



Research Article

Growth and yield performance of oyster mushroom (*Pleurotus ostreatus*) on different substrates

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Abstract Oyster mushroom (*Pleurotus oestratus*) has outstanding flavor and taste with fan shaped pileus which is rich source of both macro and micro nutrients. It is of paramount importance to choose appropriate substrates in a given place to grow oyster mushroom successfully. The experiment was conducted at Bangaun, Lamahi, Dang, Nepal during 2018-19 to study the growth performance of oyster mushroom on locally available substrates as well as to find out the best substrate. The substrates used in the experiment were lentil straw, rice straw, wheat straw, maize stover, maize cob, along with the mix ratio of corn cob 1:3 with these substrates under factorial completely randomized design (CRD) design with four replications during winter season with an average daily temperature of 12-21°C and RH ranging from 80 to 90%. Among the tested substrate composition, significantly the lowest days (17.5 days) to complete spawn running was recorded on maize cob followed by lentil straw (22.5 days) while highest days (30.75 days) was required to complete spawn running on rice straw. The lowest time (25.50 days) for first fruiting initiation, the lowest time (33 days) for harvesting and the highest yield (2.47 kg) was revealed by lentil straw. The highest pileus diameter (6.81 cm) was recorded on wheat straw followed by rice and maize cob mix at 3:1 ratio (6.58 cm). Lentil straw was found the best substrate and rice straw mix with maize cob was more efficient as compared to rice straw only for the production of *Pleurotus ostreatus* mushroom.

Keywords: Oyster mushroom, substrates, straw, spawn, yield

Introduction

Mushrooms are a good source of protein, vitamins and minerals (Kimenju *et al.*, 2009.) and their protein is intermediate between that of animals and vegetables (Kurtzman, 1976). Mushrooms have played an important role as a human food due to its nutritional and medicinal properties. Oyster mushrooms are one kind of edible saprophytic fungi growing on dead organic matters of vegetative origin belonging to the genus *Pleurotus* under the class Basidiomycetes (Mondal *et al.*, 2010). They are having outstanding flavor and taste with fan shaped pileus which is rich source of both macro and micro nutrients. Oyster mushroom has no starch, low sugar content and high amount of fiber, hence it serves as the least fattening food (Oei, 1996). Oyster mushrooms is rich in nutritional value has with dried protein (25-50%), fat (2-5%), sugars (17-47%), mycocellulose (7-38%) and minerals (potassium, phosphorus, calcium, sodium) of about 8-12% (Sher, 2010). Recently, its importance and nutritive value has been realized and well utilized in human consumption diet. Livelihood can be improved because the demand of mushroom has been increasing due to increasing population, market expansions and changing of

consumer behavior (Celikand and Pekker, 2009). There are several species of *Pleurotus* identified in the world and suitable for cultivation, some of them are *Pleurotus ostreatus*, *P. florida*, *P. sajorcaju*, *P. eryngii* (Nadir *et al.*, 2016). However, the most important cultivated species is *Pleurotus ostreatus*, being easier to cultivate, favorable to grow on different kinds of agriculture by products i.e. rice straw, sawdust, wheat straw, corn silk, sugarcane bagasse and other plant fibers having cellulose content (Ju, 1994; Kong, 2004). Several species of oyster mushroom can be grown on lignocelluloses, forest by-products and agricultural wastes (Chang, 1999). Cultivation of oyster mushroom with agricultural residues, such as rice and wheat straw is a value added process to convert these materials into human food (Pokhrel *et al.*, 2013). Agricultural substrates such as paddy straw, vegetable residues, maize stalks and cotton waste are utilized for cultivation of oyster mushroom (Hassan *et al.*, 2011). Substrates having high levels of nitrogen and carbohydrate contents are categorized as ideal for mushroom growth (Khare *et al.*, 2010). Ecological requirements of oyster mushrooms vary at the various stages of growing period. The growth of oyster mushroom requires high humidity (80-90%) and high

temperature (25-30°C) for the vegetative growth called spawn running and lower temperature (18-25°C) with high humidity 80 to 95% during fruit body formation, (Onyango *et al.*, 2011 and Nadir *et al.*, 2016). Oyster mushroom can be grown on various agricultural wastes with the use of different technologies, however in Nepal rice straw is the most common. Majority of farmer use rice straw for oyster mushroom production as and they are not familiar with efficiency and methods of *Pleurotus* mushroom production using other agro bi-products like lentil straw, wheat straw, maize stover, maize cob etc. During the main harvesting period, corn cobs and stalks are in abundance and farmers dispose of them by burning. If grounded corn cob can support the growth of oyster mushroom, then it would serve as a cheap source of substrate for mushroom growers. The grounded form of corncob is very firm and retains good amount of moisture to make it a plausible alternative to saw dust (Buah *et al.*, 2010). The experiment was conducted on rice straw, wheat straw, lentil straw, maize stover, maize cob along with the mix ratio of corn cob 1:3 with these substrates with a view to determine the cheapest substrate with best yield performance. This study we will be able to suggest

best alternative substrates other than single rice straw substrate.

Materials and methods

Experimental site

The experiment was conducted in Mushroom production house of Prithu Technical College, Bangaun, Dang, Nepal. Geographically the experimental site was located at latitude 27.9904° N and longitude 82.3018° E, 567 masl. The experiment was conducted during November 30, 2018 to February 27, 2019.

Spawn Collection

The oyster mushroom *Pleurotus oestratus* was used in the experiment and spawn for the conduction of experiment was collected from the Regional Agricultural Research Station, NARC, Khajura, Banke Nepal. All together 15 packets of 250g sized spawn was collected.

Preparation of Substrates

The experiment was laid by using Factorial Completely Randomized design having four replications.

Table 1: Detail of treatments and composition

S. N.	Treatments	Composition
1	Substrate -1	Rice straw
2	Substrate -2	Lentil straw
3	Substrate -3	Maize stover
4	Substrate -4	Wheat straw
5	Substrate -5	Maize cob
6	Substrate -6	Rice straw : Maize cob = 3:1
7	Substrate -7	Lentil straw: Maize cob = 3:1
8	Substrate -8	Maize stover: Maize cob = 3:1
9	Substrate -9	Wheat straw : Maize cob = 3:1

The required substrates like corn cobs, wheat straw, rice straw, lentil straw, maize stover, were collected from farms around the Prithu Technical College, Bangaun. Corn cob was reduced into small sizes using a hammer where as remaining other substrates were chopped into small pieces of 1-2 inch with a sickle after sun drying. The substrate composition was solely the rice straw, wheat straw, lentil straw, maize stover along with the mix ratio of corn cobs in 1:3 with all these substrates each of 6 kg.

The substrate materials were washed thoroughly with clean water and soaked for 30 minutes and excess water was allowed to drain down so that water didn't ooze out when squeezed with hand.

Sterilization of substrates

Each substrate was individually sterilized by steam using metallic drum for 1 to 2 hrs and were allowed to cool to normal temperature or 20-25°C, which was then filled into plastic bags of size 16''x 24'' making four layers.

Spawning and filling the substrates

The different substrate composition were mixed thoroughly on sterilized cemented floor and filled in to the polypropylene bags (16 x24 cm). Each mushroom ball was prepared by filling 6 kg weight of the substrates. Spawning was done at periphery of each layer with 20 g of spawn and altogether four spawn layers was made alternately with substrates maintaining 5 cm gap. Top layer spawning was also done on each mushroom ball.

After completion of spawning the bags were tied at the mouth and for aeration few holes were made around the periphery of plastic bag with a pencil size thickened wooden stick. The bags were then marked treatment wise with a permanent marker.

Incubation

The experiment was laid out in factorial completely randomized design (CRD) with nine treatments and 4 replications. Thus, there were altogether 36 bags. The mushroom balls were placed randomly in a floor of a sterilized dark room for incubation. The bags were incubated until mycelium had fully colonized the substrate.

Fruiting

After complete colonization the mushroom balls were taken to the fruiting room. The thickening of the mycelia in the bags and colonization of the bags was an indication for the completion of the spawn run. After the substrates were fully colonized with mycelium, the plastics were removed and placed in dispersed light with well ventilated condition. Watering was done twice a day to maintain high relative humidity (80-85%), low temperature (22-27°C) at culture for the development of fruiting body. After complete fruiting, harvesting was done in different flushes.

Data collection and statistical analysis

Data on time required for spawn running, primordial initiation, harvesting, stalk length, stalk diameter, pileus diameter, and biological yield were recorded. The stipe

length, stipe diameter, pileus diameter was measured as an average of five samples taken randomly from each treatment during harvest time. Observed data were then analyzed by R-Studio. Analysis of variance (ANOVA) was used to test differences among the treatments and means were separated using Duncan's multiple range test (DMRT) at the 5% level of significance (Gomez and Gomez, 1984).

Result

Nine different types of substrates along with mix ratio were compared with respect to production of oyster mushroom. The substrates used in this study exhibited variation in spawn run, days to harvest, stipe length and diameter, pileus diameter and total yield.

Time (days) required for complete colonization, primordia formation and harvesting

Treatment means are separated by Duncan's Multiple Range Test (DMRT) and the columns represented by the same letter (s) are not significantly different among each other at 5%.

Analysis of variance (ANOVA) revealed highly significant results among the tested substrates ($p \leq 0.05$) in colonization duration, first fruiting duration and first harvest duration. Days to complete colonization ranged from 17 days to 30 days on different substrates. Significantly the lowest days (17.5 days) to complete spawn running was recorded on maize cob followed by lentil straw (22.5 days) while the highest day (30.75 days) was required to complete spawn running on rice straw followed by maize straw (29.50 days).

Table 2: Effect of different substrates on first colonization duration, first fruiting duration, first harvesting duration of oyster mushroom

Substrates	1 st colonization duration(days)	1 st Fruiting duration(days)	1 st Harvesting duration (days)
Maize cob	17.5 ^g	42.75 ^a	58.25 ^a
Wheat straw	33 ^a	37.50 ^b	45.50 ^{bc}
Wheat mix	28 ^d	34.25 ^{bc}	48.00 ^b
Rice straw	30.75 ^b	33.75 ^c	45.50 ^{bc}
Maize straw	29.50 ^c	33.00 ^{cd}	46.50 ^b
Rice mix	28 ^d	32.75 ^{cd}	42.75 ^c
Maize straw mix	27 ^d	30.00 ^{de}	37.25 ^d
Lentil mix	24 ^e	27.25 ^{ef}	38.75 ^d
Lentil straw	22.5 ^f	25.50 ^f	33.00 ^e
Grand Mean	26.69	32.97	43.94
CD($P \leq 0.05$)	1.04	3.40	3.62
CV%	2.67	7.10	5.68
F test	**	**	**

** = Significant at 1% level, Mean values within the same column that bear different superscript letters are significantly different ($\alpha < 0.05$), CV=Coefficient of variation and CD= Critical difference.

The fruiting duration was also statistically significant to the different substrate composition. Significantly lowest time (25.50 days) for first fruiting initiation was recorded on lentil straw followed by lentil and maize cob mixture 3:1 (27.25 days) while the highest time (42.75 days) for first fruiting initiation was found in maize cob followed by wheat straw (37.50 days).

The harvesting duration was also statistically significant to the different substrate composition. The lowest time (33 days) for harvesting was recorded from lentil straw followed by maize straw and maize cob mixture 3:1 (37.25 days) while the highest days for harvesting was recorded on maize cob (58.25 days) followed by wheat and maize cob mixture 3:1 (48 days).

Effect of different substrates on yield of oyster mushroom

Analysis of variance showed highly significant result among the tested substrates ($p \leq 0.05$) for final yield. The yield was measured during each harvest and the total yield was calculated finally. It was found highest from lentil straw (2.47 kg) followed by rice and maize cob mixture 3:1 (1.74 kg) while the lowest yield was observed in maize cob (0.16 kg) followed by wheat and maize cob mixture 3:1 (1.01 kg) under similar environment and cultural practices among other substrates.

Table 3: Effect of different substrates on yield of oyster mushroom

Treatments	Yield (kg)
Lentil straw	2.47 ^a
Rice mix	1.74 ^b
Maize Stover mix	1.52 ^{bc}
Wheat straw	1.46 ^{bc}
Rice straw	1.43 ^{bc}
Lentil mix	1.15 ^{bc}
Maize Stover	1.15 ^{bc}
Wheat mix	1.01 ^c
Maize cob	0.16 ^d
Grand Mean	1.34
CD($P \leq 0.05$)	0.59
CV(%)	2.05
F test	**

** = Significant at 1% level, Mean values within the same column that bear different superscript letters are significantly different ($\alpha < 0.05$), CV=Coefficient of variation and CD= Critical difference

Effect of different substrates on pileus diameter of oyster mushroom

The diameter of the pileus differed significantly on different substrates. The pileus diameter was measured as an average of five samples taken randomly from each treatment. The highest pileus diameter was recorded on

wheat straw (6.81 cm) followed by rice and maize cob mix at 3:1 ratio (6.58 cm) and lentil straw (6.57 cm) while the lowest diameter was recorded on maize cob (3.87 cm) under similar environment and cultural practices among other substrates.

Table 4: Effect of different substrate on pileus diameter of oyster mushroom

Treatments	Cap diameter (cm)
Wheat straw	6.81 ^a
Rice mix	6.58 ^a
Lentil straw	6.57 ^a
Rice straw	6.41 ^a
Wheat mix	6.15 ^{ab}
Maize Stover	5.47 ^{bc}
Lentil mix	5.39 ^{bc}
Maize Stover mix	4.89 ^c
Maize cob	3.87 ^d
Grand Mean	5.77
CD(P≤0.05)	0.83
CV (%)	9.97
F test	**

** = Significant at 1% level, Mean values within the same column that bear different superscript letters are significantly different ($\alpha < 0.05$), CV=Coefficient of variation and CD= Critical difference

Effect of different substrates on stipe diameter of oyster mushroom

Analysis of variance showed highly significant result among the tested substrates ($p \leq 0.05$) for stipe diameter. The stipe diameter was measured as an average of five

samples taken randomly from each treatment. In case of stipe diameter, it was found highest from wheat and maize cob mixture 3:1 (1.65 cm) followed by wheat straw (1.59 cm) while, lowest stipe diameter was observed in maize cob (0.75 cm) under similar environment and cultural practices among other substrates.

Table 5: Effect of different substrates on stipe diameter of oyster mushroom

Treatments	Stipe diameter (cm)
Wheat mix	1.65 ^a
Wheat straw	1.59 ^{ab}
Lentil straw	1.43 ^{bc}
Rice mix	1.36 ^{cd}
Lentil mix	1.19 ^{de}
Rice straw	1.11 ^e
Maize Stover mix	1.08 ^e
Maize Stover	1.01 ^e
Maize cob	0.75 ^e
Grand Mean	1.24
CD(P≤0.05)	0.23
CV (%)	12.66
F test	**

Mean values within the same column that bear different superscript letters are significantly different ($\alpha < 0.05$), LSD=Least significant difference at 5% probability, ** indicates mean values are highly significant at 1% level, CV=Coefficient of variance, MsEm=Mean sum of square.

Effect of different substrates on stipe length of oyster mushroom

Stipe length was significantly differed on the different substrates compositions. Among the tested substrates composition the highest stipe length was recorded on

lentil straw mix (4.40 cm) followed by rice straw (4.33 cm) and lentil straw (4.26 cm) while the lowest stipe length (2.60 cm) was recorded on maize cob followed by wheat straw (3.30 cm).

Table 6: Effect of different substrates on stipe length of oyster mushroom

Treatments	Stipe length (cm)
Lentil mix	4.40 ^a
Rice straw	4.33 ^a
Lentil straw	4.26 ^a
Maize straw mix	4.17 ^a
Maize Stover	4.10 ^a
Rice mix	4.05 ^a
Wheat straw	3.30 ^b
Wheat mix	3.10 ^{bc}
Maize cob	2.60 ^c
Grand Mean	3.81
CD(P≤0.05)	0.53
CV(%)	9.74
F test	**

** = Significant at 1% level, Mean values within the same column that bear different superscript letters are significantly different ($\alpha < 0.05$), CV=Coefficient of variation and CD= Critical difference

Relation between yield attributes (cap diameter) and yield

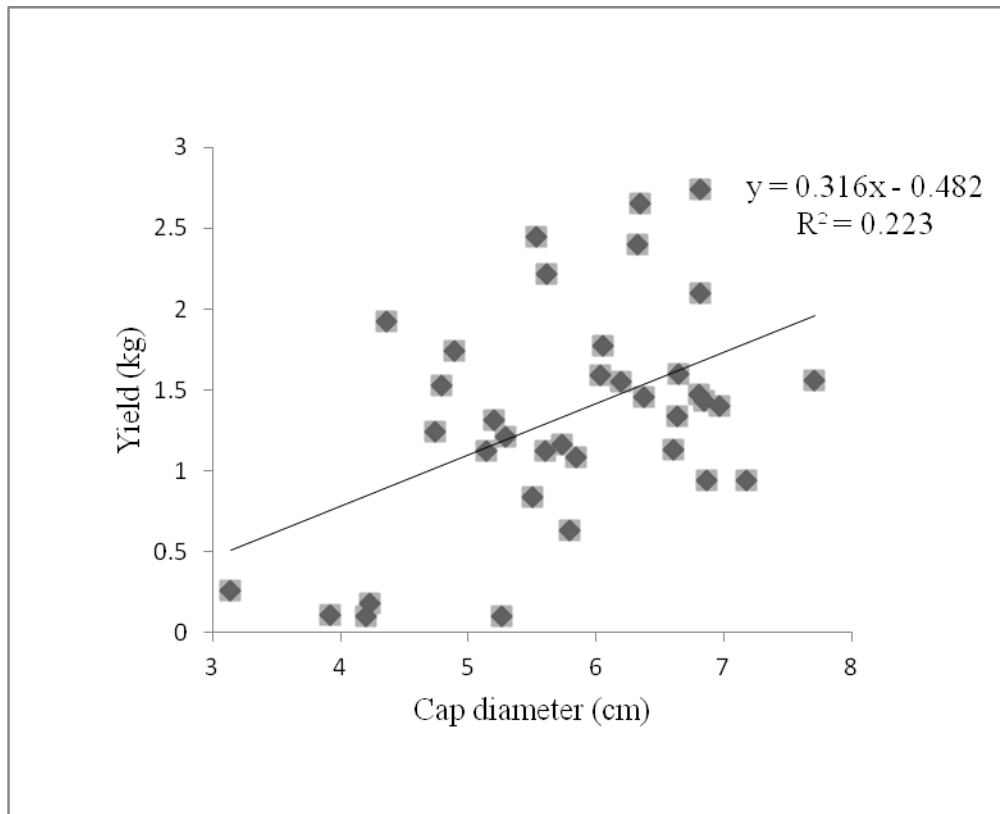


Figure 1: Relation between pileus diameter and yield

A positive linear relationship was observed between economic yield and cap diameter (Fig. 1).

This suggests that yield is dependent on pileus diameter of effective fruiting body. More than 22 % ($R^2=0.223$) of variation in the yield may be explained by variation of pileus diameter and remaining by other factors.

Discussion

The days to complete colonization of oyster mushroom on different substrates was recorded and found significantly different among the substrates this might due to the variation in their chemical composition and C:N ratio as reported by Bhatti *et al.* (1987). The shortest period of colonization (22.5 days), first fruiting (25.5 days) and first harvesting (33 days) along with the highest yield (2.47 kg) was revealed by the substrate lentil straw which might be due to the presence of right proportion of hemicelluloses, lignin and carbon /nitrogen ratio on lentil straw. Quimio and Sardud (1981) also supported the results, who found that the optimum carbon /nitrogen ratio for mycelial growth of *P. ostratus* was ranged from 40:1 to 90:1. Our findings was also supported by the Iqbal *et al.*, (2005) and Kimenju *et al.*, (2009), they also reported that the growth of the mushroom is considered to be dependent upon the performance of the substrates .Days to complete spawn running was ranged from 17 days to 30 days on different substrates where as Ahmed (1998) stated completion of spawn running in 17-20 days on different substrates. The result of present experiment are in agreement with the findings of Bugarski *et al.*, (1994) who found that the first fruiting occurred on different days depending on substrates. Those substrates recording highest stipe length recorded the poor yield which was also supported by Zadrazil (1978) who reported that the quality of oyster mushroom depends on the length of stalk and the higher the length of stalk, the poor the quality of mushroom. The positive relationship was observed between the pileus diameter and the yield. The lowest yield was recorded on corn cobs.

Conclusion

From the research study, it is concluded that the substrate source affects greatly the performance and growth of oyster mushroom and lentil straw is more efficient for the production of oyster mushroom (*Pleurotus ostreatus*), as compared to rice straw which is very common in practice and other different substrates. Length and diameter of stipe, pileus diameter and spawn running duration were the most important yield attributing character of mushroom. Rice straw mix with maize cob is also more efficient as compared to rice straw only for the production of *oyster mushroom*.

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