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Cultivation of blue oyster medicinal mushroom (*Hypsizygus ulmarius* (Bull.: Fr.) Redhead) on various agricultural residue for growth, yield and nutrient content

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Abstract
The research experiment of blue oyster mushroom was carried out to investigate the cultivation on different agricultural and weed substrates. Among, the seven treatments agricultural substrates such as (wheat straw, banana leaves, sawdust, bajra dry stem and bamboo leaves) and weed substrates (dood grass and sarpat) replicated six times under the complete randomized design. The data were recorded and analyzed at the different stages of growth, total yield, biological efficiency as well as the protein and carbohydrate content of the mushroom. The data was observed from the 1st, 2nd and 3rd flushes of all the treatments. The objective of this study was to evaluate the performance of best agricultural and weed substrates on the growth, maximum yield production with highest biological efficiency and nutritional content of mushroom. The best substrates for spawn run, primordial initiation, primordial stage to harvesting was recorded (wheat straw + banana leaves) in (1:1). The maximum yield was recorded in T_3 ((wheat straw + banana leaves) (936.6 gm) with the highest biological efficiency and minimum yield were recorded in T_5 (wheat straw + saw dust) (665 gm) as compared with the wheat straw (control). The maximum protein and carbohydrates content were recorded in T_3 (wheat straw + banana leaves) (35%) and (25.33%) in comparison to the other treatments. The revealed data show that banana leaves substrates in combination with wheat straw proved to be best and weed substrates also good for cultivation of *Hypsizygus ulmarius.*

Keywords: *Hypsizygus ulmarius*, growth, yield, nutrient content and lignocellulosic substrates

Introduction
Mushrooms found in nature (on soil, stumps, rotting wood or other organic substrates) are basidiomata of fungal species (fruiting bodies or sporocarps). Mushroom was those fungi that have a stem (stipe), a cap (pileus), and gills (lamellae) or pores on the underside of the cap. The main body of these fungi is situated on substrate and consists of a network of branched hyphae (thread-like structures), which form the fungal mycelium. Mushroom belongs to the kingdom Fungi under the subdivision Basidiomycotina due to its unique fungal characteristics (Song *et al*., 2004) [12]. *Pleurotus* (Fr.) was first cultivated during the first world war in Germany (Kaufert *et al.*, 1936) [6].

India has diverse climatic conditions in different regions and possible to cultivate many varieties of mushrooms (Sharma *et al.*, 2017) [11]. More than 2000 edible species, about 300 species belonging to 70 genera are reported from India (Karthika and Murugesan, 2015). The total mushroom production in India is 0.13 million tons. The recent production data revealed that button mushroom production holds the maximum share of about 73 per cent and followed by oyster mushroom with 16 percent (Sharma *et al.*, 2017) [11]. Shiitake, oyster, wood ear and button mushroom contribute 22, 19, 18 and 15%, respectively in terms of total mushroom production in the world (Singh *et al*., 2017).

In India mushroom production was increased by approximately 120,000 tons annually, which is 1.8% of the global production. The highest production of oyster mushroom is in Odisha (6310 MT) followed by Bihar (1500 MT), Uttar Pradesh (100 MT) and lowest in Sikkim (2 MT) in 2016.

Hypsizygus ulmarius commonly called as "Elm oyster" or "Blue oyster" is similar to oyster mushroom, but differ in morphology and biological efficiency. It is a novel species with very large fruiting bodies, blue colored pinheads becoming light white on maturity, high yield repeatable with meaty flavour and attractive keeping quality. *H. ulmarius* is a high yielding mushroom and is gaining popularity in Asia and Europe owing to its simple and low-cost

production technology and higher biological efficiency (Mane *et al.*, 2007) [8]. *Hypsizygus ulmarius* are efficient lignin degraders which can grow on wide variety of agricultural wastes with broad adaptability to varied agro-climatic conditions. Mushroom cultivation technology is environmentally-friendly; the mushroom mycelia can produce a group of complex extracellular enzymes which can degrade and utilize the lignocellulosic wastes and thereby reducing pollution. Mushrooms are highly tasty and nutritional foods liked by many populations around the world. Protein in oyster mushroom has the nutritional requirements of all essential amino acids for adults (Carrasco-González *et al.*, 2017) [1]. They appear as a good source of several vitamins (thiamine, riboflavin, niacin, ascorbic acid, vitamin A, B, C, D) and mineral (sodium, potassium, calcium, iron, etc.). As nutrient source of protein, carbohydrates, vitamins, calcium and iron, it can be used in a variety of applications (Correa *et al.*, 2016) [3]. Oyster mushroom can be used for medicinal purposes which can increase the immune power of our body against diseases. Therefore, it can be used as a dietary supplement (Khatun *et al.*, 2015) [7].

Mushroom cultivation technology is very vital to tackle against shortage of food, diminishing quality of human health and pollution of the environment, which human beings still face, and will continue to face, due to the continued increase of the world population, natural resource degradation and impacts from climate change (Chang, 2008; Oseni *et al.*, 2012) [2]. Substrate which is known as compost is a solid waste fermentation process, and exploits the phenomenon of microbial degradation and mineralization. Mushroom cultivation, typical commercial industry focused on profits gain in terms of most effective, low cost and locally available mushroom substrates materials (Fatriasari *et al.*, 2016) [4]. Wheat straw, sarpat, bajra dry stem, banana leaves, bamboo leaves, sawdust and doob grass are evaluated due to the varied nature and nutrient content of the substrates. *Hypsizygus ulmarius* popularized at large scale due to greater biological efficiency (97.5%) and higher protein content (33.6%). Mushroom cultivation is sustainable farming, high production per surface area in low input, cheap and improved method of growing.

Materials and Methods

The experiment was carried out at Sam Higginbottom University of Agriculture, Technology And Sciences, during the period of October 2018 to 2019.

Wheat straw, saw dust, sarpat, doob grass, bajra dry stem, banana leaves and bamboo leaves were collected from local areas of village. The room was complete sterilization with 0.2% formaldehyde kept in Petri plates in all the four corners of the mushroom crop room. The crop room was opened next day to allow the complete liberation of the fumigated gas. The wheat straw, bamboo leaves, bajra dry stem, sarpat, banana leaves and doob grass were chopped into small pieces of 2-3 cm. Hundred liters of tap water was filled in plastic drum. The water was mixed with Bavistin (0.03%), calcium carbonate (2 gm) and formalin (2%) to make solution with water. Sixty per cent moisture content in the straw was ready for spawning. The wheat spawn was thoroughly broadcasted @ 6% (60 g/kg) of substrates. Each treatments of 2.0 kg wet substrates were used which was equally divided in six bags representing each as replication. After inoculation and bagging of substrates these bags were put for spawn running in the crop room for 15-17 days in the dark room at appropriate temperature. Completely colonized by the mushroom mycelium (complete spawn run), the polythene bags were cut and removed. The mature fruiting bodies were harvested by hand pick in clock or anti-clockwise rotation before spraying of water. All the experiment data were analyzed by completely randomized design (CRD). The data was recorded at different stages of growth, development and nutrient of *Hypsizygus ulmarius*.

Result and Discussion

All seven treatments were recorded at different stages of growth, number of days required for spawn run, primordial initiation, width of pileus (cm), length of stipe (cm), yield of three flushes (g), biological efficiency (%), protein (%) and carbohydrate (%) of mushroom. The growth of mycelium on different substrates differed from each other. The minimum number of days was taken for complete spawn running in T_3(wheat straw + banana leaves) (19.33 days).The presence of right proportion of alpha-cellulose, hemicellulose and lignin is responsible for higher mycelium running rate in banana leaves. Minimum number of days was taken for pinhead initiation in T_3 (wheat straw+ banana leaves) (22.83 days). Primordial initiation depends on spawn running after the complete colonization of the substrates. The minimum number of days was taken from spawn run to harvest of T_3 (wheat straw + banana leaves) (25.83 days). The difference in number of days for fruiting body formation may be due to the ability of *Pleurotus* species to breakdown the cellulose to simpler molecules which are utilized for the growth.

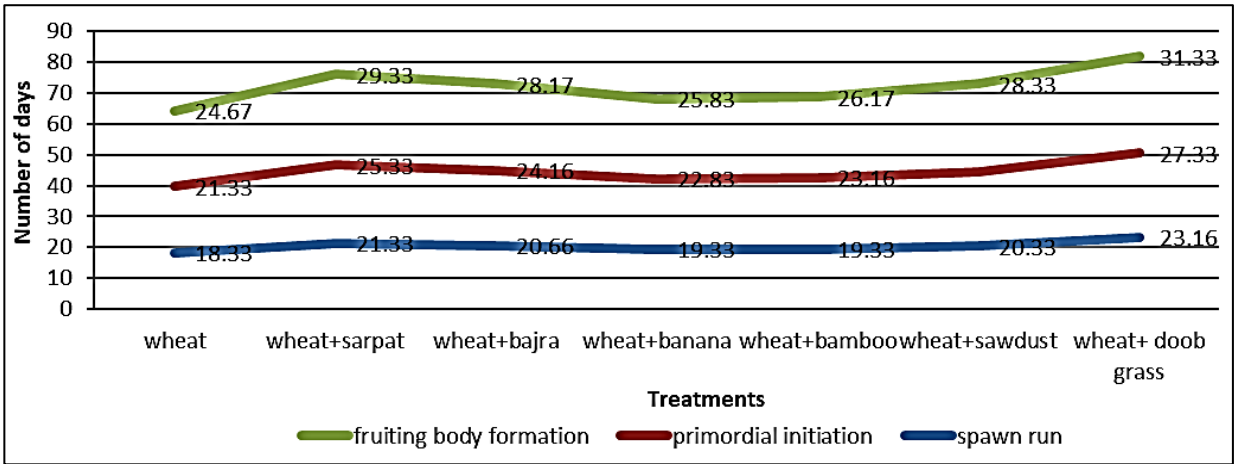

Fig 1: Number of days required for complete spawn run, primordial initiation and fruiting body formation of *Hypsizygus ulmarius* as affected by different treatments

The difference in width of pileus may be due to the substrate material which affects stalk height, stalk diameter and cap size in mushroom. The maximum stipe length was observed on T_2(wheat straw + bajra dry stem) (11.17 cm) and the minimum length of stipe of T_1 (wheat straw + sarpat). The maximum width of pileus of T_2 (wheat straw+ bajra dry stem) was (8.33 cm) and the minimum in T_1 (wheat straw + sarpat) (5.67).

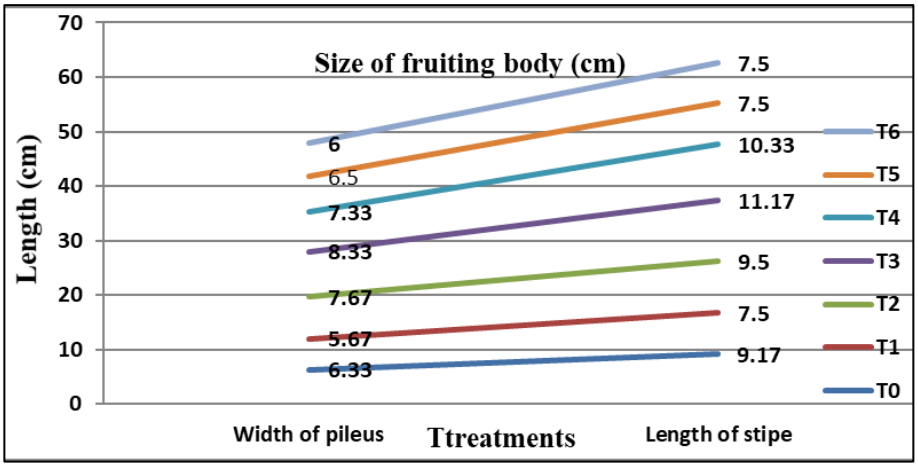

Fig 2: Width of pileus and length of stipe (cm) of *Hypsizygus ulmarius* as affected by different substrates

The highest production of mushroom was weighed in T_3 (wheat straw + banana leaves) (936.6 g) and lowest yield was recorded in T_5 (wheat straw + sawdust) (665 g). The difference in yield may be due to lower mycelium run rate which might be due to presence of various kinds of polyphenolic substances, low content of cellulose and low moisture holding capacity. The maximum biological efficiency was of wheat straw+ banana leaves (93.66%).The reason for higher yield from banana leaves rather than the other treatments may be due to the high-water holding capacity of banana leaves.

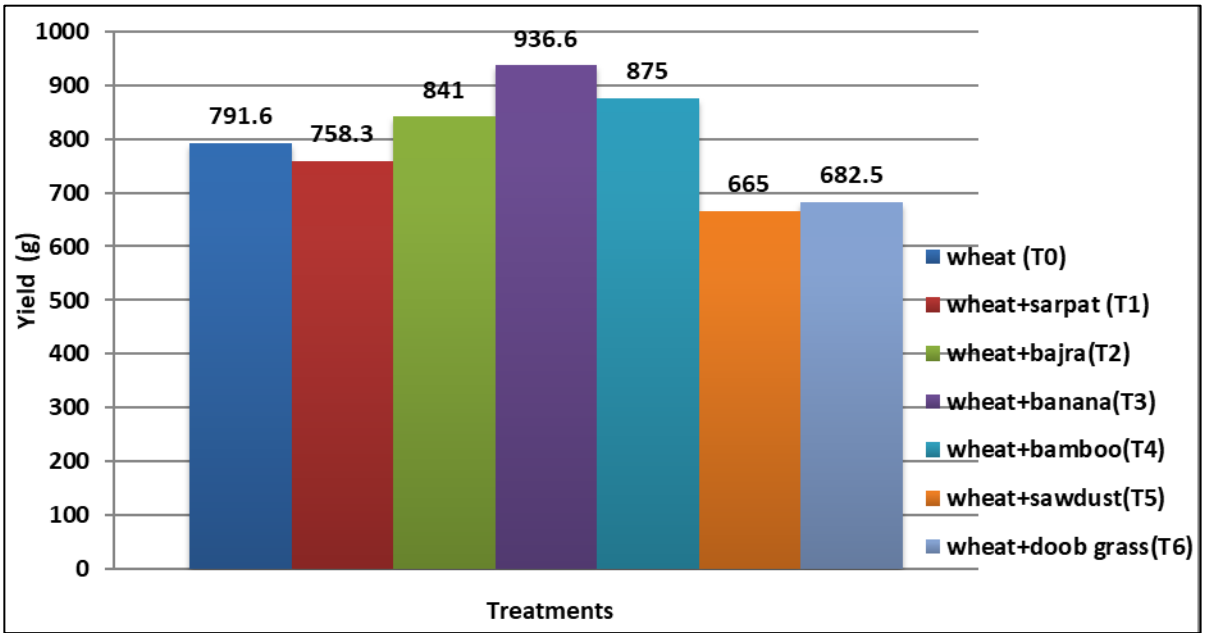

Fig 3: Yield of three flushes on different substrates of *Hypsizygus ulmarius*

The protein content of mushroom was highly variable due to strain of some of species, tissue type, stage of development, substrate and method of analysis. The decomposition of total carbohydrate, cellulose, hemicelluloses and fiber during inoculation stage promoted to high protein content in fruit bodies of mushrooms. The maximum protein content was recorded in T_3 (wheat straw + banana leaves) (31.50%). The maximum carbohydrate content was recorded in T_3 (wheat straw + banana leaves) (25.33%). Carbohydrates content was differed may be due to fiber, such as the structural polysaccharides, glucans, chitin, hemicelluloses and pectic substances.

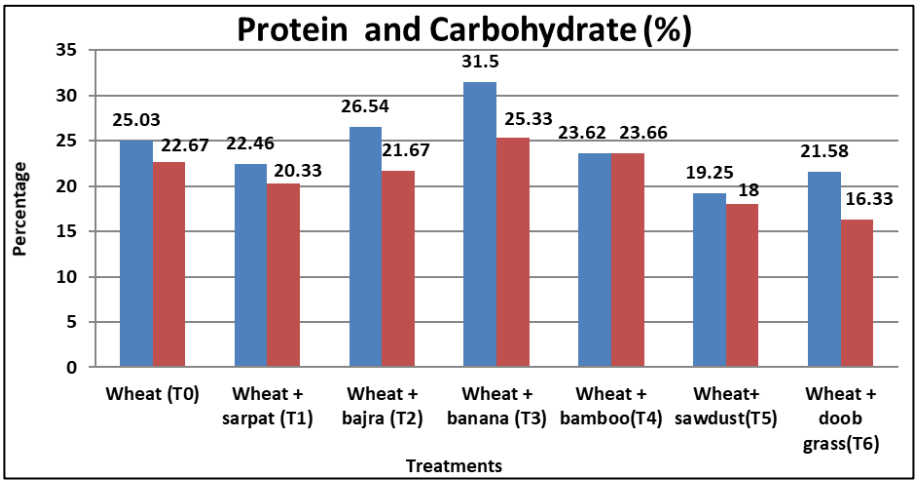

Fig 4: Protein (%) and carbohydrate (%) of *Hypsizygus ulmarius* on different substrates

Conclusion

The combination of wheat straw and banana leaves for the cultivation of blue oyster mushroom recorded minimum spawn run (days), pinhead initiation (days), fruiting bodies formation (days) and maximum yield (g/ kg wet weight substrates), biological efficiency (%), protein content (%) and carbohydrate (%). The results of the present study are of one crop season (October 2018- February 2019) at Prayagraj (U.P) as such to validate the findings more such trials should be carried out in future.

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