Zn content while P content was higher in rice straw alone. Considering all the parameters rice straw supplemented with cow dung @ 10% is more or less feasible.

The effect of chemical fertilizer as supplement with rice straw showed significant effect on mycelial running rate of oyster mushroom that reduced the required days to complete mycelium running in the spawn packet compared to the rice straw alone. The supplementation of chemical fertilizer with rice straw

found to be significant in yield and yield contributing characters of oyster mushroom with some extent. Average number of primordia and average weight of individual fruiting body was higher in case of rice straw supplemented with chemical fertilizer (N=0.5%, P_2O_5=0.3%, K_2O=0.3%). Rice straw supplemented with chemical fertilizer (N=0.5%, P_2O_5=0.3%, K_2O=0.3%) gave the best result with the highest yield, biological efficiency and benefit cost ratio (BCR). The chemical fertilizer as supplement with rice straw also had a great effect on proximate composition and mineral content of *Pleurotus ostreatus.* Rice straw supplemented with chemical fertilizer (N=0.6%, P_2O_5=0.3%, K_2O=0.3%) performed best in terms of percent protein while percent lipid and carbohydrate content was higher in rice straw alone. Rice straw supplemented with chemical fertilizer (N=0.4%, P_2O_5=0.3%, K_2O=0.3%) gave the best result with highest amount of K, Ca, Mg, Fe and Zn content.

The effect of wheat bran as supplement with rice straw showed significant effect on mycelial running rate of oyster mushroom that reduced the required days to complete mycelium running in the spawn packet compared to the rice straw alone. The supplementation of wheat bran with rice straw found to be significant in yield and yield contributing characters of oyster mushroom with some extent. Average number of primordia and average number of fruiting body was higher in case of rice straw supplemented with wheat bran @ 20 %. Rice straw supplemented with wheat bran @ 30% gave the best result with the highest average weight of individual fruiting body, yield, biological efficiency and benefit cost ratio (BCR). Wheat bran as supplement with rice straw also had a great effect on proximate composition and mineral content of *Pleurotus ostreatus.* Rice straw supplemented with wheat bran @ 30% performed best in terms of percent protein content while percent lipid and carbohydrate content was higher in rice straw alone. Rice straw supplemented with wheat bran @ 30% gave the best result with highest amount of N, P, Ca and Mg content while Fe and Zn content was higher in rice straw supplemented with wheat bran @ 20%.

Conclusion

Rice straw supplemented with different levels of cow dung, chemical fertilizer and wheat bran, found to be significant in yield and yield contributing characters with some extent. Rice straw supplemented with chemical fertilizer (N=0.5%, P_2O_5=0.3%, K_2O=0.3%) gave the best result with the highest yield, biological efficiency and benefit cost ratio (BCR). Rice straw supplemented with chemical fertilizer (N=0.6%, P_2O_5=0.3%, K_2O=0.3%) performs best in terms of percent N and protein content. Rice straw supplemented with 10% cow dung gave the best result with the highest Mg, Zn while K found as highest percent from the treatment rice straw supplemented with chemical fertilizer (N=0.4%, P_2O_5=0.3%, K_2O=0.3%).

Recommendation

In this experiment more than one treatment performed better in compared with benefit cost ratio. Therefore, rice straw supplemented with chemical fertilizer (N=0.5%, P_2O_5=0.3%, K_2O=0.3%) can be recommended as an economically effective due to the highest yield. On the other hand 10% cow dung and 30% wheat bran supplemented with rice straw may be a fair option.

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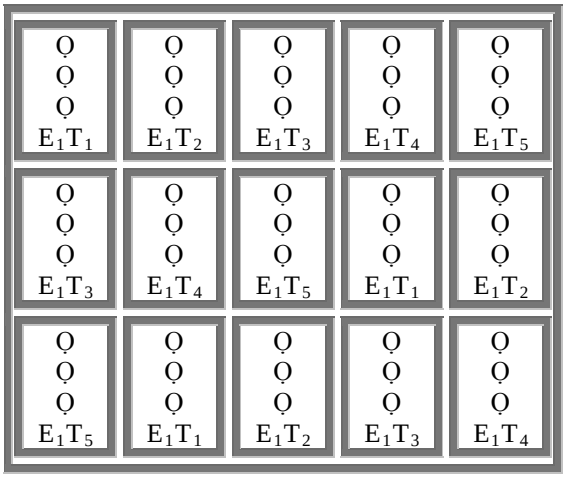
APPENDICES

Appendix I. Monthly temperature, relative humidity and rainfall of the experimental site during the period from January to June, 2009

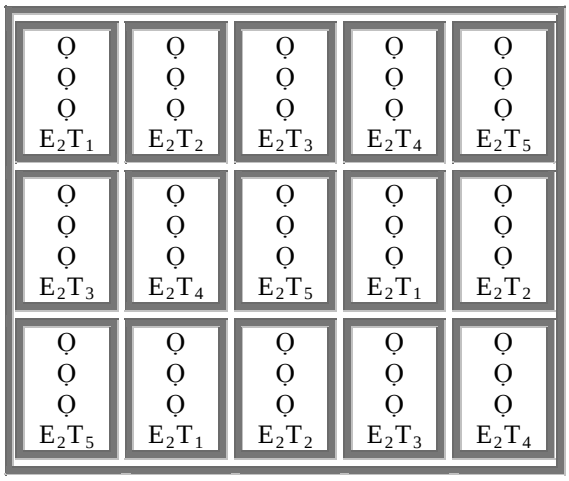
Month	Temperature (°C)		Relative humidity (%)	Rain fall (mm)
	Minimum	Maximum		
January, 2009	11.00	15.00	90.15	00.00
February, 2009	17.74	22.25	85.60	0710
March, 2009	25.89	31.42	69.15	06.40
April, 2009	29.00	32.10	75.00	57.50
May, 2009	27.42	31.33	76.15	250.10
June, 2009	29.15	32.00	64.10	377.50

Source: Bangladesh Meteorological Department, Agargaon, Dhaka

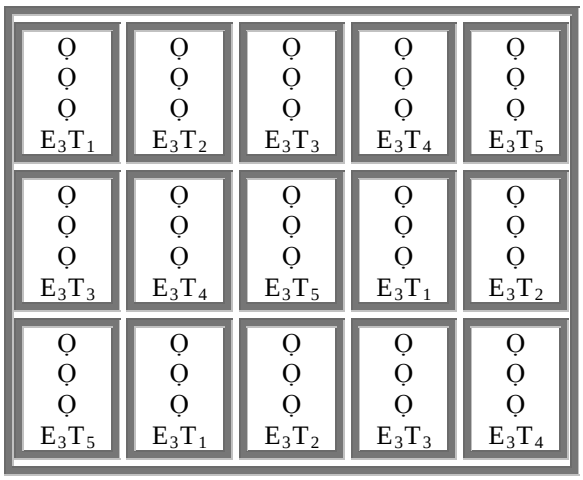
Appendix II. Experimental layout for the study



Experiment 1



Experiment 2



Experiment 3

Legend

Ô: Mushroom spawn packet

Appendix III. Analysis of variance on data with the effect of different levels of cow dung with rice straw on mycelium growth and yield contributing characters of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of					
		Mycelium running rate in spawn packets (cm)	Time from stimulation to primordial initiation (days)	Time from primordial initiation to harvest (days)	Average number of primordia /packet	Average number of fruiting body /packet	Average weight of individual fruiting body (g)
Replication	2	0.001	0.089	0.033	3.467	8.467	0.203
Treatment	4	0.014**	0.783**	0.774**	173.567**	127.767**	2.895**
Error	8	0.00	0.039	0.057	3.717	2.467	0.075

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix IV. Analysis of variance on data with the effect of different levels of cow dung with rice straw on the yield, biological efficiency and cost benefit ratio of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of				
		Biological yield (gm)	Economic yield (gm)	Dry yield (gm)	Biological efficiency (%)	Benefit cost ratio
Replication	2	93.953	82.429	0.947	13.345	0.109
Treatment	4	6150.576**	6037.142**	59.38** 1	875.795**	7.241**
Error	8	2.361	1.529	0.057	0.335	0.003

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix V. Analysis of variance on data with the effect of different levels of cow dung with rice straw on chemical composition of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of						
		Moisture (%)	Dry matter (%)	Protein (%)	Lipid (%)	Ash (%)	CHO (%)	Crude fiber (%)
Replication	2	0.024	0.024	1.305	0.013	0.051	3.267	0.00
Treatment	4	0.120*	0.120*	144.503**	1.380**	2.097**	206.167**	5.411**
Error	8	0.018	0.018	0.37	0.012	0.017	3.767	0.009

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix VI. Analysis of variance on data with the effect of different levels of cow dung with rice straw on mineral content of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of						
		N (%)	P (%)	K (%)	Ca (mg/ 100g)	Mg (mg/ 100g)	Fe (mg/ 100g)	Zn (mg/ 100g)
Replication	2	0.000	0.001	0.000	0.032	0.061	0.266	0.029
Treatment	4	4.601**	0.005**	0.026**	1.622**	11.221**	6.748*	3.659**
Error	8	0.000	0.000	0.000	0.011	0.013	0.265	0.020

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix VII. Analysis of variance on data with the effect of different levels of chemical fertilizer with rice straw on mycelium growth and yield contributing characters of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of					
		Mycelium running rate in spawn packets (cm)	Time from stimulation to primordial initiation (days)	Time from primordial initiation to harvest (days)	Average number of primordia /packet	Average number of fruiting body /packet	Average weight of individual fruiting body (g)
Replication	2	0.002	0.056	0.019	31.40	14.60	0.155
Treatment	4	0.018**	2.193**	0.654**	56.50**	26.73**	4.129**
Error	8	0.000	0.063	0.084	2.90	1.183	0.030

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix VIII. Analysis of variance on data with the effect of different levels of chemical fertilizer with rice straw on the yield, biological efficiency and cost benefit ratio of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of				
		Biological yield (gm)	Economic yield (gm)	Dry yield (gm)	Biological efficiency (%)	Benefit cost ratio
Replication	2	117.248	145.091	1.149	16.695	0.138
Treatment	4	7102.691**	7076.357**	69.038**	1011.45**	8.366**
Error	8	11.99	8.738	0.234	1.709	0.014

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix IX. Analysis of variance on data with the effect of different levels of chemical fertilizer with rice straw on chemical composition of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of						
		Moisture (%)	Dry matter (%)	Protein (%)	Lipid (%)	Ash (%)	CHO (%)	Crude fiber (%)
Replication	2	0.007	0.007	3.133	0.006	0.025	7.485	0.006
Treatment	4	0.067**	0.067**	127.027**	1.392**	1.880**	171.169**	1.578^{NS}
Error	8	0.002	0.002	4.003	0.057	0.055	6.138	1.818

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix X. Analysis of variance on data with the effect of different levels of chemical fertilizer with rice straw on mineral content of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of						
		N (%)	P (%)	K (%)	Ca (mg /100g)	Mg (mg/ 100g)	Fe (mg/ 100g)	Zn (mg/ 100g)
Replication	2	0.208	0.000	0.000	0.145	0.181	0.062	0.181
Treatment	4	3.013**	0.013**	0.086**	2.467**	3.666**	6.201*	4.098**
Error	8	0.045	0.001	0.007	0.115	0.113	0.111	0.323

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix XI. Analysis of variance on data with the effect of different levels of wheat bran with rice straw on mycelium growth and yield contributing characters of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of					
		Mycelium running rate in spawn packets (cm)	Time from stimulation to primordial initiation (days)	Time from primordial initiation to harvest (days)	Average number of primordia /packet	Average number of fruiting body /packet	Average weight of individual fruiting body (g)
Replication	2	0.009	0.071	12332.40	42.467	28.467	0.922
Treatment	4	0.012**	1.110**	12284.33**	38.600**	19.233**	2.572**
Error	8	0.000	0.018	12302.34	2.800	3.133	0.024

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix XII. Analysis of variance on data with the effects of different levels of wheat bran with rice straw on the yield, biological efficiency and cost benefit ratio of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of				
		Biological yield (gm)	Economic yield (gm)	Dry yield (gm)	Biological efficiency (%)	Benefit cost ratio
Replication	2	39.762	36.460	0.410	5.671	0.048
Treatment	4	4684.70**	4638.962**	46.624**	667.024**	5.521**
Error	8	19.762	19.232	0.170	2.812	0.023

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix XIII. Analysis of variance on data with the effect of different levels of wheat bran with rice straw on chemical composition of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of						
		Moisture (%)	Dry matter (%)	Protein (%)	Lipid (%)	Ash (%)	CHO (%)	Crude fiber (%)
Replication	2	0.238	0.238	0.190	0.122	0.450	3.471	0.223
Treatment	4	0.410*	0.410*	83.282**	1.010**	1.311**	80.596**	4.135^{NS}
Error	8	0.010	0.010	0.060	0.043	0.005	0.971	1.177

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix XIV. Analysis of variance on data with the effect of different levels of wheat bran with rice straw on mineral content of oyster mushroom (*Pleurotus ostreatus*)

Source of variance	Degrees of freedom	Mean square of						
		N (%)	P (%)	K (%)	Ca (mg/100g)	Mg (mg/ 100g)	Fe (mg/ 100g)	Zn (mg/ 100g)
Replication	2	0.125	0.001	0.098	0.098	0.063	0.072	0.050
Treatment	4	2.629**	0.003*	0.037**	5.870**	0.345**	8.535**	1.693**
Error	8	0.003	0.001	0.003	0.063	0.017	0.002	0.035

^{NS} Not significant; * Significant at 5% level; ** Significant at 1% level

Appendix XV. List of plate

Plate 1: Mycelium running in spawn packet after 8 days of inoculation

Plate 2: Mycelium running in spawn packet after 18 days of inoculation

Plate 3: Mycelium running complete in spawn packet

Plate 4: Pin head primordia in the spawn packet

Plate 5: Young fruiting body in the packet

Plate 6: Matured fruiting body in the spawn spawn packet

Plate 7: Taking biological yield in the laboratory

Plate 8: Drying of mushroom in the laboratory

Plate 9: Autoclave used in sterilization of spawn packets

Plate 10: Oven used for drying of mushroom