EFFECT OF MAIZE ADDITIVES AND WHEAT BRAN ON THE GROWTH AND YIELD OF OYSTER MUSHROOM

ZANNAT JAHAN

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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By

ZANNAT JAHAN

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Approved by:

Prof. Dr. Md. Ismail Hossain
Dept. of Horticulture, SAU
Supervisor

Dr. Md. Saifullah
PSO, NRM Division, BARC
Co-supervisor

Dr. Tahmina Mostarin
Chairman
Examination Committee

DEDICATED TO

MY

BELOVED PARENTS

DEPARTMENT OF HORTICULTURE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
PABX: 9110351 & 9144270-79

CERTIFICATE

This is to certify that the thesis entitled **" EFFECT OF MAIZE ADDITIVES AND WHEAT BRAN ON THE GROWTH AND YIELD OF OYSTER MUSHROOMS "** submitted to the Faculty of Agriculture**,** Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **HORTICULTURE,** embodies the results of a piece of bonafide research work carried out by **ZANNAT JAHAN** Registration. No. **10-04097** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

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

Date: December,2015

Dhaka, Bangladesh

Prof. Dr. Md. Ismail Hossain
Department of Horticulture, SAU

Supervisor

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The Author

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ABSTRACT

An experiment was conducted at Olericulture Division, BARI, Gazipur, during the period from July to December 2015 to evaluate the effect of maize additives (viz., M_0= 0, M_1= 5, M_2 = 10, M_3= 15, M_4= 20 and M_5= 25 g /500 g packet) and wheat bran (i.e., W_0= 0, W_1= 40, W_2= 60, W_3= 80, W_4= 100 and W_5=120 g/500 g packet) substrate rate respectively and their combination on the growth and yield of Oyster mushroom. Different levels of maize additives and wheat bran showed significant effect on growth and yield of Oyster mushroom. For maize additives the highest number of fruiting body/packet, breadth of individual stripe, effective fruiting body, and yield /packet (168.20 g) were obtained in M_2 and the lowest result found with M_5. For wheat bran W_3 gave highest value of fruiting body/packet, breadth of individual stripe, effective fruiting body, yield/packet (181.30 g) and the lowest results found from control. For combination effect, M_2W_3 showed the highest for length of individual stripe, effective fruiting body/packet (46.67) and yield/packet (191.00 g). So, application of 10 g maize additives /packet and 80 g wheat bran /packet to be a promising practice for Oyster mushroom production in Bangladesh.

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LIST OF ABBREVIATIONS

Abbreviation		Full word
%	:	Percent
@	:	At the rate
°C	:	Degree Centigrade
Anon.	:	Anonymous
AOAC	:	Association of Official Analytical Chemist
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 of United Nations
g	:	Gram
IRRI	:	International Rice Research Institute
ISTA	:	International Seed Testing Agency
kg	:	Kilogram
LSD	:	Least Significant Difference
no.	:	Number
SAU	:	Sher-e-Bangla Agricultural University
wt.	:	Weight
BE	:	Biological efficiency
MRR	:	Mycelium Running Rate
NMDEC	:	National Mushroom Development and Extension Center
MCC	:	Mushroom Culture Centre
Conc.	:	Concentration
HRC	:	Horticulture Research Center

CHAPTER I

INTRODUCTION

Mushrooms have been known for centuries as special delicacies in human diets all over the world. The importance of mushroom in medicine is now highly recognized. They are known to be rich in proteins, sugars, lipids, amino acids, glycogen, vitamins and mineral elements (Isikhuemhen, 1999). Mushrooms also have potential medicinal benefits (Chang and miles, 1989; San, 1996 and Lin, 1995). Commonly, they are gathered in the wild in many cultures but because of demand, they are now commercially cultivated by man. Mushrooms are propagated by spawn inoculated into the substrate. Harvesting commences three to five days after mushroom appearance (Chang and Li, 1982). *Pleurotus ostreatus* is a well known edible mushroom usually cultivated by farmers. It has a well defined stipe which is whitish and about 5 – 9 cm long. It also has a pileus of about 1.5 – 5 cm in diameter, whitish and conical or belt shaped which contains gills under it where white spores are produced. It is cultivated on coffee pulp, corn cob, sawdust et.c. (Royse and Schisler, 1986).

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. 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 200-250 g vegetable per day (FAO, 1998). But in our country, on an average, we get only 40-50 g 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 (Yoshika *et al.*,1975 and Mori 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, and 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 (Klingan, 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.

In mushroom cultivation however, the reason for insignificant results in the used of maize additive and wheat bran, is tied to the fact that it has been used without recognizing percentage levels hence, the optimum level of maize additive and wheat bran to mushroom substrate has not been defined. Sequel to these, this study has been structured to delve into significance and optimum levels of maize additive with wheat bran in the substrate with following objectives.

1. To know the optimum level of maize additive in the substrate as well as its consequential effect on the growth and yield of mushroom ;
2. To know the optimum level of wheat bran in the substrate as well as its consequential effect on the growth and yield of mushroom and
3. To assess combination effect of maize additive with wheat bran on the growth and yield of mushroom.

CHAPTER II

REVIEW OF LITERATURE

A number of literatures relating to the performance of different substrate on mushroom cultivation were available but performances on combination effect of maize additives and wheat bran 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.

Bhuyan (2008) conducted an experiment to study the effect of various supplements at different levels with wheat bran showed significant effect 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 wheat bran supplemented with NPK mixed fertilizer (N=0.6%, P=0.3%, K=0.3%). Wheat bran supplemented with different levels has a profound effect on chemical composition of Oyster mushroom. Wheat bran 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 wheat bran 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.

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

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 (1.39 g/mg), calcium (22.08 mg), magnesium (20.21 mg), sulfur (0.042 g/mg), iron (43.11 mg) 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).

Sainos *et al*. (2006) conducted a study to determine the mycelial growth, intracellular activity of proteases, lactases and beta -1,3-glucanases, and cytoplasmic protein were evaluated in the vegetative phase of *Pleurotus ostreatus* grown on wheat straw and in wheat bran media in Petri dishes and in bottles. The productivity of the wheat straw and wheat bran based spawn in cylindrical polyethylene bags containing 5 kg of chopped straw was also determined. They 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 bran showed a high radial growth rate in petri dishes and a high level of mycelial growth in bottles. The productivities of wheat straw and wheat bran based spawn were similar. Mushroom spawn can be prepared by developing the mycelium on wheat straw and wheat wheat bran based substrates.

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).

Kulsum *et al.* (2009) conducted an experiment to determine the effect of five different levels of maize additives (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 primordial /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 maize additives @ 10% (3.69 g). The supplementation of sawdust with maize additives 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 (213 g), dry yield (21.27 g) biological efficiency (75.06%) and cost benefit ratio (8.41) were observed due to sawdust supplemented with maize additives @ 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 maize additives @ 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 maize additives @ 10%.

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 maize additives, 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 maize additives (427 and 400 g/ 500 g, respectively).

Sarker *et al*. (2007a) carried out an experiment to find out the performance of different cheap agricultural 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 bran (215.72 g/packet).The economic yield on sugarcane bagasse was 191.98g/packet, which was statistically identical to that grown on wheat bran (183.28 g/packet), kash (182.93 g/packet) and ulu (175.15 g/packet).The economic yield on sawdust was 160.40 g/packet, which was statistically identical to that on ulu. The lowest economic yield was observed in water hyacinth (33.59 g/packet). No fruiting body and economic yield were obtained from para and 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), wheat bran (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 bran and water hyacinth. The lowest protein (7.81%) was observed in that grown on wheat bran. Mushrooms are good source of minerals. Maximum of 18400 ppm Ca was found in mushroom which was grown on wheat bran. 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.

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 bran 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 maize 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 *et al.* (2005) conducted an experiment to grow Oyster mushroom (*Pleurotus ostreatus* (Jacq.: Fr.) Kummer in either maize or pumpkin additives. 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 stripe 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, wheat bran, 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. He reported 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 bran. The treatments comprised : 90% straw + 5% wheat bran + 5% gypsum (control); 80% straw + 10% olive cake + 5% wheat bran + 5% gypsum (T_1); 70% straw + 20% olive cake 5% wheat bran + 5% gypsum (T_2); 60% straw + 30% olive cake + 5% wheat bran + 5% gypsum (T_3); 50% straw + 40% olive cake + 5% wheat bran +.5% gypsum (T_4); and 90% olive cake + wheat bran + 5% gypsum (T_5). After inoculation and incubation, transparent plastic bags were used for cultivation. The pinheads 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.

Amin (2004) in his experiment revealed that the highest number of primordia of Oyster mushroom was found in sterilized wheat bran 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 - wheat bran 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 wheat bran 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, maize additives, 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 bran, 75 % sawdust + 25 % leaves, 50 % wheat straw + 50 % leaves, 100 % sawdust, 100 % wheat bran 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% maize straw 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 additives, 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 31.50 days. The final and third picking was completed in 43.50 days in case of soybean straw which was statistically higher compared to paddy and wheat straw (42.25) and cotton and jowar straw (42.75). The highest yield of 993.00 g/kg was obtained from cotton, followed by soybean straw (935.25 g/kg) and paddy straw (816.00 g/kg). The lowest yield of 445.50 g/kg was recorded in jowar straw.

Ayyappan *et al.* (2000) used sugarcane trash and coir waste alone and in combination with maize additives (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 wheat bran on the yield and quality of Oyster mushroom (*Plelrrotus ostrentus*) in Jorhat, Assam, India. Treatments comprised: (i) addition of wheat 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. Wheat 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 701 g/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 bran 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 maize additives (3:1, 1:1 and 1:3 ratios) for cultivation of *Pleurotus sajor-caju* and *P. Florida*. Maize additives alone sustained highest mushroom yield (83.3-84.6% BE). Water hyacinth in combinationwith maize additives 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 bran without nutrient supplementation. The effects of straw size reduction methods and particle sizes spawn inoculation level and types of substrate (rice straw vs. wheat bran) 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.

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 wheat straw (1:1). The results indicate that wheat 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.

Kalita *et al.* (1997) studied the growth of *Pleurotus sajor-caju* in polyethylene bag on different combinations of substrates viz. only wheat straw, wheat straw plus wheat bran mixture (1:1 v/v), water hyacinth, chopped banana leaves, areca nut husk and sugarcane bagasse. They found that only wheat straw, wheat straw plus wheat bran 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 maize additives 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 maize additives 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 wheat bran. *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 bran 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.

Murugesan *et al.* (1995) cultivated mushroom P. *sajor-caju* (Fr.) Sing, on water hyacinth (*Elchhorni crassipe*). They compared water hyacinth with other conventional substrates wheat bran. 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 wheat bran). 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 wheat bran (2 kg) + spawn (200 g) + boiled wheat (200 g). Highest yield was observed in *P. Florida*, followed by *P. sajor-caju*, *P. citrinopileatus*, *Pleurotus ostreatus* 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 ostreatus* was cultivated on wheat bran, 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 bran, 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 bran. 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 bran 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*.

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.

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.

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 bran, 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 ostreatus* 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 bran alone.

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 bran substrate gave the highest yields (275-300 kg/substrate) of *Pleurotus ostreatus*.

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 bran and *Pleurotus ostreatus* 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 additives, 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 wheat bran, banana leaves, saw dust, oil palm refuse, oil palm bunch refuse or grass straw in Andamans to study conversion efficiency of *Pleurotus sajor-caju*. Wheat bran 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 wheat bran, grass straw, oil palm bunch refuse, sawdust and oil palm waste. *Pleurotus ostreatus* was successfully grown under local conditions utilizing chopped wheat bran, cotton waste, maize cobs or rice straw as bedding material. Wheat bran 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.

Labuschagne *et al.* (2000) found that main raw material for *Pleurotus ostreatus* (Oyster mushroom) cultivation is wheat straw. Estimation of straw biodegradability from 15 different spring wheat cultivars under irrigation in South Africa was determined using linear discriminant analysis to discriminate or group the 15 cultivars by combining chemical analysis and in vitro enzymatic hydrolysis. Significant differences ($P < 0.01$) were found between ash, nitrogen, reducing sugars, anthrone reactive-carbohydrates, water-soluble dry matter and Oyster mushroom yields.

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

Lim *et al.* (1997) analyzed the cost and return of *Volvariella* and *Pleurotus* mushroom production and found the ROI of 89.16 percent and 51.93 percent, respectively. This indicates that mushroom production is economically feasible. The feasibility of low input mushroom production for upland farmers in reforested areas under the closed canopy high-diversity forest faming system was determined. Agricultural and tree wastes were tested and utilized for spawn and mushroom production. Findings showed that among 10 agricultural/tree wastes tested, mung bean pods, kakawate and cassava leaves, log sawdust, and ipil-ipil leaves, sugarcane bagasse with rice bran, and water hyacinth can be used as alternative substances for *Volvariella* spawn production. Local isolate (VISCA) of *Volvariella volvacea* gave higher yield (2263.65g) compared with *Volvariella* (1574.80 g) isolates from BIOTECH College, Laguna, Philippines. This fruited well in the closed-canopy area than when cultivated in the open area. *Pleurotus* yield was higher (209.60 g/bag) inside mushroom house under closed-canopy area than when grown inside mushroom house in relatively open area (198.54 g).

Reyes *et al.* (1994) conducted a study with the objective of utilizing selected agro industrial wastes for the production of *Pleurotus sajor-caju* (Fr.) Singer. Five agro-industrial wastes were evaluated singly or in combination with other substrates. Three parts coarse materials (cotton wastes, rice straw and rice hull) and two are fine materials (sawdust and rice bran). Three parts of coarse materials were combined with every one part of fine materials. Results of the experiment revealed that composted substrates generally produced more and heavier basidiocarps and relatively high biological efficiency compared to the uncomposted materials. *Pleurotus sajor-caju* grown in composted rice hull + rice straw + cotton waste with a ratio of 3:3:3 produced the heaviest basidiocarp (80.54 g) with a biological efficiency of 26.84 percent.

Mukesh *et al.* (2004) evaluated different substrates, i.e. wheat, chickpea, pea, sugarcane bagasse and water hyacinth, for production of Oyster mushroom (*Pleurotus sajor-caju*), during 2002-03 in Uttar Pradesh, India. The period of spawn run on water hyacinth straw (21 days) was longer than other straws during 15 January to April when minimum temperature varied from 13.93 to 20.62 degrees C and average temperature varying from 23.57 to 28.16 degrees C. The relative humidity during these period varied from 76.38 to84.34 percent (morning) and 57.54 to 63.33 percent (evening). The number of days taken for pin head initiation on water hyacinth straw (25 days) was also longer compared to other straws. The biological efficiency of mushroom was higher on wheat straw (8.1.00) followed by chickpea (80.00), pea (77.77), water hyacinth (67.77) and sugarcane bagasse (66.67). Biological efficiency started declining with an increase in temperature (25+or-2 observed in wheat straw (810 g).

Scherba *et al.* (2004) considered the lack of a large scale production system for sowing mycelium slowing down production of mushrooms in Belarus. The possibility of production of sowing mycelium in conditions of deep fermentation allowing a significant decrease of growing time of mycelium is discussed. Investigations were conducted to study growing habits and fructification of *Pleurotus ostreatus* strains No 42 and 186 on sterile and pasteurized rye straw. Diagrams are presented on the effect of methods of treatment of the substrate, application methods (surface application or mixing with the substrate) and quantity of spawn (1, 5 and 10% of the mass of the raw substrate) on mushroom yield. Diagrams are included on the effect of the method of application of spawn on speed of growing of mushrooms. Evidence was obtained of advantages of using liquid spawn material compared with grain spawn.

Peng-JinTorng *et al.* (2000) studied the effect of sawdust (from Trema orientalis) substrates containing different percentages of rice bran on the production of fruiting bodies by *Pleurotus eryngii* (stains ATCC 36047 and Holland 150). The average yield, biological efficiency (BE) and production efficiency (PE) of ATCC 36047 increased significantly with increasing supplementation of the substrate with rice bran (0-47.95%). In Holland 150, BE and PE were highest with 38.08% rice bran, but decreased significantly when rice bran supplementation increased to 47.95%. It was concluded that ATCC 36047 and Holland 150 could be grown commercially in substrates containing 48 and 38% rice bran, respectively.

Kothandaraman *et al.* (1989) in a study it was reported that in the split or the logs of *Hevea brasiliensis* was inoculated with spawn of *Pleurotus sajor-caju*, *Pleurotus* citrinopileatus and *Pleurotus florida*. They were covered with polythene sheeting and kept in darkness at around 26°C until mycelium was visible. Rubber tree sawdust was also investigated as a growing medium; it was soaked in water for 24 hours, then dried to about 70% moisture and mixed with 5% CaCO3; in bottles before inoculation. All 3 species began to grow on the logs within 3 days of inoculation and small fruiting bodies appeared 4 days alter spawn running was completed. However, almost all ceased development shortly afterwards; only 5 (*Pleurotus florida*) reached maturity. Mycelia on sawdust ceased to grow alter penetrating to about three-quarters of the depth of the medium. The reason(s) for the failure to develop fully are not yet known but, since rubber wood appears to have no inhibitory activity against *Pleurotus spp*., further studies are proposed.

CHAPTER III
MATERIALS AND METHODS

The experiment was carried out to find out the growth and yield of Oyster mushroom (*Pleurotus ostreatus*) grown on supplemented maize additives and wheat bran. 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 Olericulture Division, HRC, BARI, Gazipur, during the period from July to December 2015. The environmental condition of the experimental location presented 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 ostreatus*) 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. Experimental treatments

The experiment consisted of two treatment factors as mentioned below. The treatment combinations were randomly distributed in this experiment. There were 36 treatment combinations

Factor A: The experiment was comprised six levels of maize additives viz.

M_0 = Control (no maize additives)

M_1= 1% (5 g/500 g packet)

M_2=2% (10 g/500 g packet)

M_3=3% (15 g/500 g packet)

M_4=4% (20 g/500 g packet)

M_5=5% (25 g/500 g packet)

Factor B: The experiment was comprised six levels of wheat bran viz.

W_0= Control (no wheat bran)

W_1=8% (40 g/500 g packet)

W_2=12% (60 g/500 g packet)

W_3=16% (80 g/500 g packet)

W_4=20% (100 g/500 g packet)

W_5=24% (120 g/500 g packet)

3.5 Treatment combination: There were thirty six (36) treatment combinations was used under present study mentioned as follows-

$M_0 \times W_0$, $M_0 \times W_1$, $M_0 \times W_2$, $M_0 \times W_3$, $M_0 \times W_4$, $M_0 \times W_5$, $M_1 \times W_0$, $M_1 \times W_1$, $M_1 \times W_2$, $M_1 \times W_3$, $M_1 \times W_4$, $M_1 \times W_5$, $M_2 \times W_0$, $M_2 \times W_1$, $M_2 \times W_2$, $M_2 \times W_3$, $M_2 \times W_4$, $M_2 \times W_5$, $M_3 \times W_0$, $M_3 \times W_1$, $M_3 \times W_2$, $M_3 \times W_3$, $M_3 \times W_4$, $M_3 \times W_5$, $M_4 \times W_0$, $M_4 \times W_1$, $M_4 \times W_2$, $M_4 \times W_3$, $M_4 \times W_4$, $M_4 \times W_5$, $M_5 \times W_0$, $M_5 \times W_1$, $M_5 \times W_2$, $M_5 \times W_3$, $M_5 \times W_4$, $M_5 \times W_5$

3.6 Design and layout of the experiment

The experiment was laid out in single factor Completely Randomized Design (CRD). The experiment considered two factors with six treatment combinations with three replications and three spawn packets in each replication.

3.7 Preparation of substrates

At first weight of dry substrate respectively wheat bran and maize additives were taken. Maize additive (local maize**)** was reduced to the powdered form added to the substrate at 5 levels (1%, 2%, 3% 4% and 5%) while 0% was used as the control and wheat bran was added to the substrate at 5 levels (8%, 12%,16% 20% and 24%) while 0% was used as the control. Then the sawdust 30% and 1% $CaCO_3$ were mixed. The measured materials were taken in a plastic bowl and mixed thoroughly by hand and moisture was increased by adding water. After proper mixing, they were loaded into heat resistant polythene bags measuring 18cm x 30cm. Small rubber pipes was passed through the top of the bags, after which the mouth of the bags were plugged with cotton wool. Moisture was measured by using the moisture meter and adjusted the moisture content at 65%. Three replicate bags were prepared for each level. The bags were heated to a temperature of 100^{o}C for 3 hours. The bags were allowed to cool in an air conditioned room to a temperature of 30^{o}C.

3.7.1 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.

3.7.2 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.

3.7.3 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.

3.7.4 Collection of produced mushrooms

Oyster mushrooms matured within 2-3 days after primordial 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.

3.8 Data collection

3. 8.1. Days required for development of pin head from seed in Packet

Development of pin head was counted by taking the full packet as a full unit and generally the data was taken at every two days intervals.

3. 8. 2. Days required for pin head to first harvest

Days required for pin head to first harvest was counted by taking the full packet as a full unit and generally the data was taken at every two days intervals.

3. 8. 3. No. of harvest/packet

The well–developed mushroom was harvested. No. of Harvest/packet were recorded all harvesting period.

3. 8. 4. 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. 8. 5 Length of individual stripe

To effectively get the right stripe length the readings were taken before trimming the stripe to get the total marketable yield. The length was measured by placing the string from one end where it was attached to the substrate to the point where the gillson the pileus start on the stripe. Like the pileus diameter the string was placed along a rule to get the length in millimeters (mm). The average for that day’s harvest was then calculated using the 3 readings.

3. 8. 6 Breadth of individual stripe

The collected fruiting bodies of the mushroom were transferred to the laboratory. The mushroom pileus diameter was taken from one end of the pileus to the other passing through the centre of the pileus and measured in millimetres (mm). This was done using a string which was then placed along a rule to get the diameter. The pileus diameter was obtained on 5 randomly picked mushrooms, from the harvest and then the average pileus diameter was calculated for a given harvest.

3. 8. 7 Effective fruiting body per packet

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

3. 8. 8 Yield/packet

Yield per 500 g packet was measured by weighing the whole cluster of fruiting body without removing the lower hard and dirty portion. The mushrooms were harvested in a bundle when the outer margin of the fruiting body had only just rolled inwards, on the verge of becoming horizontal and care was taken so as to reduce any disruption of the substrate during harvesting. The mushrooms were then weighed using a scale taking the mass in grams (g).

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.

CHAPTER IV
RESULTS AND DISCUSSION

This chapter comprises of presentation and discussion of the results obtained from a study to investigate the effect of maize additives and wheat bran on the growth and yield of Oyster mushroom. The treatment combinations were randomly distributed in this experiment. There were 36 treatment combinations. The data on crop growth characters and yield contributing characters like days required for pin head development in packet, days required for pin head to first harvest, fruiting body/packet, no. of harvest/packet, length of individual stripe, breadth of individual stripe, effective fruiting body, and yield/packet were recorded during experiment. The results have been presented and discussed with the help of table, graphs and possible interpretations given under the following headings:

4.1. Days required for development of pin head

Days required for pin head development was showed significant variation for maize additives (Appendix II). The highest days (29.61 days) was found for pin head development was in the treatment M_1 and the lowest days (28.28 days) was observed for pin head development in the treatment M_2 (Table 1) and statistically similar results found from $M_{3,}$ M_4 treatment. It seems that 5 g maize additives are responsible for highest days required. But 10 g maize additives reduce days for pin head formation. Although more than 10 g maize additives again increase required days for pin head development. So 10 g maize additives is optimum dose for minimize cultivation period. The present findings corroborated with the findings of previous researchers Kulsum *et al.,* 2009 and Khan *et al.* (1991).

Significant variation was recorded for wheat bran in days required for pin head development (Appendix II). Highest days required (30.67 days) for pin head development was in the treatment W_0 and the lowest days required (28.17 days) for wheat bran packet was observed in the treatment W_3 and followed by W_4, W_5 treatment which also near to W_3 (Table 2). It seems that by using 80 g wheat bran we can reduce number of days for pin head development. So it can reduce time waste for cultivation because in optimum dose (80 g wheat bran) mushroom can uptake actual rate of carbohydrate. So it can reduce number of days for pin head development. The present findings keep in with the findings of previous researchers (Obodai *et al.*, 2003 and Sarker *et al*., 2007). Biswas *et al.* (1997) found that supplementation of wheat bran (30.0 days). Kalita *et al.* (1997) observed that days required for seed in packet for wheat bran was ranged from 28-30 days.

Statistically significant variation was found in combination treatment for required days of pin head development (Appendix II). The highest days required (31.33 days) for pin head development for combine effect was in the treatment combination M_1W_o and also statistically similar results found from M_0W_0. The lowest days required (26.67 days) for pin head development was observed in the treatment M_3W_3 and also near lowest days (27.67days) was found in M_2W_3 treatment (Table 3). From this experiment it is clear that 80 g wheat bran gives lowest day by giving optimum level of carbohydrate and maize additives 10-15 g is also helps for reduce day for development of pin size of mushroom. It is clear that in this parameter mostly influenced by wheat bran.

4.2. Days required for pin head to first harvest

The days required for pin head to first harvest was significant for maize additives (Appendix II). Maximum days required (4.50 days) for first harvest for maize additives was in the treatment M_5 and lowest days required (4.14 days) for pin head to first harvest was observed in the treatment M_0 and nearest lowest day required (4.19 days) in M_2 , M_1 treatment (Table 1). From this we can understand that excess maize additives increase required days for first harvest and without maize additives reduce required days. The present findings corroborated with the findings of previous workers (Khan *et al.*, 1991; Kalita *et al,).*They also get significant result with their substrate. If moisture level is reduced from substrate, then it will influence number of days for harvesting.

Table 1. Effect of maize additives on days required for pin head development, days required for first harvest, fruiting body/packet and no. of harvest of Oyster mushroom.

[M_0 = Control (no maize additives), M_1= 1% (5 g /500 g packet), M_2=2% (10 g/500 g packet), M_3=3% (15 g/500 g packet), M_4= 4% (20 g/500 g packet), M_5= 5% (25 g/500 g packet.)]

Treatments	**Days required for pin head development**	**Days required for first harvest**	**No. of fruiting body/packet**	**No. of harvest/packet**
M_o	29.22 ab	4.14 b	41.83 b	4.06 a
M_1	29.61 a	4.18 b	43.39 a	4.03 ab
M_2	28.28 c	4.19 b	44.17 a	3.82 cd
M_3	28.39 c	4.27 ab	43.72 a	3.92 bc
M_4	28.39 c	4.20 b	43.56 a	3.73 d
M_5	28.89 b	4.50 a	41.61b	3.93 bc
LSD $_{(0.05)}$	0.44	0.26	0.81	0.12
CV (%)	2.32	9.06	2.82	4.40

Significant variation was recorded for wheat bran in days required for pin head to first harvest. (Appendix II). The highest days required (4.67 days) for first harvest for wheat bran was in the treatment Wo and it also similar in W_1 ,W_5 treatment. The lowest days required (3.83 days) for seed in packet for wheat bran was observed in the treatment W_4 and similar with W_3 (Table 2). From this result, it is clear that without wheat bran, more days required for pin head to first harvest. Minimum days were found by using 100 g wheat bran. So this is the optimum dose for mushroom cultivation. The present findings corroborated with the findings of previous workers (Khan *et al.*, 1991; Kalita *et al.*, 2001 and Kulsum *et al.*, 2009). Kulsum *et al.* (2009) observed that the days required for first harvest was 4 days due to wheat bran supplemented with cow dung @ 15% which is more or less similar to the present study.

Days required for pin head to first harvest was showed significant (Appendix II) for combine effect of wheat bran and maize additives. The highest days required (5.10 days) for pin head to first harvest for combine effect of wheat bran and maize additives on the growth and yield of Oyster mushroom was in the treatment M_5Wo (Table 3) and also statistically similar results found from M_0W_0, M_3W_5. The lowest days (3.50 days) required for first harvest for combine effect was observed in the treatment M_0W_5 (Table 3). From this combination required days basically influenced by wheat bran. By increasing amount of wheat bran it reduce day requirement gradually and optimum level up to 120 g wheat bran.

4. 3. Fruiting body/packet

Significant variation was observed among different maize additives for fruiting body\packet (Appendix III). The highest fruiting body/packet (43.39) for maize additives was in the treatment M_1 and also similar fruiting body was found in $M_{2,}$ M_3, M_4 treatment. The lowest fruiting body/packet (41.61) was observed in the treatment M_0 (Table 1). It seems that 5 g, 10 g, 15 g maize additives shows highest fruiting body per packet. But below 5 g and above 20 g reduce fruiting body number. 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) also observed fruiting body/packet was similar.

Fruiting body/packet was showed significant for wheat bran (Appendix III). The highest number of fruiting body/packet (49.56) for wheat bran was in the treatment W_3 and the lowest fruiting body/packet (36.17) was observed in the treatment W_0 (Table 2).So from this result ,it is clear that 80 g wheat bran gives maximum required carbohydrate which helps to produce maximum fruiting body per packet. Excess and less both amount of carbohydrate reduce fruiting body.

Different combination treatment was found statistically significant for fruiting body/packet (Appendix III). The highest fruiting body/packet (53.67) required for combine effect of wheat bran and maize additives was in the treatment M_3W_4 and the lowest fruiting body /packet (35.0) required for combine effect of wheat bran and maize additives was observed in the treatment M_4W_0 (Table 3). It seems that combine effect of 15 g maize additives with 100 g wheat bran is optimum dose for obtained highest amount of fruiting body. For maize additives 15 g is optimum but it will fluctuate when used 20 g maize additives. Without wheat bran in substrate reduces carbohydrate and decrease fruiting body. Optimum dose are effective for maximum nutrient uptake. Excess and lower amount carbohydrate reduce maximum nutrient uptake rate.

Table 2. Effect of wheat bran on the pin head development, days required for first harvest, no of fruiting body/packet and no of harvest of Oyster mushroom.

[W_0 = Control (no wheat bran), W_1 = 8% (40 g wheat bran/500 g packet), W_2=12% (60 g wheat bran/500 g packet) ,W_3=16% (80 g wheat bran/500 g packet), W_4=20% (100 g wheat bran/500 g packet), W_5=24% (120 g wheat bran/500 g packet)]

4. 4 No. of harvest/packet

Number of harvest was showed statistically significant for maize additives (Appendix III). The highest no. of harvest/packet (4.06) for maize additives was in the treatment Mo and also similar M_1 treatment. The lowest no. of harvest/packet (3.73) was observed in the treatment M4 (Table 1). So from this result it is clear that without maize additives, it can give highest no of harvest. 0-5 g maize additives give the highest no of harvest but it mostly fluctuate at 20 g maize additives. Basically optimum level of nutrient from substrate helps to maintain highest number of harvest. Excess and lower amount of nutrient reduce total harvest number. 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.

Table 3.Combined effect of maize additives and wheat bran on days for pin head development,days required for first harvest, no. of fruiting body /packet, no. of harvest of Oyster.

Treatments	Days required for pin head development	Days required for first harvest	No of fruiting body/packet	No. of harvest/packet
W_o	30.67a	4.67a	36.17f	3.34d
W_1	29.11b	4.42a	39.39e	3.84c
W_2	28.17b	4.02b	44.44c	4.04b
W_3	28.17c	4.04b	49.56a	4.27a
W_4	27.89c	3.83b	47.28b	4.18a
W_5	28.78c	4.48a	41.44d	3.81c
LSD $_{(0.05)}$	0.44	0.26	0.81	0.12
CV (%)	2.32	9.06	2.82	4.40

Treatments	Days required for pin head development	Days required for first harvest	No. of fruiting body/packet	No. of harvest/packet
M_OW_O	31.00 ab	5.00 ab	36.33 n-p	3.43 j-l
M_OW_1	29.67 c-f	4.33 c-h	38.33 lm	4.03 b-e
M_OW_2	28.00 h-k	4.00 f-j	46.00 f	4.37 a
M_OW_3	30.00 b-e	4.33 c-h	49.33 c-e	4.33 a
M_OW_4	28.67 f-i	3.67 ij	42.67 hi	4.17 a-d
M_OW_5	28.00 h-k	3.50 j	38.33 lm	4.03 b-e
M_1W_O	31.33 a	4.33 c-h	36.67 m-p	3.35 kl
M_1W_1	30.33 a-d	4.67 a-e	40.33 jk	4.10 a-d
M_1W_2	29.67 c-f	3.67 ij	49.67 c-e	4.03 b-e
M_1W_3	30.00 b-e	3.70 ij	49.33 c-e	4.37 a
M_1W_4	28.33 g-j	3.77 h-j	45.67 fg	4.27 a-c
M_1W_5	28.00 h-k	4.93 a-c	38.67 kl	4.03 b-e
M_2W_0	30.00 b-e	4.33 c-h	35.67 op	3.23 l
M_2W_1	28.67 f-i	3.83 g-j	40.67 j	3.60 h-k
M_2W_2	27.67 i-l	3.87 g-j	44.67 fg	3.67 g-j
M_2W_3	27.67 i-l	4.53 a-f	51.00 bc	4.37 a
M_2W_4	27.00 kl	3.70 ij	49.00 de	4.23 a-c
M_2W_5	28.67 f-i	4.87 a-c	44.00 gh	3.80 e-h

Table 3.Continued

Treatments	Days required for pin head development	Days required for first harvest	No. of fruiting body/packet	No. of Harvest/packet
M_2W_5	28.67 f-i	4.87 a-c	44.00 gh	3.80 e-h
M_3W_0	30.33 a-d	4.60 a-f	35.67 op	3.23 l
M_3W_1	28.67 f-i	4.43 b-g	38.00 l-n	3.73 f-i
M_3W_2	27.67 i-l	4.00 f-j	40.33 jk	4.03 b-e
M_3W_3	26.67l	3.77 h-j	49.67 c-e	4.27 a-c

M_3W_4	27.67i-l	3.83 g-j	53.67 a	4.30 ab
M_3W_5	29.33d-g	5.00 ab	45.00 fg	3.93 d-g
M_4W_0	30.67 a-c	4.67 a-e	35.00 p	3.30l
M_4W_1	28.67 f-i	4.50 a-f	38.67 kl	3.47 i-l
M_4W_2	27.67 i-l	4.10 e-j	40.67 j	3.80 e-h
M_4W_3	27.00 kl	4.10 e-j	50.00 b-d	4.00 c-f
M_4W_4	27.33 j-l	3.83 g-j	51.67 b	4.20 a-d
M_4W_5	29.00 e-h	4.00 f-j	45.33 fg	3.63 h-j
M_5W_0	30.67 a-c	5.10 a	37.67 l-n	3.50 i-l
M_5W_1	28.67 f-i	4.77 a-d	40.33 jk	4.10 a-d
M_5W_2	28.33 g-j	4.50 a-f	45.33 fg	4.33 a
M_5W_3	27.67 i-l	3.83 g-j	48.00 e	4.27 a-c
M_5W_4	28.33 g-j	4.20 d-i	41.00 ij	3.93 d-g
M_5W_5	29.67 c-f	4.60 a-f	37.33 l-o	3.43 j-l
LSD $_{(0.05)}$	1.09	0.63	1.97	0.28
CV (%)	2.32	9.06	2.82	4.40

[M_0= Control (no maize additives), M_1= 1% (5 g/500 g packet), M_2= 2% (10 g/500 g packet), M_3= 3%(15 g/500 g packet), M_4= 4%(20 g/500 g packet), M_5= 5% (25 g/500 g packet. W_0=Control (no wheat bran), W_1= 8% (40 g wheat bran/500 g packet), W_2= 12% (60 g wheat bran/500 g packet) ,W_3= 16% (80 g wheat bran/500 g packet), W_4 = 20% (100 g wheat bran/500 g packet), W_5=24% (120 g wheat bran/500 g packet)]

Significant variation was observed among wheat bran for no. of harvest (Appendix III). The highest number of harvest/packet (4.18) for wheat bran was in the treatment W_4 and also similar highest was found in W_3 treatment. The lowest no. of harvest/packet (3.81) for wheat bran was observed in the treatment W_5 and also similar lowest found in W_1 (Table 2). From this result it is clear that 80 g wheat bran per packet gives maximum number of harvest. So this is the optimum dose for mushroom cultivation. It seems that wheat bran at low and high rate show minimum number of harvest due to excess and lower carbohydrate. Amin *et al.* (2007) found significant differences among the level of supplements used for preparing the substrates

Different combination treatment was found statistically significant for no of harvest /packet (Appendix III).The highest no. of harvest/packet (4.33) for combine effect of wheat bran and maize additives was in the treatment M_2W_3, and also statistically similar results found from M_0W_2, M_0W_3 treatment. The lowest no. of harvest/packet (3.30) for combine effect was observed in the treatment M_4W_0 (Table 3). From this result it is clear rate of 0 g, 5 g, 10 g, 25 g maize additives gives highest result with 60-80 g wheat bran. Optimum rate of maize additives and wheat bran makes nutrient available.

4.5. Length of individual stripe

Significant variation was observed among wheat bran for length of individual stripe (Appendix IV). The highest length of individual stripe (5.16 cm) for maize additives was in the treatment M_4 and statistically similar results found from M_3.The lowest length of individual stripe (4.29 cm) was observed in the treatment M_0 (Table 4). It seems that stripe length increase by increasing maize additives up to 20 g and above 20 g its length becomes decrease. So it is clear that 20 g maize additives are optimum rate per 500 g packet. 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 length of individual stripe on different substrates.

Different wheat bran treatment was found significant for length of individual stripe (Appendix IV). The highest length of individual stripe (5.46 cm) for wheat bran was in the treatment W_3 and the lowest length of individual stripe (4.29 cm) was observed in the treatment W_O (Table 5). This result shows that 80 g wheat bran is optimum dose for maximum length of stripe. It seems that wheat bran at low and high rate show minimum stripe length due to excess and lowest carbohydrate. 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 length of individual stripe with wheat bran alone. Sarker *et al.* (2007) reported the individual length of individual stripe 4-5cm. Bhuyan (2008) found significant effect.

Length of individual stripe was showed statistically significant for combination effect (Appendix IV).The highest length of individual stripe (5.93 cm) for combine effect of wheat bran and maize additives was in the treatment M_4W_2 and statistically similar results found from $M_2W_{3,}$ $M_4W_{3,}$ M_4W_4 treatment. The lowest length of individual stripe (3.73 cm) was observed for combine effect of wheat bran and maize additives in the treatment M_1W_o (Table 6). This result shows that 80 g wheat bran with 10 g maize additives is optimum dose for maximum length of stripe. It seems that wheat bran at low and high rate show minimum stripe length due to excess and lowest carbohydrate.

4.6. Breadth of individual stripe

Breadth of individual stripe was found statistically significant for maize additives (Appendix IV). The highest breadth of individual stripe (4.04 cm) for maize additives was in the treatment M_2 and also statistically similar results found in M_1. The lowest breadth of individual stripe (3.61 cm) was observed in the treatment M5 (Table 4). From this result it is clear that optimum breadth remain when 10 g maize additives used. By increasing maize additives it reduce breadth. So excess maize additives reduce standard breadth of individual stripe. 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 breadth of individual stripe.

Table 4. Effect of maize additives on the length and breadth of individual stripe, effective fruiting body and yield/packet of Oyster mushroom.

Treatments	Length of individual stripe (cm)	Breadth of individual stripe (cm)	No of effective fruiting body	Yield/packet (g)
M_o	4.29 e	3.88 c	37.39 a	166.10 b
M_1	4.62 d	3.97 ab	37.39 a	163.60 c
M_2	4.94 c	4.04 a	37.94 a	168.20 a
M_3	5.09 ab	3.89 bc	35.06 b	161.40 d
M_4	5.16 a	3.90 bc	33.78 c	155.90 e
M_5	5.02 bc	3.61 d	32.61 d	148.10 f
LSD $_{(0.05)}$	0.14	0.08	0.84	1.55
CV (%)	4.31	3.25	3.53	1.45

[M_0 = Control (no maize additives), M_1= 1% (5 g /500 g packet), M_2=2% (10 g/500 g packet), M_3=3% (15 g/500 g packet), M_4= 4% (20 g/500 g packet), M_5= 5% (25 g/500 g packet.)

Significant different was found in breadth of individual stripe for wheat bran (Appendix IV). The highest breadth of individual stripe (4.11 cm) for wheat bran was in the treatment W_3 and the lowest breadth of individual stripe (3.67 cm) was observed in the treatment W_O and also similar result was found in W_1 (Table 5). It seems that 80 g wheat bran is optimum dose for maximum breadth of stripe. So that wheat bran at low and high rate shows minimum individual breadth due to excess and lowest carbohydrate. 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 breadth of individual stripe. Kalita *et al.* (1997) observed that breadth of individual stripe for wheat bran.

Table 5. Effect of wheat bran on the length and breadth of individual stripe, effective fruiting body and yield/packet of Oyster mushroom.

[W_0 = Control (no wheat bran), W_1 = 8% (40 g wheat bran/500 g packet), W_2=12% (60 g wheat bran/500 g packet) ,W_3=16% (80 g wheat bran/500 g packet),, W_4=20% (100 g wheat bran/500 g packet), W_5=24% (120 g wheat bran/500 g packet)]

Breadth of individual stripe was found significant for combination treatment (Appendix IV). The maximum breadth of individual stripe (4.77 cm) for combine effect of wheat bran and maize additives was in the treatment M_1W_5 and the lowest breadth of individual stripe for combine effect of wheat bran and maize additives on the growth and yield of Oyster mushroom was observed in the treatment M_5W_1 (3.17 cm) (Table 6). It seems that combine effect of 5 g maize additives with 120 g wheat bran is optimum dose for obtained highest amount of fruiting body. For maize additives 5 g is optimum but it was fluctuate when used below and above level of optimum maize additives. Without wheat bran in substrate reduce carbohydrate and decrease fruiting body. Optimum dose are effective for maximum nutrient uptake. Excess and lower amount carbohydrate reduce maximum nutrient uptake rate.

Treatments	**Length of individual stripe(cm)**	**Breadth of individual stripe(cm)**	**No of effective fruiting body**	**Yield/Packet(g)**
W_o	4.29f	3.68d	30.22e	138.10f
W_1	4.45e	3.71d	33.22d	149.30e
W_2	4.97c	3.89c	37.83b	168.40c
W_3	5.46a	4.11a	40.44a	181.30a
W_4	5.28b	3.99b	37.78b	170.90b
W_5	4.67d	3.92bc	34.67c	155.30d
LSD $_{(0.05)}$	0.14	0.08	0.84	1.55
CV (%)	4.31	3.25	3.53	1.45

4.7. Effective fruiting body

Effective fruiting body for maize additives was showed statistically significant (Appendix V). The highest effective fruiting body (37.39) for maize additives was in the treatment M_2 and also nearest results found in $M_{0,}$ M_1 treatment. The lowest effective fruiting body (32.61) was observed in the treatment M_5 (Table 4). Excess use of maize additives reduces effective fruiting body. Highest level of fruiting body obtains from 10 g maize additives and it gradually reduces by using above 10 g maize additives. The result of the present findings keeps in with the findings of previous scientists (Amin, 2004 and Kulsum *et al.*, 2009). Yoshida *et al.* (1993) reported that the number of fruiting effective bodies was lower but increased when the substrates was mixed with different supplements.

Statistically significant different was found in effecting fruiting body for wheat bran (Appendix V). The highest effective fruiting body for wheat bran was in the treatment W_3 (40.44) and the lowest effective fruiting body was observed in the treatment W_0 (30.22) (Table 5). This result showed that 80 g wheat bran is optimum dose for production of maximum fruiting body. It seems that wheat bran at low and high rate show minimum number of effective fruiting body due to excess and lowest carbohydrate. 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%.

Different combination of treatment was found significant for effecting fruiting body (Appendix V). Effective fruiting body is very important factor which is related with yield production. The highest effective fruiting body (46.67) for combine effect of wheat bran and maize additives on the growth and yield of Oyster mushroom was in the treatment M_2W_3 and the lowest effective fruiting body (28.67) for combine effect of wheat bran and maize additives was observed in the treatment M_4W_0 (Table 6). From this experiment it is clear 80 g wheat bran with 10 g maize additives supply optimum level of carbohydrate .This optimum rate gives highest fruiting body. Above or below combine dose reduce effective fruiting body. Without wheat bran, it gives lowest rate of effective fruiting body.

4.8. Yield/Packet

Significant variation was observed among wheat bran for yield/packet (Appendix V). The highest yield/packet (168.2 g) for maize additives was obtain from the treatment M_2 .The lowest yield/packet (148.1 g) was observed in the treatment M_5 (Table 4). It seems that 10 g maize additives gives optimum yield per packet. Optimum level of required nutrient was found from 10 g maize additives and it reduce gradually by increasing maize additives. Bhuyan (2008) observed that the yield of *Pleurotus ostreatus* increased with increasing the levels of supplements used with maize additives thereafter. Kulsum *et al.* (2009) found that the highest yield was 213 g due to maize additives supplemented with cow dung @ 10%.

Table 6. Combined effect of maize additives and wheat bran on the length of individual and breadth of individual stripe, effective fruiting body and yield/packet of Oyster mushroom.

Treatments	Length of individual stripe (cm)	Breadth of individual stripe (cm)	No. of effective fruiting body	Yield/Packet (g)
M_oW_o	4.07 o-r	3.70 gh	31.00 n-p	144.00 k-n
M_oW_1	4.25 op	4.03 d-f	35.67 ij	160.30 g

M_oW_2	4.13 o-q	3.70 gh	41.00 de	181.00 d
M_oW_3	4.67 k-m	4.10 c-e	41.67 cd	184.30 cd
M_oW_4	4.37 m-o	4.00 d-f	35.00 i-k	161.00 g
M_oW_5	4.27 n-p	3.73 gh	35.00 i-k	158.30 gh
M_1W_o	3.73 r	3.45 ij	32.33 m-o	133.0 0r
M_1W_1	3.80 qr	3.43 ij	34.00 j-m	155.30 h
M_1W_2	4.15 op	3.73gh	44.00 b	188.70 ab
M_1W_3	5.57 b-d	4.17cd	43.67 bc	187.00 bc
M_1W_4	5.53 b-e	4.27bc	38.33 fg	172.30 e
M_1W_5	4.93 g-l	4.77a	32.00 m-o	145.30 k-m

Table 6. Continued

Treatments	Length of individual stripe (cm)	Breadth of individual stripe (cm)	No. of effective fruiting body	Yield/Packet (g)
M_2W_0	4.73kl	4.07c-e	29.67 pq	138.70 pq
M_2W_1	4.60 l-n	4.10cd	33.33 k-m	146.30 kl
M_2W_2	5.33 c-f	4.13cd	40.67de	183.00 d
M_2W_3	5.80 ab	4.17 cd	46.67 a	191.00 a
M_2W_4	5.17 f-i	4.03 d-f	41.67 cd	184.30 cd
M_2W_5	4.00 p-r	3.76 gh	39.00 ef	166.00 f
M_3W_0	4.23 op	3.33 jk	29.00 pq	134.70 r
M_3W_1	5.00 f-k	4.10 c-e	31.00 n-p	140.70 n-p
M_3W_2	5.10 f-j	4.00 d-f	32.67 l-o	150.30 ij
M_3W_3	5.60 a-d	4.10 c-e	39.33 ef	184.30 cd
M_3W_4	5.67 a-c	4.03 d-f	41.67 cd	190.30 ab
M_3W_5	4.93 g-l	3.77 gh	36.67 g-i	168.30 f
M_4W_0	4.23 p	3.73 gh	28.67 q	139.00 o-q
M_4W_1	4.20 op	3.43 ij	32.00 m-o	142.00 m-p
M_4W_2	5.93 a	4.40 b	32.67 l-o	146.70 jk
M_4W_3	5.87 ab	4.10 c-e	36.67 g-i	175.00 e
M_4W_4	5.73 ab	3.83 fg	38.00 f-h	174.70 e
M_4W_5	5.00 f-k	3.90 e-g	34.67 i-l	158.30 gh
M_5W_0	4.77 j-l	3.77 gh	30.67 o-q	139.30 o-q
M_5W_1	4.83 i-l	3.17 k	33.33 k-m	151.30 i
M_5W_2	5.17 f-i	3.37 i-k	36.00 h-j	161.00 g
M_5W_3	5.27 d-g	4.03 d-f	33.00 k-n	158.70 gh

M_5W_4	5.20 e-h	3.77 gh	32.00 m-o	142.70 l-o
M_5W_5	4.87 h-l	3.57 hi	30.67 o-q	135.70 qr
LSD $_{(0.05)}$	0.34	0.20	2.10	3.79
CV (%)	4.31	3.25	3.53	1.45

[M_0= Control (no maize additives), M_1= 1% (5 g/500 g packet), M_2= 2% (10 g/500 g packet), M_3= 3%(15 g/500 g packet), M_4= 4%(20 g/500 g packet), M_5= 5% (25 g/500 g packet. W_0=Control (no wheat bran), W_1= 8% (40 g wheat bran/500 g packet), W_2= 12% (60 g wheat bran/500 g packet) ,W_3= 16% (80 g wheat bran/500 g packet), W_4 = 20% (100 g wheat bran/500 g packet), W_5=24% (120 g wheat bran/500 g packet)]

Statistically significance was found in yield/packet **for** wheat bran (Appendix VI). The highest yield/packet (181.3 g) for wheat bran was in the treatment W_3 and the lowest yield/packet (138.1 g) was observed in the treatment W_0 (Table 5). It seems that optimum level of wheat bran gives higher amount of yield. Higher and lower dose of wheat bran gives lowest result due to amount of carbohydrate. In this experiment optimum level of wheat bran is 80 g/500 g packet. Baysal *et al.* (2003) found the highest yield of Oyster mushroom (*Pleurotus ostreatus*). 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.

Different combination treatment was found significant for yield/packet (Appendix V). The highest yield/packet (191.0 g) for combine effect of wheat bran and maize additives was in the treatment M_2W_3 and also nearest yield performance found from M_3W_4 treatment and statistically similar results found from M_1W_2, M_3W_4 treatment. The lowest yield/packet (133.1 g) for combine effect was observed in the treatment M_1W_o (Table 6). This result shows that 80 g wheat bran with 10 g maize additives is optimum dose for maximum yield. It seems that wheat bran at low and high rate show minimum yield due to excess and lowest carbohydrate. In this optimum rate is effective for maximum nutrient uptake which is essential for highest yield production.

4.9 .Functional relationship between number effective fruiting bodies and yield of fruiting bodies/packet.

The direct linear relation is obtained between number of effective fruiting bodies and average yield of mushroom by plotting yield against number of effective fruiting bodies. The figure indicates that average yield of mushroom per spawn packet increased as raising the number of fruiting bodies. The results show that about 90 %(R^2 =0.890) of yield is affected by number of effective fruiting bodies (Figure-1). This findings is also supported by Das *et al* (2014) and Sarker, *et al* (2014).

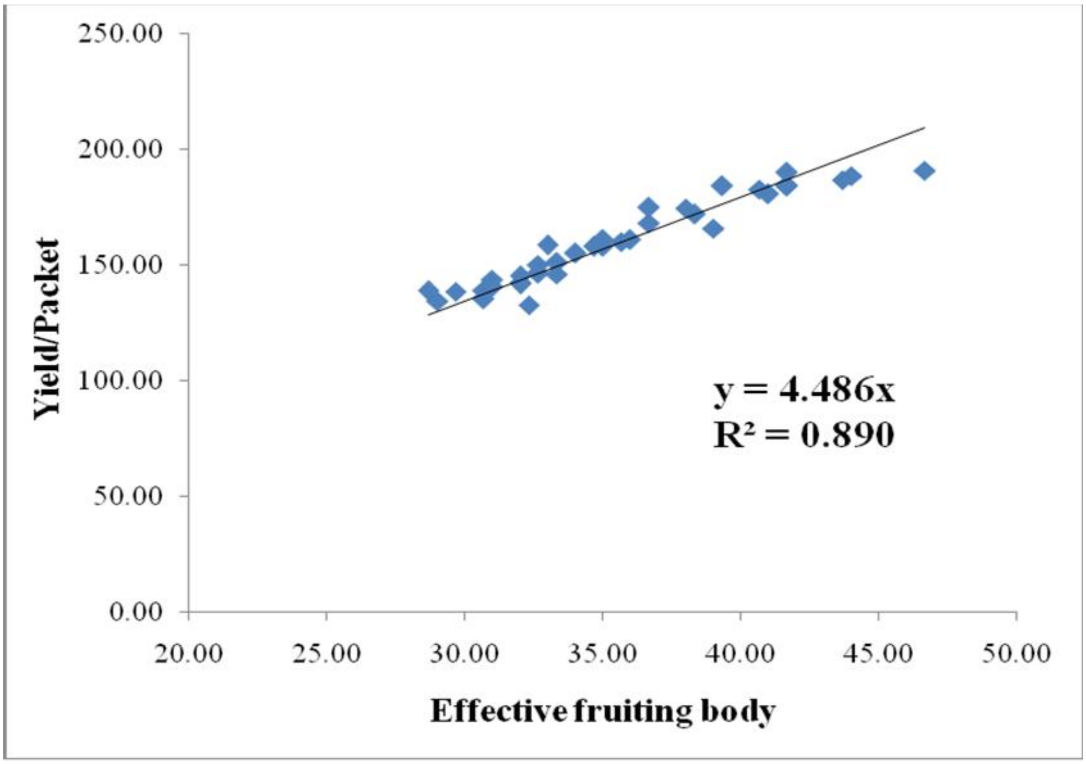

Figure 1. Functional relationship between average number effective fruiting bodies and average yield of fruiting bodies/packet

CHAPTER IV
SUMMARY AND CONCLUSION

The field experiment was conducted at Olericulture Division, HRC, BARI, Gazipur, during the period from July to December 2015 to evaluate the effect of maize additives and wheat bran on the growth and yield of Oyster mushroom. The experiment was layout in a completely randomized design. The experiment was comprised (a) six levels of maize additives viz. (M_0 =Control, M_1= 1%, M_2=2% M_3=3% M_4=4% M_2=5% (b) six levels of wheat bran viz.W0= Control W_1=8% W_2=12% W_3=16% W_4=20% W_5=24%). The treatment combinations were randomly distributed in this experiment. There were 36 treatment combinations.

The data on crop growth characters and yield contributing characters like days required for pin head development in packet, days required for pin head to first harvest , fruiting body/packet, no. of harvest/packet, length of individual stripe, breadth of individual stripe, effective fruiting body, yield/packet were recorded during experiment. Data were analyzed using MSTAT-C computerized package program. The mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance.

Summary

All characters of Oyster mushroom were significantly influenced by different levels of maize additives, wheat bran and their combine effect. The highest days required (29.61 days) for pin head development was in the treatment M_1 and the lowest days required (28.28 days) for seed in packet was observed in the treatment M_2 (Table 1) and statistically similar results found from $M_{3,}$ M_4 treatment. Maximum days required (30.67 days) for pin head development was in the treatment W_0 and minimum days required (28.17 days) for wheat bran packet was observed in the treatment W_3 and followed by W_4, W_5 treatment which also near to W_3 (Table 2). The highest days required (31.33 days) for pin head development for combine effect was in the treatment combination M_1W_o and also statistically similar results found from M_0W_0. The lowest days required (26.67 days) for pin head development was observed in the treatment M_3W_3 and also near lowest days (27.67days) was found in M_2W_3 treatment (Table 3). Maximum days required (4.50 days) for first harvest for maize additives was in the treatment M_5 and lowest days required (4.14 days) for pin head to first harvest was observed in the treatment M_0 and nearest lowest day required (4.19 days) in M_2 , M_1 treatment (Table 1) The highest days required (4.67 days) for first harvest for wheat bran was in the treatment Wo and it also similar in W_1 ,W_5 treatment. The lowest days required (3.83 days) for seed in packet for wheat bran was observed in the treatment W_4 and similar with W_3 (Table 2).Maximum days required (5.10 days) for pin head to first harvest for combine effect of wheat bran and maize additives on the growth and yield of Oyster mushroom was in the treatment M_5Wo (Table 3) and also statistically similar results found from $M_0W_{0,}$ M_3W_5. Minimum days (3.50 days) required for first harvest for combine effect was observed in the treatment M_0W_5 (Table 3). The highest fruiting body/packet (43.39) for maize additives was in the treatment M_1 and also similar fruiting body was found in $M_{2,}$ M_3, M_4 treatment. The lowest fruiting body/packet (41.61) was observed in the treatment M_0 (Table 1). The highest number of fruiting body/packet (49.56) for wheat bran was in the treatment W_3 and the lowest fruiting body/packet (36.17) was observed in the treatment W_0 (Table 2). The highest fruiting body/packet (53.67) required for combine effect of wheat bran and maize additives was in the treatment M_3W_4 and the lowest fruiting body /packet (35.0) required for combine effect of wheat bran and maize additives was observed in the treatment M_4W_0 (Table 3). The highest no. of harvest/packet (4.06) for maize additives was in the treatment Mo and also similar M_1 treatment. The lowest no. of harvest/packet (3.73) was observed in the treatment M4 (Table 1). The highest number of harvest/packet (4.18) for wheat bran was in the treatment W_4 and also similar highest was found in W_3 treatment. The lowest no. of harvest/packet (3.81) for wheat bran was observed in the treatment W_5 and also similar lowest found in W_1 (Table 2). The highest no. of harvest/packet (4.33) for combine effect of wheat bran and maize additives was in the treatment M_2W_3, and also statistically similar results found from $M_0W_{2,}$ M_0W_3 treatment. The lowest no. of harvest/packet (3.30) for combine effect was observed in the treatment M_4W_0 (Table 3). The highest length of individual stripe (5.16 cm) for maize additives was in the treatment M_4 and statistically similar results found from M_3.The lowest length of individual stripe (4.29 cm) was observed in the treatment M_0 (Table 4). The highest length of individual stripe (5.46 cm) for wheat bran was in the treatment W_3 and the lowest length of individual stripe (4.29 cm) was observed in the treatment W_O (Table 5). The highest length of individual stripe (5.93 cm) for combine effect of wheat bran and maize additives was in the treatment M_4W_2 and statistically similar results found from $M_2W_{3,}$ $M_4W_{3,}$ M_4W_4 treatment. The lowest length of individual stripe (3.73 cm) was observed for combine effect of wheat bran and maize additives in the treatment M_1W_o (Table 6). The highest breadth of individual stripe (4.04 cm) for maize additives was in the treatment M_2 and also statistically similar results found in M_1. The lowest breadth of individual stripe (3.61 cm) was observed in the treatment M5 (Table 4). The highest breadth of individual stripe (4.11 cm) for wheat bran was in the treatment W_3 and the lowest breadth of individual stripe (3.67 cm) was observed in the treatment W_O and also similar result was found in W_1 (Table 5). The maximum breadth of individual stripe (4.77 cm) for combine effect of wheat bran and maize additives was in the treatment M_1W_5 and the lowest breadth of individual stripe for combine effect of wheat bran and maize additives on the growth and yield of Oyster mushroom was observed in the treatment M_5W_1 (3.17 cm) (Table 6). The highest effective fruiting body (37.39) for maize additives was in the treatment M_2 and also nearest results found in $M_{0,}$ M_1 treatment. The lowest effective fruiting body (32.61) was observed in the treatment M_5 (Table 4). The highest effective fruiting body for wheat bran was in the treatment W_3 (40.44) and the lowest effective fruiting body was observed in the treatment W_0 (30.22) (Table 5). The highest effective fruiting body (46.67) for combine effect of wheat bran and maize additives on the growth and yield of Oyster mushroom was in the treatment M_2W_3 and the lowest effective fruiting body (28.67) for combine effect of wheat bran and maize additives was observed in the treatment M_4W_0 (Table 6). The highest yield/packet (168.2 g) for maize additives was obtain from the treatment M_2 .The lowest yield/packet (148.1 g) was observed in the treatment M_5 (Table 4). The highest yield/packet (181.3 g) for wheat bran was in the treatment W_3 and the lowest yield/packet (138.1 g) was observed in the treatment W_0 (Table 5). The highest yield/packet (191.0 g) for combine effect of wheat bran and maize additives was in the treatment M_2W_3 and also nearest yield performance found from M_3W_4 treatment and statistically similar results found from $M_1W_{2,}$ M_3W_4 treatment. The lowest yield/packet (133.1 g) for combine effect was observed in the treatment M_1W_o (Table 6).

CONCLUSION

From the above discussions it may be concluded that application of maize additives and wheat bran influenced Oyster mushroom growth and yield as well as production.

1.The optimum level of maize additives is 10 g per packet. This optimum dose gives maximum yield, maximum length and breadth, effective fruiting body and over all lower days for cultivation.

2. For wheat bran 80g per packet is optimum for Oyster mushroom. It seems that wheat bran at low and high rate show minimum yield due to excess and lowest carbohydrate

3. Combination effect of wheat bran and maize additives on the growth and yield of Oyster mushroom was optimum in the treatment M_2W_3 (Table 6). This result shows that 80 g wheat bran with 10 g maize additives is optimum dose for maximum yield and also gives maximum growth.

From this combination, we can get maximum yield, maximum length and breadth, effective fruiting body and over all lower days for cultivation. Therefore, judicious combine application of these two vital elements through maize additives and wheat bran respectively is needed and based of this research results it could be suggested that application of 10 g/ packet and 80 g/packet to be a promising practice for Oyster mushroom cultivation in Bangladesh.

However, to reach a specific conclusion and recommendation, more research work on the application of maize additives and wheat bran in Oyster mushroom cultivation should be done over the country.

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APPENDICES

Appendix I. Monthly average of lab temperature and relative humidity during the period from July to December.

Month	Temperature (°C)		Relative humidity (%)
	Minimum	Maximum	
July, 2015	10	25	90
August, 2015	10	28	90
September, 2015	15	25	90
October, 2015	10	25	90
November, 2015	10	25	90
December, 2015	11.00	25.00	90

(Source:BARI, 2015)

Appendix II. Mean square values for days required for development of pin head and days required from pin head to first harvest.

Sources of variation	Degrees of freedom	Mean square value	
		Days required for development of pin head of mushroom from seed in packets	Days required from pin head to first harvest
Replication	2	0.065	0.804
Maize additives	5	5.237**	0.312**
Wheat bran	5	18.770**	1.908**
Interaction	25	1.606**	0.421**
Error	70	0.446	0.148

** Indicates significant at 1% level of probability

Appendix III. Mean square values for fruiting bodies produced\packet and no. of harvest/packet .

Sources of variation	Degrees of freedom	Mean square value	
		Fruiting bodies produced\packet	No. of harvest/packet
Replication	2	4.231	0.023
Maize additives	5	20.231**	0.275**
Wheat bran	5	451.809**	2.003**
Interaction	25	28.689**	0.101**
Error	70	1.470	0.030

** Indicates significant at 1% level of probability

Appendix IV. Mean square values for length of individual stripe and breadth of individual stripe

Sources of variation	Degrees of freedom	Mean square value	
		Length of individual stripe	Breadth of individual stripe
Replication	2	0.017	0.016
Maize additives	5	1.996**	0.387**
Wheat bran	5	3.871**	0.493**
Interaction	25	0.492**	0.277**
Error	70	0.044	0.016

** Indicates significant at 1% level of probability

Appendix V. Mean square values for no. of effective fruiting bodies and yield of fruiting bodies/packet

Sources of variation	**Degrees of freedom**	**Mean square value**	
		No. of effective fruiting bodies	**Yield /packet**
Replication	2	0.361	5.954
Maize additives	5	87.817**	993.215**
Wheat bran	5	246.92**	4527.681**
Interaction	25	28.208**	409.704**
Error	70	1.590	5.420

** Indicates significant at 1% level of probability

PLATES

Plates 1. Maize additives substrate

Plates 2. Wheat bran substrate

Plates 3. Mycelium running complete

Plates 4. Spawn packets are arranged in shelf

Plates 5. Spawn packet is cut in “D” shape

Plates 6. Pin head primordia in the spawn packet

Plate 7.Yeild performance of $M_2 \times W_3$ treatment